5. Aluminum Anodising and Powder Coating Comparison
Difference Between Powder Coating and Anodising

Coating is exactly as it sounds – applying a layer of material onto the surface of the aluminum. Anodising is oxidation of the aluminum itself, with color coming from dyes trapped in the oxide layer. Therefore anodising is not really a “coating”, although we can refer to the thickness of the anodising layer as though it were a coating.

History

Use of aluminum in architectural facades became popular in the 1960s. Anodising and liquid coatings were both available, with anodising especially popular in the 1970s. Powder coating became possible for aluminum in 1972, and by the late 1980s had almost completely replaced liquid coatings in Europe. Liquid is still extensively used today in many parts of Asia and the Americas, especially for long-term durability (pvdf systems).

Types of Anodizing

For architectural aluminum the sulphuric acid process is used. Grades of anodising are often defined by the thickness of the anodising layer, with 25μm being required for high quality, weather-resistant finishes.

It is of great importance that the pores in the anodised film are sealed. This is done normally by immersion in hot water. 1 minute of immersion is typically needed per micron of anodising thickness, so a 25μm layer would need around 25 minutes sealing time.

Finish Colors

In anodising, color can be introduced using electrolytic deposition of a metal or metal oxide giving colors from pale champagne to bronze and black.

The Anolok® process licensed by Alcan International is such a process. Dyes can also be used to produce exotic colors, either added to natural anodising or in combination with electrolytically colored anodising. So-called Anolok II (withdrawn trademark of Alcan) colors can produce blue-grey shades which are currently very popular. This is a variation of the electrolytic process which creates an interference effect.

Warranties for anodising are typically quite comprehensive and for long periods – 20 years is often available.

A matte finish is standard. Etched, semi-bright and bright polished effects are possible at a premium.

In coatings, almost any color or effect is possible, from white and black to bright colors and metallic shades. For 99% of shades, color warranties of 10-20 years are typical. Bright shades such as Coca Cola red or Shell yellow use pigments that would fade and so often have lower warranties, or are not available in high-performance resin systems, as the pigment will prematurely fade within the lifetime of the coating.

Testing Standards for Specification

There are separate national and international standards for coatings and anodising available for specifiers.

The most important standards for exterior coatings are:

- AAMA 2603
- AAMA 2604
- AAMA 2605
- British Standards BS 6496 and BS EN 12206
- Quality labels Qualicoat and GSB

The important parameter for exterior coating standards is the durability as measured by years in Florida the coating can be expected to endure (from 1 to 10 years).

For anodising, the most important quality attribute is the thickness of the anodized layer, with the highest quality being 25μm. The American standard AAMA 611 demands only 18μm, Qualanod 15μm. The British standard demands 25μm, while the Australian standard requires different thicknesses depending on environment, with 25μm for severe environments.
Which Finish is Better?

There are proponents for both anodising and coating. There is no doubt that the two technologies appear different, and that if a “living” finish showing a real metal surface is needed, then anodizing is the only choice (though newer powder coating finishes with a pattern imprinted into them can also give the effect of seeing the metal grain).

Coating of Non-Aluminium elements

Anodising can only be applied to aluminum, while coatings can be applied to steel, aluminum, plastics and wood so that different elements can be made to match. This means that if a job contains steel structures, or handles, brackets and balustrades, they will appear different to the anodised aluminum window. Welded areas can also not be anodised, though they can be coated.

Exterior Weathering

There is a belief that anodising is superior to powder coatings when long-term performance outside is required. As with any comparison, it depends what is being assessed.

Cheaper grades of anodising, and bright anodizing colors, have worse performance even than cheaper grades of powder coating. Top-quality 25um sealed anodizing has excellent weather resistance and color retention.

Until the 1990s, most coating specifications called for only a system that survived 1 year in Florida. Nowadays there are much tougher specifications available, and superior coatings are available which meet them.

Applying the toughest specification, both systems need to meet a 10-year weathering test in Florida with comparable requirements for how they look after the 10 years:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Florida exposure / color change</th>
<th>Salt Spray Corrosion Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAMA 611 Class I (anodizing)</td>
<td>10 years, Delta E &lt;5 units</td>
<td>3000 hours, minimal corrosion</td>
</tr>
<tr>
<td>AAMA 2605 (coatings)</td>
<td>10 years, Delta E &lt;5 units</td>
<td>4000 hours, minimal corrosion</td>
</tr>
<tr>
<td>AAMA 2604 (coatings)</td>
<td>5 years, Delta E &lt;5 units</td>
<td>3000 hours, minimal corrosion</td>
</tr>
</tbody>
</table>

All coating standards demand real exterior weathering, normally in Florida, with defined maximum gloss and color change limits.

All Anodising standards, other than AAMA611 have weak weathering requirements either based on textile light fastness tests in simulated weathering apparatus, or say that weathering requirements are to be agreed between buyer and seller.
Coating Thickness

Coating standards vary in their thickness requirements, but generally ask for 50 microns average. For more hazardous environments, they call for a stronger pre-treatment regime, and coating guarantees for these environments often call for primers or thicker coating (70um +). Among Anodising standards only the British standard demands universally the accepted 25um thickness for high-quality and long term performance.

Table 2: Film Thickness Requirements for Anodising

<table>
<thead>
<tr>
<th></th>
<th>AAMA 611 Class 1</th>
<th>AAMA 611 Class 2</th>
<th>Australian 1231</th>
<th>BS 3987</th>
<th>Qualanod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum thickness*</td>
<td>18um</td>
<td>n/a</td>
<td>15-25um (depending on environment)</td>
<td>25um</td>
<td>15um</td>
</tr>
<tr>
<td>– exterior parts</td>
<td></td>
<td></td>
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</table>
Hazardous Environments

Anodising is more susceptible to polluted environments than coatings. Coatings slowly lose film weight as the film breaks down, but as long as gloss remains high it is clear that film erosion is hardly proceeding, and thereafter at < 1um per year. Therefore a coating passing 5 years Florida weathering will not begin to erode until after 5 years and will still have a substantial coating thickness after 20 years. An acidic or marine environment will accelerate the time to first loss of gloss, but evidence shows that film integrity remains strong even after 20 years.

By contrast, an Anodised film in an acidic environment can lose substantial thickness, weakening the film and accelerating its degradation. In Sheffield in the UK over a 20 year period, 10um was lost from the anodised layer thickness of a test panel. This weathering loss can be accompanied by chalking, iridescence, blooming and pitting.

The academic paper reporting this can be viewed at this link:
**Sustainability**

Aluminium is good for sustainability. It can be infinitely recycled, and re-melting aluminium to form new profiles takes only 5% of the energy of primary aluminium production.

Both powder coated and anodised profiles can be melted down for re-use. There are claims that powder coating requires an extra step to first remove the organic coating, but in fact all profiles which contain a polyamide thermal break require an extra step, as the thermal break and coating are removed at the same time, so in fact all profiles are equally recyclable.

A report by KMH Sustainable Infrastructure in Australia claimed that anodising emits less CO2 over the lifetime of a building, but this depends on how many times the building is re-clad. The data was based on aluminium being anodised twice in 100 years, but coated with pvdf three times or powder coated four times. When equal lifetimes are applied, anodising emits the most CO2.

Anodising produces a sludge of sulphuric acid and aluminium hydroxide which must be disposed of. Powder coating produces very little waste, as waste powder can be re-sprayed multiple times, and any that does need to be disposed of can be treated as non-hazardous waste. Liquid paints do contain solvent, but modern plants have burn-off incinerators to remove this before it reaches the atmosphere.

A life-cycle analysis study by a US aluminium finisher (Frontier Aluminium, Declaration number 12CA49678.101.1) found that anodising scored worst on all factors for sustainability (including global warming potential)—see figure.

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**Scratching**

Anodising rightly has a reputation for being tough. Powder coatings are also tough. The AAMA 2605 specification calls for a sand abrasion test, to ensure that in desert sandstorms the coating will not be affected. A fully cured organic coating will typically pass the BS 3900 test of 4000g weight loaded on a 1mm tungsten needle without scratching. Any scratches can be repaired—see below.

Anodising can scratch, as shown in the images below, and when it does there is no way to repair it. The Apple iPhone 5 received poor commentary at launch owing to the scratching of its anodised finish.

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Scratched anodised surface
**Color Difference batch-to-batch, and part-to-part**

Major projects will consume aluminum over many months or even more than a year. Since no producer is willing to stock aluminum for such a long period it is inevitable that material from different batches will be used.

Anodising can struggle to maintain a consistent quality from batch to batch. This is recognised in the standards. The AAMA 611 standard is the only one with a numerical limit for batch-to-batch variation. There can even be differences between one end of an extrusion and the other, making for differences when cutting and assembling a window.

<table>
<thead>
<tr>
<th>Color tolerance – delivered</th>
<th>AAMA 611 Class 1</th>
<th>Australian 1231</th>
<th>British Standard 39871</th>
<th>Qualanod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range samples must vary by DE &lt;5</td>
<td>Light/dark limits to be agreed</td>
<td>No visible defects from &gt;5m</td>
<td>Light/dark limits to be agreed</td>
<td></td>
</tr>
</tbody>
</table>

For illustration, a Delta E of 5 is the same as the difference in color between RAL 1013 and RAL 9002 as shown below. This would be a very marked difference and means in practice that all work for a facade should be completed from a single batch – which is normally impractical.

![RAL 1013 Oyster White](image)

![RAL 9002 Grey White](image)

By contrast, coating suppliers are held to strict limits. One of the most common is produced by CEPE, the European society for paints, coatings and inks. It insists that pale colours vary by no more than Delta E 0.8 from batch to batch (Delta E of 1 is a just-perceptible difference, so Delta E <1 is in theory not visible to the human eye). For very chromatic shades, the difference can be up to Delta E 2.5 – still half the value of the AAMA anodising standard. This allows coated finishes to be fabricated from different batches with lower risk – though it is still advisable to try and minimise batches.

The images below show some examples of batch colour variation when different elements were coated from different anodising batches.

![Batch colour variation](image)

It is a difficult art when anodising light and heavy parts to achieve the same depth of colour, as heavy parts require longer in the tank and the final colour is not apparent until after the anodising is complete.

Where sill and bead extrusions have to be snapped together and are in a different plane, colour differences will also be apparent.

Extruded aluminium will be a different colour to rolled sheet aluminium.
Repair of Damaged or Weathered Surface

It is almost impossible to repair an anodised surface. As it is not a coating, and a building facade or completed window cannot be re-inserted in an anodizing tank, once damaged or weathered it needs to be replaced. Coatings, both powder and liquid, can be repaired in-situ with a suitable matched liquid repair coating, either a small brush for minor scratches, or spray-applied for larger areas.

Coating Equivalents to Anodising

While coating will never give an identical finish to anodising, it can give a shade which from a distance looks very similar.

Many prestigious projects in recent years have switched specification from anodising to powder in order to overcome the disadvantages outlined in this note.
Conclusion

An anodised finish is very attractive. As shown below, it is sleek and shows the natural metal grain. Achieving a high-quality, consistent and weather-resistant anodised finish is problematic. Some of the potential problems are outlined in this guidance note.

Both coated and anodised finishes give similar long-term performance if specified correctly, and there are long-standing track records for each technology on major projects going back to the 1970s*.

The final cost of the finish will totally depend on the specification. A weak anodising specification will have lower cost in the short-run, but lead to later problems. A strong anodising specification (25um sealed anodizing) will cost more than comparable quality coating finishes. With either finish, choosing a low price product will save cost in the short term, but repairs and maintenance bills will mean cost of ownership is higher in the long term.

Coatings generally give less problems for fabricators – they are repairable, batch-to-batch colour variation is less, and other substrates can be coated with the same material. For these and cost reasons, the number of suppliers offering anodising has been decreasing for several years.

Sustainability of aluminium is already good, but arguments for which finish most enhances sustainability depends on how this is measured. Modern powder coatings produce virtually no waste in production or application and can last on a building for 40 years or more.

There are many false statements and biased opinions in the market regarding coating and anodising. This guidance note has attempted to address some of these, and to show that while coatings are not always perfect, anodizing also has to be treated with caution in order to achieve a high-quality, problem-free finish.

*Global track record of powder coatings can be viewed at www.interponbuildings.com
# Why Powder?

<table>
<thead>
<tr>
<th></th>
<th>Anodising</th>
<th>Powder Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasion</td>
<td>Abrasion resistance is excellent</td>
<td>Powder coatings are tough and resilient</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>Susceptible to attack from acidic pollutants and construction materials</td>
<td>Building materials can be easily cleaned without damage</td>
</tr>
<tr>
<td>Finish Consistency</td>
<td>Difficult to control colour consistency between batches, heavy/light extrusions, extrusion vs sheet profiles. Standards allow for large colour variation</td>
<td>Colour consistency can be controlled through the sourcing of one batch, use of automatic application and non-recycling of powder during application</td>
</tr>
<tr>
<td>Fabrication</td>
<td>Welding joints are very difficult to anodise and creates significant colour variation. Curved panels also problematic.</td>
<td>Good adherence and colour consistency on welds. Bare metal edges need to be sealed in hazardous environments</td>
</tr>
<tr>
<td>Environment</td>
<td>Acid solutions required during process</td>
<td>Solvent free application process. 100% recyclable</td>
</tr>
<tr>
<td>Substrate cost</td>
<td>Aluminium must be of high quality as imperfections will be visible- Higher reject rates- added cost</td>
<td>Coating thicknesses of &gt;50microns enable substrate imperfections to be hidden</td>
</tr>
<tr>
<td>Repair</td>
<td>Once scratched anodising cannot easily be repaired-not an organic paint</td>
<td>Powder coatings can be “touched up” using a primer and a 2 pack Polyurethane (PU)</td>
</tr>
<tr>
<td>Cost (3mm solid aluminium panel)</td>
<td>Can have significantly higher applied/material cost. Total finish system can cost between £160-£350/m²</td>
<td>Typical cost between £75-£110/m² dependant on durability grade and shade.</td>
</tr>
</tbody>
</table>
Colour Variation of bronze anodised between extruded profiles and pressed metal

Permanent staining to bronze anodised panels owing to alkaline/acidic run offs
Colour Variation of blue-grey anodised between extruded profiles

Colour Variation of bronze anodised between extruded profiles