# HARD ANODISING

Aluminium oxide is extremely hard and anodic films should theoretically also possess high levels of hardness and abrasion resistance. However, the cellular pore structure of standard anodic films generally prevents them achieving their theoretical potential in these areas.

By controlling the mechanism of oxide formation and thereby reducing porosity, significantly harder films can be produced. Hard anodising provides this control, usually by low temperature dilute electrolyte solutions operated at high current densities and voltages. The Dioxal hard anodising process is the main process used at Acorn. This process produces anodic films with an unusual and versatile combination of properties. The physical properties of a hard anodic film depend largely on the processing conditions and to some extent on the grade of Aluminium alloy being processed.

The Hardas process utilises a combined ac and dc electrical currant to achieve high film thickness' in a short time. The ac is used as a means of achieving maximum current densities with the minimum risk of burning. This is particularly useful for high copper alloys.

Hard Anodising film thickness' are typically 40-50 microns on most alloys. For alloy suitability refer to data sheet 8. Titled; "Design notes, and special considerations for anodising."

# PROPERTIES OF HARD ANODISED FILMS

## HARDNESS AND ABRASION RESISTANCE

Hardness and abrasion resistance are characteristics which have a degree of interdependence. As the inherent hardness of the anodic film is difficult to determine due to the pore structure, hardness values alone can be misleading.

Microhardness values in the region of 350 to 500 VPN are quite normal. Under light load conditions however, it has been found that hard anodising will give satisfactory performance for far longer than might be inferred from its measured hardness. In fact it often exceeds the performance of alternative materials. **In practice, the wear resistance of hard anodised Aluminium at 450 VPN is greater than that of tool steel having a measured hardness of 900 VPN. Both glass and hard chrome plate can be scratched by a hard anodised needle.**

The porosity of a hard anodic film, though relatively low, is nevertheless sufficient to accept impregnation with, for instance, dyestuffs to produce an identifying or decorative colour. This property of hard anodising has been developed to accept PTFE so that the anodic film can incorporate the advantages of this material. This process is known in the UK as 'Lubrok' and produces a highly abrasion resistant, non-stick finish having outstanding wear life and a coefficient of friction lower than 0.05.

## THERMAL CHARACTERISTICS

An anodic film is a good insulator with less than $1/10^{th}$ of the thermal conductivity of Aluminium itself. Anodised Aluminium shows good heat resistance and will withstand short exposure of up to 2000 Celsius. The thermal emissivity of bright raw Aluminium is very low, but increases rapidly with anodising. A normal hard anodic film is very close to being a true black body radiator without being dyed black.

## ELECTRICAL BREAKDOWN

Electrical breakdown is a complex phenomenon to summarise but it can be stated that anodic films generally exhibit breakdown voltages of approximately 25 Volts per micron of film thickness. This figure is affected by the purity of the Aluminium, the homogeneity of the alloy and the smoothness of the metal surface. Hard anodic films have an advantage over plastics because they can withstand higher mechanical pressure and operate at much higher temperatures.

## FATIGUE LIFE

The fatigue life of an Aluminium test piece is reduced by hard anodising by approximately 30 to 40%. Under normal operating conditions this reduction is often overshadowed by the component's mechanical configuration but it must be taken into account for critical applications. Fatigue life can, however, be restored to some extent by sealing the hard anodic film, though this may be at the expence of the abrasion resistance.

## COLOUR

Colour is part of all hard anodised films and is dependent on the alloy composition and the processing conditions. The anodising action causes minute particles of the base material to be entrapped in the anodic film and the resultant effect on light reflected from the surface produces a colour which can range from light to dark grey. Variations in the material specification, heat treatment and surface finish may affect the final appearance and should be considered at the design stage. A variety of dyed colours can be applied to hard anodic oxide coatings, the resultant shades are also dependent on the formation of the alloy-dependent natural colouring.

## CORROSION RESISTANCE

A feature of sulphuric anodising processes for Aluminium components used in architectural and general industrial applications is the necessity to achieve corrosion protection by sealing the anodised surface usually in boiling water or steam. This hydrates the surface of the film, causing it to expand and plug the pores of the cellular anodic structure preventing attack of the base material.
Unfortunately this also has the effect of reducing the hardness of the outer part of the film so, for applications requiring maximum abrasion resistance, hard anodic films are usually supplied unsealed. Their natural corrosion resistance is usually better than that of standard sulphuric anodising.

Sealing with alternative chemical solutions, such as dichromate's or Nickel acetates will enhance the inherent corrosion resistance, although abrasion resistance is still slightly reduced.

Where especially arduous conditions are to be encountered, in marine applications for example, duplex sealing using a combination of nickel acetate and dichromate has been shown to improve performance.

The corrosion resistance of a hard anodic film may be improved by PTFE treatment without adversely affecting abrasion resistance.

Sealed and unsealed hard anodic films have been shown to perform well in comparison with some steels by long term corrosion tests in marine and industrial environments. The hardcoats (hard anodic coatings) compare very favourably with 18/8 steel and are significantly better than 5% chrome steel, cadmium-plated steel and hard chrome-plated steel. See table opposite.

| **Test Material** | **Atmosphere** | |
|---|---|---|
| | **Marine** | **Industrial** |
| | **Degree of corrosion exhibited** | |
| Hard anodised | | |
| -unsealed | None | None |
| -dichromate sealed | None | None |
| -PTFE sealed | None | None |
| Cadmium plated | Slight | Heavy |
| 18/8 stainless steel | None | None |
| Hard chrome plate | Very slight | Very slight |
| 5% chrome steel | Heavy | Heavy |

**Long term corrosion tests based on Min. of Technology report ST 6/68, 1968. Exposure: 1 year**

## APPLICATIONS

The number of applications for hard anodising continues to grow as designers and engineers become aware of the cost saving that can result from combining Aluminium's light weight and machinability with a hard anodic finish.

The versatility of hard anodised Aluminium can be further extended by post-treating with PTFE, reducing the coefficient of friction and improving the total abrasion resistance to give a broad range of precision engineering applications. The aerospace, electronics, defence and general engineering applications of PTFE coated hard anodic film are steadily increasing. There are many military applications for hard anodic films. These include shells, ammunition guides and hull sections for torpedoes and missiles.

General engineering applications are quite diverse, and include textile and cigarette making machinery, marine hardware, drive pulley teeth and grooves, pistons, rollers, gear sprockets and transfer chutes.

Electrical components make use of the dielectric properties of the hard coating electronic, heat sinks and computer plates for example. Modern masking techniques enable selected areas of conductivity to be left unanodised, thus ensuring electrical contact when required.

**The major SPECIFICATIONS worked to at Acorn Surface Technology for hard anodising are:-**

1. **DEF STAN 03-26** Hard anodising of Aluminium and its alloys. This replaces **DEF 151 type 3.**
2. **NWS 1000/5/2-3** Hard anodising.
3. **Mil-A-8625 Type 3** Hard anodising.
4. **BS 5599** Specification for hard anodic oxide coatings on Aluminium for engineering purposes.

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