BRITISH STANDARD

BS 3987 : 1991

Specification for

Anodic oxidation coatings on wrought aluminium for external architectural applications

BSI STANDARDS

Committees responsible for this British Standard

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Aluminium Federation
Aluminium Finishing Association
Aluminium Window Association
Association of Builders' Hardware Manufacturers
British Lock Manufacturers' Association
British Metal Finishing Suppliers' Association
Institute of Corrosion
Institute of Metal Finishing
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Contents

Foreword

This revision of BS 3987 was prepared under the direction of the Surface Coatings (other than Paints) Standards Policy Committee. It gives a specification for anodic oxidation coatings on wrought aluminium for external architectural applications. It supersedes the previous edition, BS 3987 : 1974, which is withdrawn.

The architect or designer of architectural components is advised to consult with the aluminium supplier to ensure that the correct grade of aluminium is selected in order to produce the required finish and with the anodizer to ensure that the dimensions and configuration of the components are such that the requirements of this standard can be met as an economic proposition. It is important to note that anodizing requirements should be considered at the design stage and attention of designers is drawn to BS 4479 : Part 5. The anodized surface develops a characteristic appearance depending on the grade of aluminium and the anodizing process used. Such coatings, which do not incorporate colouring matter, are known as 'clear' (or sometimes 'natural' or 'silver') anodized aluminium.

This revision of BS 3987 differs from the previous edition in that guidance is given in appendices on information to be supplied by the purchaser to the anodizer, on the selection of aluminium, on the surface texture and on sampling. The significant surface is defined and is no longer specified by the purchaser and colour fastness is specified. Values for thickness and the surface abrasion resistance of the coatings are also given.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Specification

1 Scope

This British Standard specifies requirements for clear and coloured anodic oxidation coatings on wrought aluminium for external architectural applications. Guidance on the information to be supplied by the purchaser to the anodizer is given in appendix A.

Guidance on properties affecting coating performance is given although reflectance and gloss are not specified (see appendix B).

NOTE 1. The coatings consist mainly of aluminium oxide and are produced by an electrolytic oxidation process during which the aluminium acts as the anode.

NOTE 2. The composition of the aluminium is not specified but that used is assumed to be suitable for anodizing (see appendix C).

NOTE 3. Temporary protection and maintenance of anodized aluminium after anodizing may be necessary (see appendices D and E).

NOTE 4. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1 aluminium

Aluminium and aluminium-based alloys.

2.2 anodized aluminium

Aluminium with an anodic oxidation coating, produced by an electrolytic oxidation process in which the surface of aluminium is converted to a coating, generally an oxide, having protective, decorative or functional properties.

2.3 clear anodized aluminium

Aluminium with a substantially colourless, translucent anodic oxidation coating.

NOTE. This is colloquially known as natural anodized aluminium.

2.4 colour anodized aluminium

Anodized aluminium coloured either during anodizing or by subsequent processing.

2.5 integral colour anodized aluminium

Aluminium that has been anodized using an appropriate (usually organic acid-based) electrolyte which produces a coloured coating during the anodizing process itself.

2.6 electrolytically coloured anodized aluminium

Aluminium with an anodic oxidation coating that has been coloured by the electrolytic deposition of a metal or metal oxide in the pore structure.

2.7 dyed anodized aluminium

Aluminium with an anodic oxidation coating coloured by absorption of dyestuffs or pigments into the pore structure.

2.8 significant surface

The part of the article covered or to be covered by the coating, for which the coating is essential for serviceability and/or appearance, and which is the surface intended to be exposed in service.

2.9 average thickness

The mean value of at least five local coating thickness measurements that are evenly distributed over the significant surface of a single anodized piece.

2.10 local coating thickness

The mean of the coating thickness measurements of which not fewer than three are made within a small area (10 mm diameter, or less) of the significant surface of a single anodized piece.

2.11 sealing

A hydrothermal treatment carried out after anodizing to reduce porosity and absorptivity of the anodic oxidation coating.

3 Visual inspection after anodizing

When viewed using normal or corrected vision from a distance of 1 m the significant surface shall be free from visible coating defects (see appendices F and G).

4 Colour

The colour anodizing method, if used, shall be such that a light fastness rating of 9 or greater is achieved when samples anodized to this specification are tested by means of BS 6161 : Part 7 or BS 6161 : Part 8 (see appendix H).

5 Thickness

5.1 Thickness of coating

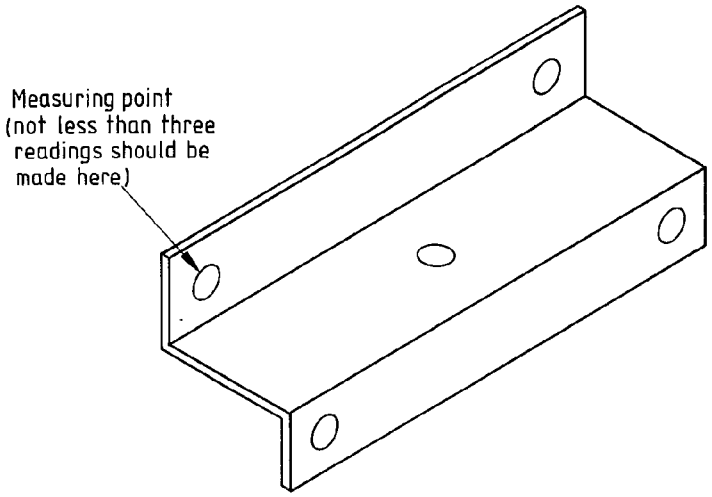
The average thickness of the anodic oxidation coating on a single component shall be not less than 25 μm. At no point on the significant surface(s) shall the local coating thickness be less than 20 μm (see **5.2** and appendix J).

5.2 Measurement of thickness

The thickness of the anodic oxidation coating shall be measured by one of the methods given in BS 5411 : Part 3 or BS 5411 : Part 5.

In cases of dispute the method given in BS 5411 : Part 5 shall be used as the referee method.

The minimum average thickness shall be determined on each component being tested by measuring the local thickness at not less than five measuring points over the significant surface of the component (see figure 1). At each measuring point three readings shall be taken and averaged to determine the local thickness value.



NOTE. Examples of average and local thickness requirements are given in appendix J.

Figure 1. Measuring points

6 Sealing

6.1 General

Clear anodized and colour anodized aluminium shall be sealed.

6.2 Sealing quality

The method described in BS 6161 : Part 3 shall be used as the referee method. Before carrying out the test according to this method, the test specimen shall be immersed for 10 min in a 50 % (*V*/*V*) nitric acid (ρ_{20} before dilution = 1.42 g/mL) solution at 18 °C to 22 °C, and shall be thoroughly rinsed in water and dried.

When tested by this method the mass loss from the sealed anodic oxidation coating shall be not greater than 3.0 g/m^2 of anodized surface tested.

NOTE 1. For production control purposes the sealing quality may be determined using the mass loss, dye spot or measurement of admittance methods described in BS 6161 : Parts 4, 5 or 6 (see appendix K).

NOTE 2. It is often useful to evaluate sealing quality by means of more than one test method.

7 Surface abrasion resistance

When tested by the method described in BS 6161 : Part 18, using glass coated paper, coatings produced by sulphuric acid anodizing shall not be abraded.

When tested by the method described in BS 6161 : Part 18, using garnet coated paper, coatings produced by integral colour anodizing shall not be abraded.

Appendices

Appendix A. Guidance on information to be supplied

A.1 General

The requirements of this specification relate to thickness, sealing quality, colour fastness and surface abrasion resistance. However the purchaser, when ordering, may need to specify further requirements or the anodizer may need additional information in order to meet the requirements of this specification. This appendix gives guidance on the information to be supplied in such cases. **A.2** and **A.3** give details of this information.

A.2 Information which should be supplied

The purchaser should supply the following information essential to the anodizer.

(a) The specification of the aluminium (see appendix C).

NOTE 1. This is essential to ensure that the agreed finish and/or properties can be achieved.

(b) The extent of the significant surface(s), indicated, for example, by drawings or by the provision of suitably marked samples.

NOTE 2. In some cases there may be different requirements for the finish on different parts of the significant surface(s).

NOTE 3. Essential jigging on significant surfaces will result in marking and locally reduced thickness of the coating at the contact points.

(c) The surface texture(s) required (see appendix F).

NOTE 4. It may be appropriate for acceptable limits of variation of final surface finish on the significant surface(s) to be agreed between the purchaser and the anodizer, preferably by the provision of agreed samples.

(d) The sampling procedure to be adopted (see appendix L).

A.3 Additional information which should be supplied in the case of coloured coatings

The purchaser should supply the following additional information to the anodizer in the case of coloured coatings:

(a) the colour required (see clause **4** and appendix H);

(b) the colouring method;

(c) the colour tolerances required, defined by agreed samples (see clause **4** and appendix H).

Appendix B. Guidance on properties affecting coating performance

The performance of an architectural anodic oxidation coating can be assessed by three main properties, namely the following:

(a) anodic oxidation coating thickness;

(b) seal quality;

(c) surface abrasion resistance to weathering.

The anodic oxidation coating thickness will strongly influence the corrosion resistance of the finish, and the seal quality is a measure of the resistance of the coating to staining and corrosion. The weathering performance of the coating is affected by its surface abrasion resistance; a soft coating produces a white bloom, described as chalking, upon exposure to the elements. This can result in an unacceptable appearance and rapid erosion of the anodic oxidation coating which in turn affects the corrosion resistance.

Production line non-destructive tests for anodic oxidation coating thickness and seal quality are well established and the test equipment to carry out these tests is readily available.

Surface abrasion resistance is a valid method of assessing the weathering resistance of an anodic oxidation coating; the higher the anodizing electrolyte concentration and temperature and the longer the immersion time in the electrolyte the lower will be the abrasion resistance of the coating. In general the lower the abrasion resistance the more likely the coating is to chalk.

There are two types of tests used to measure abrasion resistance, namely, the abrasive wheel test and the jet test; these tests are described in BS 6161 : Part 9 and Part 10 respectively.

The abrasive wheel test measures the abrasion resistance of the surface of the anodic finish which is the part of the coating exposed to the elements. The jet test measures the average abrasion resistance of the coating and as such is not as informative in this context as the abrasive wheel test.

Tests carried out suggest that for sulphuric acid anodic oxidation coatings a wear index of 1.2 when measured by the abrasive wheel test should be consistently obtainable and that any coating with a wear index greater than 1.4 is likely to be of unsatisfactory quality for external architectural applications.

These tests are destructive and cannot normally be carried out on site or in production. Consequently attention is drawn to the simple test method described in BS 6161 : Part 18 which uses the relative surface abrasion characteristics of two grades of abrasive paper.

Appendix C. Choice of aluminium for anodizing

Alloys most commonly used for general architectural anodizing purposes are 6063 extrusions (see BS 1474), 5251 sheet (see BS 1470) and 5005 sheet (see BS 1470).

Special grades and alloys of aluminium are available as anodizing quality materials for architectural applications and should be used.

Some variation in appearance and colour can be expected after anodizing, between different batches of the same material and different forms of the same material, e.g. castings, extrusions, forgings and rolled sheet. Additionally, anodic treatments may reveal some lack of homogeneity in the aluminium. These variations can be kept within acceptable limits by cooperation between the material supplier, the anodizer and the purchaser.

Appendix D. Handling and temporary protection during transportation and installation

Special care is necessary in the handling, transportation and installation of anodized products in order to avoid surface damage.

They should not be allowed to rub or slide against each other and significant surfaces should be well protected during transportation, storage and stacking by the use of suitable containers. Wrapping with stout paper, cardboard or other protective media is often a convenient means of protection, but the wrapping should not be allowed to get damp.

It is important to prevent the attack on the anodic oxidation coating by corrosive agents such as contaminated moisture, condensates, cement and plaster splashes. For this purpose, a suitable non-yellowing lacquer, e.g. methyl methacrylate, cellulose acetate butyrate, or a strippable coating is recommended as a protection. Tape and strippable coatings should be such that they can be easily removed after a considerable period of time without leaving significant residues. They are required to protect the anodized aluminium from building hazards, e.g. splashes of cement. After they have served this purpose they should be removed as soon as possible, except in the case of some lacquers which may be allowed to weather away.

It is essential that anodized components be delivered to site and installed at as late a stage as possible in building operations in order to minimize the possibility of damage.

Appendix E. Maintenance of anodized aluminium

Regular cleaning is essential if the finish of anodized aluminium is to be preserved over the years. Deterioration of the anodic oxidation coating can occur mainly as a result of grime deposition and subsequent attack by moisture, particularly when it is contaminated with sulfur compounds. Deposited grime retains the contaminated moisture on the anodized surface, permitting attack to proceed and thereby damaging the anodic oxide coating which cannot be renewed in situ.

The frequency with which cleaning should be carried out will range from monthly to six-monthly intervals according to the degree of contamination of the service environment. The aim of the cleaning operation should be the removal of grime deposited on the surface without damage to the anodic oxidation coating.

The cleaning method to be adopted depends on the degree of deterioration that may already have occurred and on the scale of the operation. Hand rubbing is often used for small work, but large expanses, as in multi-storey buildings, call for carefully controlled methods of loosening adherent deposits.

The anodized aluminium should be washed down with warm water containing a suitable wetting agent or with a mild soap solution. Fibre brushes may be used to loosen attached grime but the use of emery paper, sand paper, steel wool or other highly abrasive materials, and acid or alkaline cleaners is not recommended as they damage the anodic oxidation coating. The use of mild abrasive such as pumice powder and water may sometimes be necessary. It is essential to rinse thoroughly after cleaning using copious applications of clean water, particularly where crevices are present. Where greasy deposits are concerned, cleaning may be by means of a soft cloth dipped in white spirit. After cleaning, the anodized aluminium may be treated with a good quality wax polish.

Since emulsion cleaners or proprietary chemical agents may attack the anodic oxidation coating, they should never be used except in consultation with companies specializing in the cleaning of anodized aluminium.

Appendix F. Surface texture

Different surface textures may be obtained by a variety of treatments. For example, the work may be mechanically polished to obtain a smooth or a bright surface. More usually, the work, either polished or unpolished, is subjected to a chemical etching procedure to provide a range of textures from satin to fully matt, according to the etching conditions used. Alternatively the texture may be produced mechanically, by brushes, abrasive belts or wheels to give a range of matt finishes which are usually lined or directional, in contrast to the essentially non-directional etched finishes.

Very rough surfaces, either chemically or mechanically produced, are best avoided as they tend to hold dirt which can have an adverse effect on the durability of the anodic oxidation coatings.

Appendix G. Visual inspection after anodizing

Anodic treatment can reveal or accentuate lack of homogeneity or differences in metallurgical condition of the aluminium. This means that some non-uniformity of appearance may be encountered on different areas of the component and/or between different batches of material of the same specification, or where certain welding processes have been used.

With colour anodizing in particular, the metal composition, form and surface texture, as well as the viewing angle, can have a profound effect on the subjective impression of colour, and cooperation between the metal supplier, the anodizer and the purchaser is necessary to keep variations within acceptable limits.

It is also sometimes possible, on close inspection or from certain viewing angles, to observe variations in brightness, banding, streaking and other visual effects on the significant surfaces. These seldom impair the protective performance of the anodized aluminium.

The agreed samples used to produce colour and texture limits should, if possible, be duplicates of production components, but should in any case be shaped so as to facilitate comparison with the production component.

Appendix H. Colour

Colour anodized aluminium may be produced by the following methods:

(a) by treating anodic oxidation coatings with organic dyes;

(b) by treating anodic oxidation coatings with inorganic pigments;

(c) by electrodepositing metals or metal oxides into the pores of anodic oxidation coatings;

(d) by anodizing in special electrolytes which form integral colour coatings;

(e) by using special aluminium alloys where the alloying elements are responsible for producing coloured effects in the anodic oxidation coating.

In some cases, a combination of the methods listed in (a) to (e) may be used.

The light fastness of the colour anodized aluminium depends on the methods of colouring and the colouring medium used. Only a limited range of coloured finishes is suitable for exterior use and advice should be sought from the anodizer. In addition certain dyestuffs, though fast to light in the long term, change slightly in the earlier periods and this may need to be taken into consideration.

Appendix J. Examples of average and local thickness requirements

The following examples illustrate conformity or non-conformity to the requirements of **5.1**.

Example 1 Measured values: (in μm) 25 27 28 26 25

The sample conforms to the requirements in every respect.

Example 2 Measured values: (in μm) 25 28 27 27 23

This sample conforms to the requirements. It has an average thickness above 25 μm, and a local thickness above 20 μm.

Example 3 Measured values: (in μm) 23 25 24 25 23

This sample does not conform to the requirements as the average value is below 25 μm.

Example 4 Measured values: (in μm) 25 29 27 27 19

This sample does not conform to the requirements, as, although the average value is above 25 μm, the local thickness falls below 20 μm.

Appendix K. Sealing quality: production control methods

The adequacy of sealing for production control purposes is determined by one or more of the methods described in BS 6161 : Parts 4, 5 or 6. The criteria for acceptable sealing quality for these methods are shown below:

(a) when tested by the method described in BS 6161 : Part 4, the mass loss should not exceed 2.0 g/m^2 of anodized surface tested;

(b) when tested by the method described in BS 6161 : Part 5, a stain intensity of not more than 2 should be obtained. The presence of peripheral rings of deeper colour after the test is considered unacceptable;

(c) when tested by the method described in BS 6161 : Part 6, the corrected admittance value, i.e. the value it would be at 25 °C and at a thickness equivalent to 20 μm, should not exceed 25 μS (equivalent to $\frac{500}{T}$ μS where T is the thickness of the coating in micrometres, measured by the method described in BS 5411 : Part 3, in the same area as that used for the admittance test).

NOTE. This test may give anomalous results with some electrolytically colour anodized aluminium.

Appendix L. Guidance on sampling

L.1 Introduction

When a purchaser wishes to be assured that the quality of a lot, or lots, of anodized work conforms to the quality specified, it is recommended that sampling be carried out in accordance with one of the sampling plans given in BS 6001 : Parts 1 and 2, using the guidance given in BS 6000.

Thus, when a complete order, anodized in the same plant, is delivered in a series of lots numbering three or more, a sampling plan would be chosen on the basis of an acceptable quality level (AQL) or limiting quality (LQ) which represents the average percentage of non-conforming parts which the purchaser is prepared to tolerate. Purchasers unacquainted with the random variations in quality inseparable from mass production are inclined to ask for an AQL of zero. This, however, is quite unrealistic and can only be achieved by 100 % inspection by an ideal inspector or by setting excessively wide tolerances on the characteristics that are subject to variations (with regard to both locations and spread).

The following recommendations are therefore given to provide guidance on the sampling and inspection of anodized products. They are based on several years' experience of acceptance inspection of anodized aluminium products from many different plants and from observation of the satisfactory performance of the finishes in subsequent service when accepted according to the suggested qualities.

NOTE. Although measurement of coating thickness and assessment of sealing quality by admittance measurement (see **L.2**) produce numerical variables on a cardinal scale, rather than the usual, simple yes/no assessment of attributable data, it is recommended that BS 6002 (which describes sampling and inspection by variables) should not be used as a basis for acceptance. This is because the distribution of thickness and admittance criteria invariably depart so far from the normal (Gaussian) distribution on which the plans described in BS 6002 are based, that serious error is likely to result if they are used for acceptance.

L.2 Sampling of orders involving three or more lots

L.2.1 *Sampling and inspection involving critical major attributes*

Using general inspection II of BS 6001 : Parts 1 and 2 and non-destructive tests, coating thickness, abrasion resistance and sealing quality are treated as major attributes, since substandard parts would have a shorter life to failure (because of thin coatings) or would develop a disfiguring bloom, chalking or powdering early in service. For anodized work which would be costly to replace were faults to emerge after installation, e.g. parts built permanently into some larger structure, plans chosen to produce acceptance at an AQL of 1 % or better are recommended. If however it would be simple to replace a faulty part, an AQL of 1.5 % may prove marginally more economical, provided it is judged that the occurrence and replacement of faulty items is unlikely to harm the goodwill between supplier and purchaser.

L.2.2 *Sampling and inspection involving non-critical attributes*

For attributes which are less critical to the performance of the finish than are thickness or sealing, and especially where their presence or absence is visible and does not need instrumental detection, an AQL of 4 % is satisfactory. This is the value recommended for attributes such as colour, surface texture and defects like scratches, dents, banding and die lines.

L.3 Sampling of single lots

In the case where the whole of a purchase is presented as one complete lot, a sampling plan has to be chosen not on the basis of AQL, but on the basis of using BS 6001 : Part 2. This is the worst quality which might have a chance of 1 in 10 of slipping through inspection. It provides a more rigorous test, since with a single lot there is no protection from the switching rules (see BS 6000) which apply to plans applicable with a number of continuing lots. For major attributes where an AQL of 1 % is recommended, an LQ (at 10 % probability of acceptance) of 3.15 % is satisfactory. For other attributes where an AQL of 4 % is recommended an LQ of 8 % should be used.

L.4 Bias

The use of sampling plans described in BS 6001 : Parts 1 and 2 is based on the sample drawn being representative of the lot as a whole. This is most likely to be the case when the true random sample is drawn, and when possible such a sample should be chosen using the guidance given in BS 6000.

In the cramped conditions under which sampling usually takes place, a sample may have to be drawn as best one may, rather than as one ought. It is wise in this case to test the sample for signs of bias by performing a runs test on the thickness measurements in the order in which they were made. Practical guidance on conducting the runs test is to be found in statistics texts, e.g. R.Langley: *Practical Statistics*, Dover, New York, 1971.

Publication(s) referred to

BS 1470	Specification for wrought aluminium and aluminium alloys for general engineering purposes: plates, sheet and strip
BS 1474	Specification for wrought aluminium and aluminium alloys for general engineering purposes: bars, extruded round tubes and sections
BS 4479[1)]	Design of articles that are to be coated Part 5 Recommendations for anodic oxidation coatings
BS 5411	Methods of test for metallic and related coatings Part 3 Eddy current method for measurement of coating thickness of non-conductive coatings on non-magnetic basis metals Part 5 Measurement of local thickness of metal and oxide coatings by the microscopical examination of cross-sections
BS 6000	Guide to the use of BS 6001, sampling procedures and tables for inspection by attributes
BS 6001	Sampling procedures for inspection by attributes Part 1 Specification for sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection Part 2 Specification for sampling plans indexed by limiting quality (LQ) for isolated lot inspection
BS 6002	Specification for sampling procedures and charts for inspection by variables for percent defective
BS 6161	Methods of test for anodic oxidation coatings on aluminium and its alloys Part 3 Assessment of sealing quality by measurement of the loss of mass after immersion in phosphoric-chromic acid solution Part 4 Assessment of sealing quality by measurement of the loss of mass after immersion in acid solution Part 5 Estimation of loss of absorptive power of sealed coatings: dye spot test with prior acid treatment Part 6 Assessment of sealing quality by measurement of admittance or impedance Part 7 Accelerated determination of light fastness of coloured anodic oxidation coatings using artificial light Part 8 Determination of the fastness to ultraviolet light of coloured anodic oxide coatings Part 9 Measurement of wear properties with an abrasive wheel wear test apparatus Part 10 Measurement of mean specific abrasion resistance with an abrasive jet test apparatus Part 18 Determination of surface abrasion resistance

[1)] Referred to in the foreword only.

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