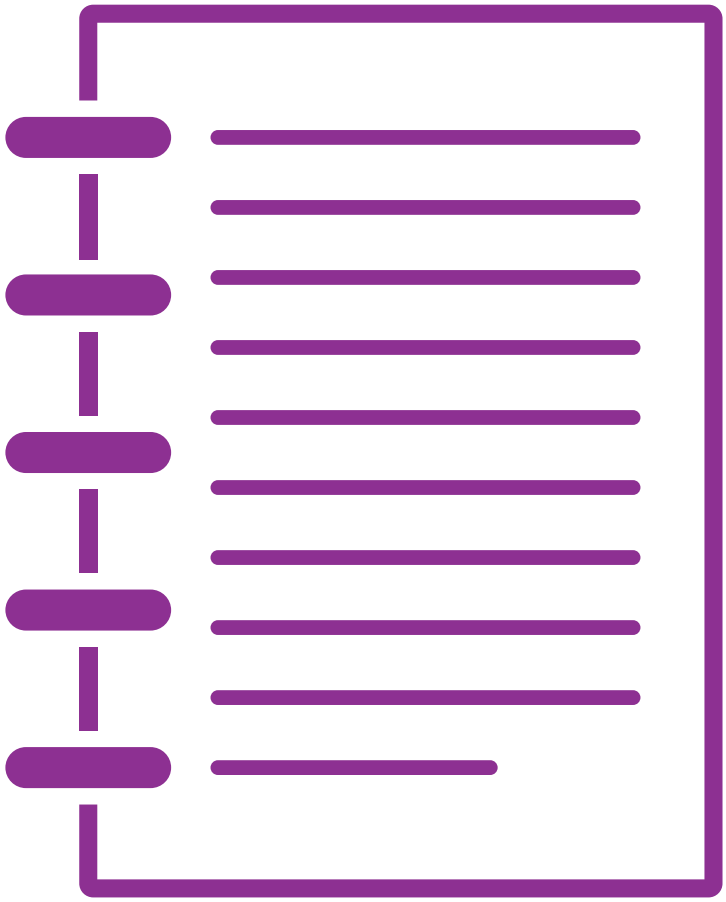
Guidance Note

5. Aluminum Anodizing and Coating Comparison

AkzoNobel



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Difference Between Coating and Anodizing

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

History

Use of aluminum in architectural facades became popular in the 1960s. Anodizing and liquid coatings were both available, with anodizing 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 anodizing are often defined by the thickness of the anodizing layer, with 25um being required for high quality, weather-resistant finishes.
It is of great importance that the pores in the anodized film are sealed. This is done normally by immersion in hot water. 1 minute of immersion is typically needed per micron of anodizing thickness, so a 25um layer would need around 25 minutes sealing time.

Finish Colors

In anodizing, 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 anodizing or in combination with electrolytically colored anodizing. So-called Anolok II (withdrawn trademark of Alcan) colors can produce blue-grey shades which are currently very popular.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 anodizing are typically quite comprehensive and for long periods – 20 years is often available

A matt 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 anodizing 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 most important standards for anodizing are:

- AAMA 611 Class I
- Australian Standard 1231
- British Standard 3987
- Quality label Qualanod

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

Which Finish is Better?

There are proponents for both anodizing 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

Anodizing 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 anodized aluminum window. Welded areas can also not be anodized, though they can be coated.

Exterior Weathering

There is a belief that anodizing 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 anodizing, 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:

Color Change in weathering test for Anodized Ochre shade

Original color

Color after test

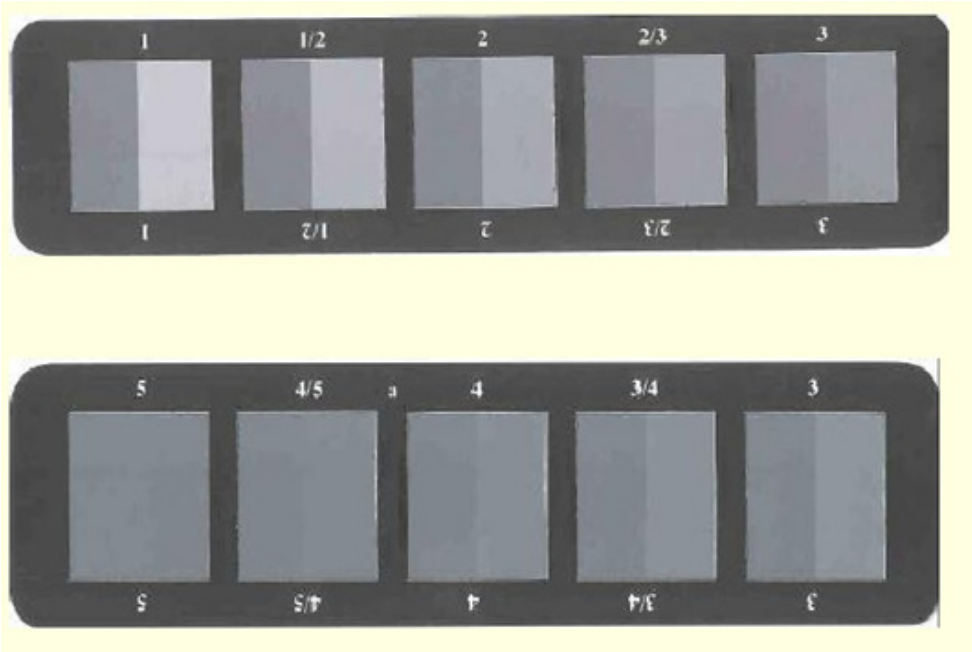
Table 1: Toughest Standards for Finishes

Standard	Florida exposure / color change	Salt Spray Corrosion Test
AAMA 611 Class I (anodizing)	10 years, Delta E <5 units	3000 hours, minimal corrosion
AAMA 2605 (coatings)	10 years, Delta E <5 units	4000 hours, minimal corrosion
AAMA 2604 (coatings)	5 years, Delta E <5 units	3000 hours, minimal corrosion

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

All Anodizing 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.

The Qualanod standard, popular in Europe, uses the textile “grey scale” to assess color fade. Four cycles of artificial weathering are carried out, after which color change must be no more than in sample 3 below. This is hard to relate to any particular length of outdoor exposure.



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 Anodizing standards only the British standard demands universally the accepted 25um thickness for high-quality and long term performance.

Table 2: Film Thickness Requirements for Anodizing

	AAMA 611 Class 1	AAMA 611 Class 2	Australian 1231	BS 3987	Qualanod
Minimum thickness* – exterior parts	18um	n/a	15-25um (depending on environment)	25um	15um

Hazardous Environments

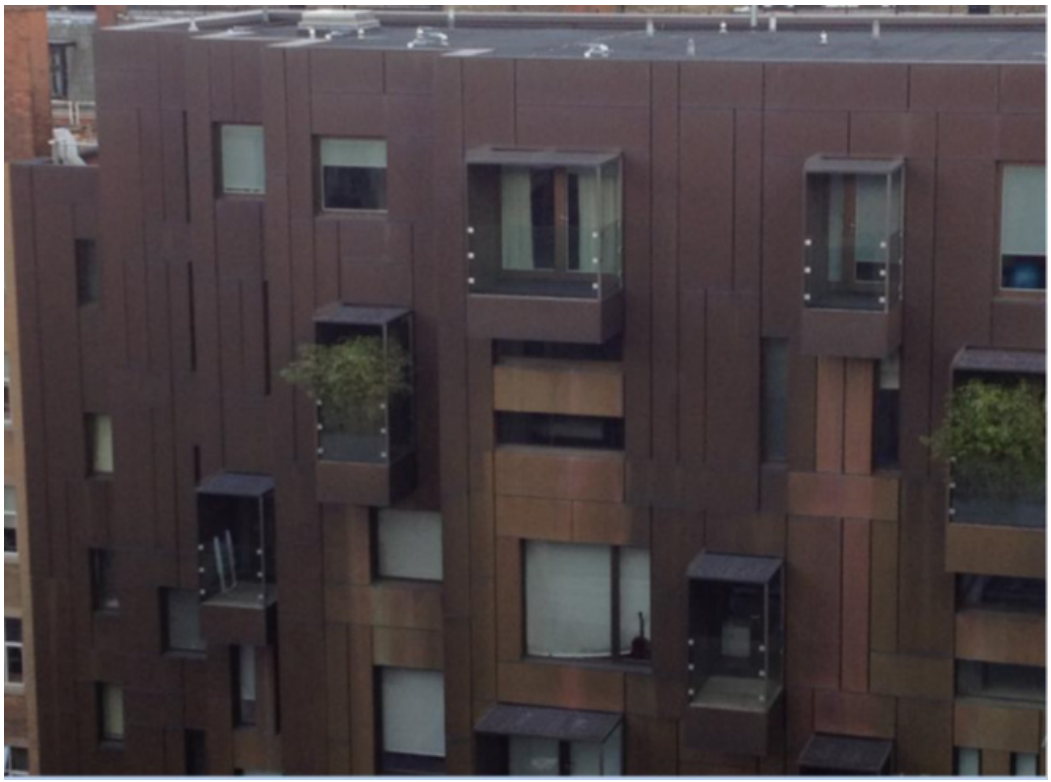
Anodizing is more susceptible to polluted environments than coatings. Coatings slowly lose film weight as the film breaks down, but as long as gloss remains high it is clear that film erosion is hardly proceeding, and thereafter at < 1um per year. Therefore a coating passing 5 years Florida weathering 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 Anodized 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 anodized 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:

http://www.bath.ac.uk/cwct/cladding_org/wlp2001/paper18.pdf

On a London building, opposite the RIBA offices, is an anodised facade showing bad discoloration from rainwater run-off, see below.



Sustainability

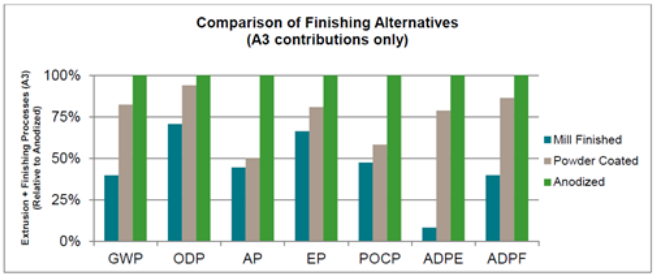
Aluminum is good for sustainability. It can be infinitely recycled, and re-melting aluminum to form new profiles takes only 5% of the energy of primary aluminum production.

Both powder coated and anodized 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 anodizing 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 aluminum being anodized twice in 100 years, but coated with pvdf three times or powder coated four times. When equal lifetimes are applied, anodizing emits the most CO2.

Anodizing 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 Aluminum, Declaration number 12CA49678.101.1) found that anodizing scored worst on all factors for sustainability (including global warming potential) –see figure.



Scratching

Anodizing 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.

Anodizing 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 anodized finish.

Scratched anodized 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.

Anodizing 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 3: Color Difference Standards from Batch to Batch for Anodizing

	AAMA 611 Class 1	Australian 1231	British Standard 39871	Qualanod
Color tolerance – delivered	Range samples must vary by DE <5	Light/dark limits to be agreed	No visible defects from >5m	Light/dark limits to be agreed

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

RAL 9002
Grey White

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 colors 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 anodizing 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 color variation when different elements were coated from different anodizing batches.

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

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

Extruded aluminum will be a different color to rolled sheet aluminum.

Repair of Damaged or Weathered Surface

It is almost impossible to repair an anodized 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 Anodizing

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

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

Quick Reference Guide

	Low-quality anodising (<10um)	High-quality anodising (18-25um) (e.g. AAMA 611 Class 1)	1-5 Year Florida Coating (e.g. AAMA 2603/4)	10-Year Florida coating (e.g. AAMA 2605)
Cost	Can be cheaper than coating.	More expensive than regular coating, although clear coating can be cost-effective.	Typically very cost-effective	Most expensive system.
Colour range	Bronze, natural, black, champagne common. Brighter colours less durable.	Bronze, natural, black, champagne common. Brighter colours less durable.	Wide range, thousands of colour and metallic effects	Wide range of pastel and dark colours and metallics.
Gloss	Generally matt. Higher gloss can be achieved by polishing and/or different etch process, at a cost.	Generally matt. Higher gloss can be achieved by polishing and/or different etch process, at a cost.	Dead matt - matt -satin - high gloss	Satin and matt
Exterior weathering	Poor	Good, up to 10 years Florida	1-5 Years Florida	10 Years Florida
Hazardous atmospheres	Poor	Susceptible to acid/alkaline attack – e.g. Especially in building stage from concrete splashes etc.	Good resistance to all atmospheres	Excellent resistance to all atmospheres
Colour tolerance between batches and parts	Up to Delta E 5 may be allowable	Up to Delta E 5 may be allowable	Delta E <1	Delta E <1
Difference between rolled and extruded aluminium	Colour difference can be noticeable, appearance differences in finish due to visible grain structure of aluminium.	Colour difference can be noticeable, appearance differences in finish due to visible grain structure of aluminium.	No difference	No difference
Colour difference between extrusions	Noticeable if not in same plane, can be an issue between e.g. sill and bead extrusions which snap or hook together.Heavy / light sections are also often different.	Noticeable if not in same plane, can be an issue between e.g. sill and bead extrusions which snap or hook together. Heavy / light sections are also often different.	No difference	No difference
Colour tolerance between batches	Up to Delta E 5 may be allowable	Up to Delta E 5 may be allowable	Delta E <1	Delta E <1
Repair of damaged surface	Not possible	Not possible	Yes with matching liquid paint	Yes with matching liquid paint
Cut-edge protection	Medium	Excellent	Medium	Medium
Cut-edge protection if seaside pre-treatment / sealed edges	n/a	n/a	Excellent	Excellent
Hardness / scratch resistance	Medium	Excellent	Medium	Medium
Control of film thickness	Difficult	Difficult	Excellent	Excellent
Hazardous waste	Alumium hydroxide and sulphuric acid sludge	Alumium hydroxide and sulphuric acid sludge	None	None
Finishing of ancillaries such as cast aluminium, steel brackets, hardware etc. (multiple ancillaries like these are common for such items as balustrades)	Not possible	Not possible	OK	OK
Finishing of welds	Not possible	Not possible	OK	OK
Brittleness	Prone to cracking / crazing when exposed to higher temperatures (above 60-70 degrees celcius) and low humidity, or if flexed unduly. More prevalent in thicker coatings.	Prone to cracking / crazing when exposed to higher temperatures (above 60-70 degrees celcius) and low humidity, or if flexed unduly.	Does not check or crack in normal use	Does not check or crack in normal use

	Low-quality anodising (<10um)	**High-quality anodising (18-25um) (e.g. AAMA 611 Class 1)**	**1-5 Year Florida Coating (e.g. AAMA 2603/4)**	**10-Year Florida coating (e.g. AAMA 2605)**
Acceptance by fabricators / builders	Resistant - colour & repair issues	Resistant - colour & repair issues	Happy to work with	Happy to work with
Thermal benefits	No thermal benefit	No thermal benefit	Thermal benefits for lighter colours	Thermal benefits for lighter colours
Film thickness	10µm	18-25µm	60-80µm	60-80µm
General wear rates (non-abrasive, normal environment)	0.0-0.1 µm per year	0.0-0.1 µm per year	0.3-2.0µm per year	0.3-2.0µm per year

Conclusion

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

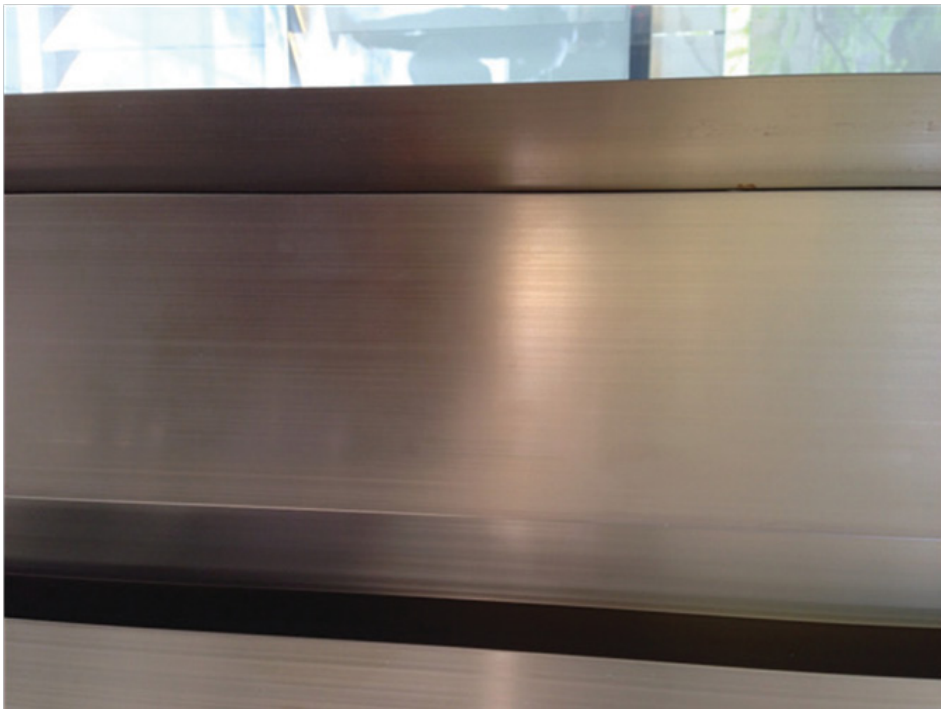
Both coated and anodised finishes give similar long-term performance if specified correctly, and there are long-standing track records for each technology on major projects going back to the 1970s*.

The final cost of the finish will totally depend on the specification. A weak anodizing specification will have lower cost in the short-run, but lead to later problems. A strong anodizing 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 color variation is less, and other substrates can be coated with the same material. For these and cost reasons, the number of suppliers offering anodizing has been decreasing for several years.

Sustainability of aluminum 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 anodizing. 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

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