British Standard

BRITISH STANDARD

BS 4479-5:1990

Design of articles that are to be coated —

Part 5: Recommendations for anodic oxidation coatings

UDC 672/673:621.795:006

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Surface Coatings (other than Paints) Standards Policy Committee (SRC/-) to Technical Committee SRC/10, upon which the following bodies were represented:

British Anodising Association
Institute of Metal Finishing
Institute of Sheet Metal Engineering
Institute of Vitreous Enamellers
International Tin Research Institute
Metal Finishing Association
Welding Institute
Zinc Development Association

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The following BSI references relate to the work on this standard:
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Foreword

This Part of BS 4479 has been prepared under the direction of the Surface Coatings (other than Paints) Standards Policy Committee and is based on a draft prepared by the Institute of Metal Finishing. The BSI Technical Committee acknowledges the contribution to this revision by the Institute[1)] and by the Committee for the Promotion of Electroplating. This Part of BS 4479 is one of a series of Parts which together form a revision of BS 4479:1969. On publication of all the Parts, BS 4479:1969 will be withdrawn. This revision of BS 4479 comprises the following Parts:

— *Part 1: General recommendations;*

— *Part 2: Recommendations for electroplated and autocatalytic coatings;*

— *Part 3: Recommendations for conversion coatings;*

— *Part 4: Recommendations for paint coatings and varnish coatings;*

— *Part 5: Recommendations for anodic oxidation coatings;*

— *Part 6: Recommendations for hot-dip metal coatings;*

— *Part 7: Recommendations for thermally sprayed coatings;*

— *Part 8: Recommendations for vitreous enamel coatings;*

— *Part 9: Recommendations for low pressure and vacuum deposited coatings.*

BS 4479 is directed towards helping to maximize the benefit obtained from coating processes. There is a wide variety of coating processes, developed and established industrially, intended to enhance or transform the surfaces of manufactured articles. However, time and money are often wasted because the design of many articles is unsuitable for the coating process to be applied. Coating is only one part of the manufacturing process and should not be ignored, or viewed in isolation, when considering the overall costs and quality.

This revision of BS 4479 has been undertaken to extend the range of coating processes covered. It is not intended to cover every conceivable design detail, type of article or service condition. Adherence to the general principles described will, however, greatly assist in the achievement of the desired results. In any case of doubt or difficulty, specialist advice in the particular type of process being considered should be sought.

This Part of BS 4479 is not a specification and should not be used as such. The recommendations are intended to provide guidance towards good practice.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 8, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

[1)] Institute of Metal Finishing.

1 Scope

This Part of BS 4479 gives recommendations for the design of metal parts that are to be coated by anodizing.

This Part of BS 4479 also outlines the nature of the processes involved, gives typical applications for finished parts, and also outlines the prime features of an anodized finish.

NOTE 1 It is recommended that Part 1 of BS 4479 be read in conjunction with this Part. Part 1 includes a list of British Standards relating to processes covered by BS 4479 but not necessarily referred to in each Part.
NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 4479, 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
hard anodized

the production, by special anodizing methods, of very hard and abrasion-resistant anodic oxidation coatings

2.4
dyed anodized aluminium

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

2.5
significant surface

the part of the article covered or to be covered by the coating and for which the coating is essential for serviceability and/or appearance

2.6
anodic oxidation coating

electrolytic oxidation process in which the surface layer of a metal is converted to an oxide coating having protective, decorative or functional properties

NOTE This is widely applied to aluminium and its alloys, but also applies to titanium, magnesium and zinc.

3 General

It is essential that the design of any article required to be coated should take into account not only the function of the article and its method of manufacture but also the limitations imposed by the coating.

Anodizing is an electrochemical process, whereby the natural oxide coating present on particular metals may be thickened. The process is applied principally to aluminium and its alloys, but it may also be applicable to materials such as magnesium, niobium, tantalum and titanium.

Anodized aluminium and aluminium alloys are widely used by many industries. The unique properties of the anodic oxidation coating may be employed in a number of ways, e.g. for decorative, protective or wear resistance purposes, or, as is usually the case, a combination of all these. Typical uses of anodic oxidation coatings include architectural fittings such as window frames and walling curtains, bathroom and household appliances, fascia panels, electrical shielding, and for hard, wear-resistant engineering finishes. Coatings produced by conventional sulphuric acid based processes readily accept a wide range of coloured dyes and are generally used for protective and decorative applications. Coatings produced by chromic acid based processes usually give pastel shades and are usually applied in situations where corrosion resistance or savings in fatigue strength are important factors.

Since anodic coatings are of an oxide based composition they are of low conductivity and, when the pores in the coatings are sealed, they can have very good insulating properties. Because most anodic coatings are porous, the pores may be partially filled with colouring materials prior to sealing. A wide range of colours is available and, when used for architectural purposes, it is necessary for the resultant finish to be lightfast and weather resistant.

By varying the type and conditions of use of the different electrolytes, anodic coatings having a wide range of properties can be obtained. For example, in the case of aluminium, thin, rather soft coatings of 2 μm to 10 μm can be produced in chromic acid which have very good corrosion resistance and which are of importance in aerospace applications. The popular sulphuric acid process gives coatings of 1 μm to 35 μm thickness and is commonly used for decorative trim coatings of thickness 5 μm to 10 μm (see BS 1615). For architectural and building components, coatings of thickness of 25 μm are usually applied (see BS 3987). Hard anodic coatings of thickness 25 μm to 100 μm are produced in refrigerated sulphuric acid electrolytes (at – 10 °C to + 5 °C), and are used for applications where wear and corrosion resistance are required. These hard coatings are also important in the engineering and electronic industries for applications where electrical insulation is needed (see BS 5599).

Whilst anodizing is normally carried out as a batch process it may be applied to continuously moving strip, or to work in special baskets, e.g. as used for anodizing rivets.

The following facts should be particularly noted:

a) different alloys can have different appearances when anodized;

b) the metal can be pre-textured mechanically or chemically;

c) metal is consumed during anodizing;

d) the anodic coating is essentially non-conducting.

Diagrams illustrating preferred and deprecated design features for articles to be anodized are given in Appendix A.

4 Design considerations

4.1 Drainage and rinsing

Welded assemblies should be avoided because their cast porous structure can cause entrapment of anodizing electrolyte which can lead to white spots or stains. They also anodize to a colour different from that of the surrounding wrought structure. Certain porous castings are prone to the same effects and care should be exercised in their selection for use in anodized assemblies. Castings where blow holes have been filled with various compounds should be avoided.

Tubular assemblies should be provided with adequate means of drainage.

4.2 Shape

Sharp edges and corners should be chamfered or rounded off as far as possible to avoid cracking and points of weakness in the anodic coating. Radii of at least 10 times the coating thickness should be used and radii of at least 30 times the coating thickness are preferred for more demanding applications, e.g. articles to be used in engineering applications in an aggresively corrosive environment.

Unnecessary blind holes, pockets and small bores should be avoided to reduce the risk of acid entrapment and airlocking. Solution in such re-entrants can be difficult to agitate sufficiently and this may lead to overheating of the anodic coating and a reduction in film quality (especially abrasion resistance). If bores and re-entrants, etc., are significant surfaces this should be clearly indicated.

It is essential to avoid entrapment of large volumes of air in parts otherwise they will not sink in the process solution.

4.3 Alloys

Mixed metals are not receptive to anodizing and aluminium alloys should not be anodized if the assembly contains metal inserts other than aluminium and/or titanium (e.g. copper, steel or brass inserts). Aluminium cannot be anodized in the same bath with zinc and magnesium.

NOTE Although aluminium and titanium can be anodized in the same bath in most conventional electrolytes, the same coating characteristics cannot be achieved for each metal.

It is not considered good practice to anodize different types of aluminium alloys at the same time. Some materials require a higher current density to produce the same coating thickness.

Similarly various aluminium alloys respond very differently to processing and may, therefore, show different textures and colours; and after anodizing give coatings of different porosity and hence variable response to colouring techniques.

Heat treatment and annealing processes applied to certain alloys greatly affect the appearance when anodized.

4.4 Surface texture

Materials of a different surface texture, produced by either mechanical or chemical means, will anodize at different rates, giving different coating thicknesses.

Generally, the rougher the surface, the thinner and darker the coating will be. Cast surfaces anodize poorly compared with machined areas. Heavily etched surfaces tend to be grey rather than silver (as do sand or shot blasted surfaces) after anodizing.

The more highly alloyed the component, the darker and rougher the coating appears, whatever the pretreatment or anodizing process.

The greatest reflectivity is produced by electrobrightening or chemically brightening a previously mechanically polished surface of a very pure aluminium alloy and the brightest dyed or electro-coloured surfaces are obtained by dyeing the coatings after anodizing these materials.

4.5 Effect on physical and mechanical properties

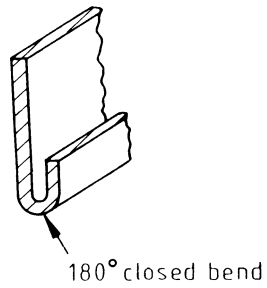
As a general rule anodizing increases the dimensions of a component by approximately 50 % of the coating thickness per surface. For some alloys, especially those containing relatively high proportions of silicon, copper, zinc or magnesium, the increase is less. The change in dimensions will depend upon the anodizing process used and is not normally significant on coatings thinner than 20 μm.

Since anodic coatings are generally harder and less flexible than the substrate, they craze on bending or as a result of excessive temperature changes. The thicker the coating and the smoother the original substrate the more crazing is apparent. Anodic coatings craze on heating, especially above 100 °C, but the temperature depends to some extent on the alloy and the process. For many purposes crazing is not necessarily detrimental to the performance of the coating.

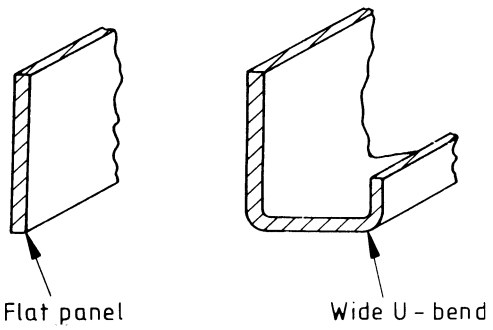
Under conditions of vibration, stress cracking may occur. Cracks will act as notches under such conditions and failure by fatigue may occur. Strong alloys, therefore, often show a significant reduction in fatigue strength on anodizing, although other mechanical properties are not normally affected. Thicker and harder anodic coatings are more prone to give rise to a reduction in fatigue strength.

Appendix A Diagrams illustrating preferred and deprecated design features for articles to be anodized

Diagrams illustrating preferred and deprecated design features for articles to be anodized are given in Figure 1 to Figure 7.

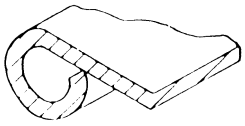


(a) Bent edge: deprecated design

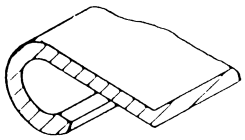


NOTE The edges should be so designed that solutions cannot be trapped.

(b) Bent edges: preferred design

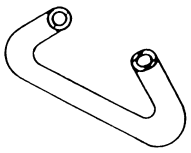


(c) Rolled edges: deprecated design

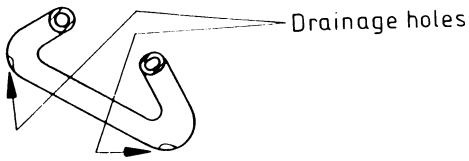


(d) Rolled edges: preferred design

Figure 1 — Rolled and bent edges



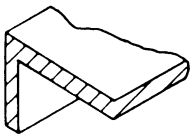
(a) Deprecated design



(b) Preferred design

NOTE Drainage holes should be provided in hollow articles.

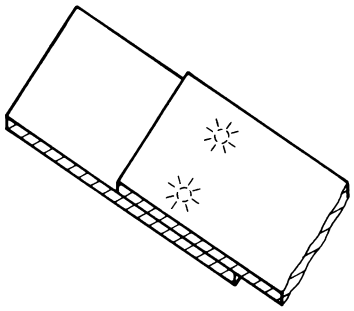
Figure 2 — Hollow articles

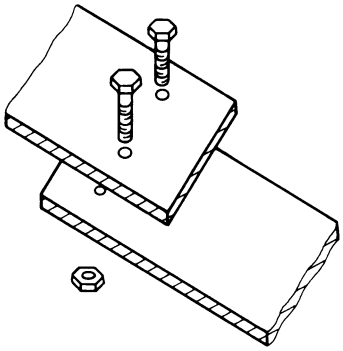


(a) Deprecated design

(b) Preferred design

Figure 3 — Corners



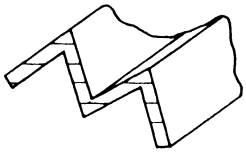


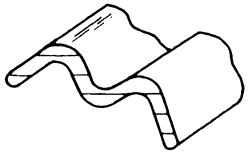
NOTE Lap joints should be so designed that parts can be processed separately and then joined.

(a) Deprecated design

(b) Preferred design

Figure 4 — Lap joints

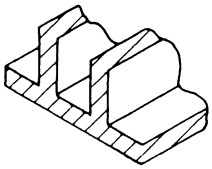


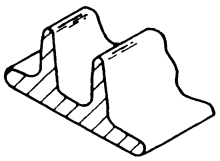


NOTE Edges and protuberances should be smoothed out as much as possible.

(a) Edges: deprecated design

(b) Edges: preferred design

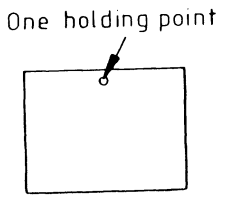




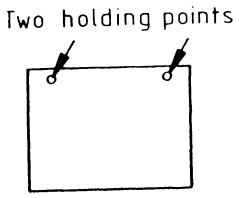
(c) Fins: deprecated design

(d) Fins: preferred design

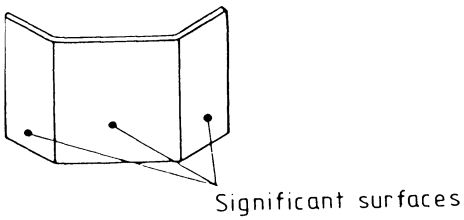
Figure 5 — Edges and protuberances



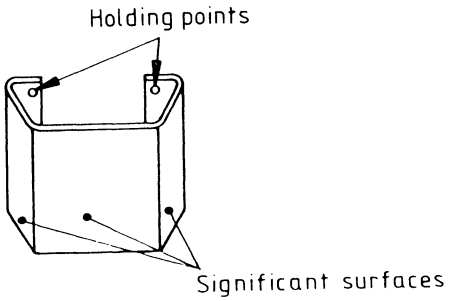
(a) Deprecated design



(b) Preferred design



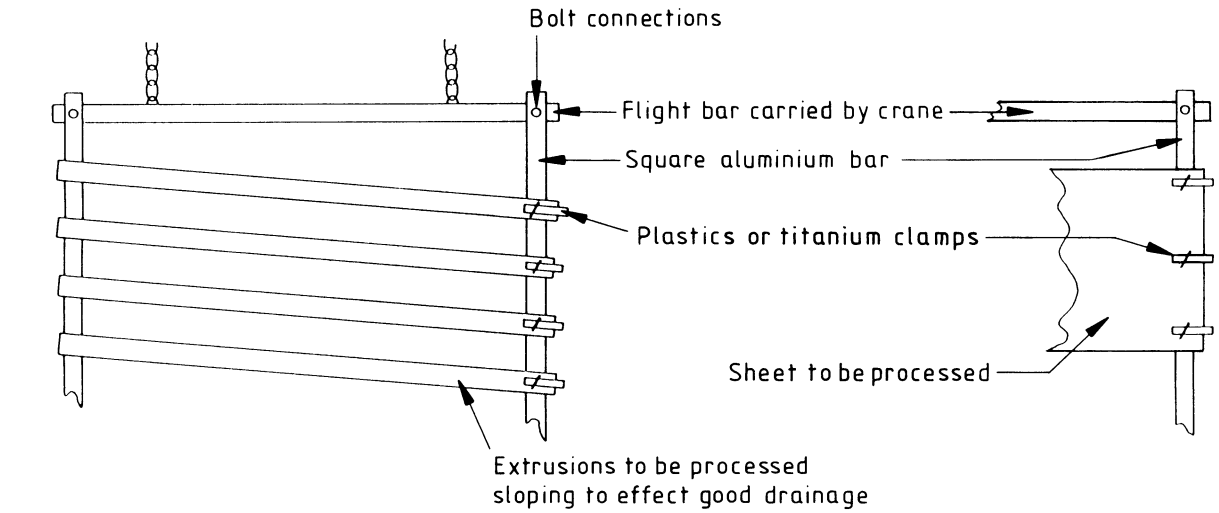
(c) Deprecated design



NOTE Holding points should be avoided on significant surface.

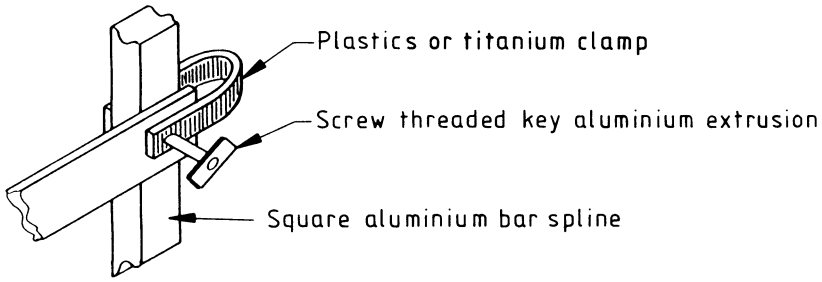
(d) Preferred design

Figure 6 — Holding points



(a) Extrusions

(b) Sheet



(c) Clamping device

Figure 7 — Jigging

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Publications referred to

BS 1615, *Method for specifying anodic oxidation coatings on aluminium and its alloys.*

BS 3987, *Specification for anodic oxide coatings on wrought aluminium for external architectural applications.*

BS 4479, *Design of articles that are to be coated.*

BS 4479-1, *General recommendations.*

BS 5599, *Specification for hard anodic oxide coatings on aluminium for engineering purposes.*

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