Weathering of Anodized Aluminium

Qualanod Technical Information

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Weathering and service life of anodized aluminium

1. INTRODUCTION

Anodized aluminium has been used in external architectural applications since the 1930s. Some surviving buildings are now over 70 years old, and the anodized aluminium is still in good condition. A well-known example is the Montecatini building in Milan, which was completed in 1938. Such examples demonstrate that anodized aluminium can have excellent weathering resistance. However, micro-climates and atmospheric pollution can be very variable, even on opposite sides of one building, such that abnormal conditions can have a marked effect on service life.

A long service life can be expected from good quality anodized aluminium. The Qualanod Specifications require the anodizer to meet quality requirements concerning coating thickness, sealing, light fastness and surface abrasion resistance. It also requires the contract between the customer and the anodizer to specify the aluminium alloy, the coating thickness class, the appearance, and cleaning and maintenance procedures. Inadequate or incorrect cleaning during service shortens the life of anodized aluminium. Mechanical damage during fabrication or contact with cement during installation can also affect service performance.

Customers and users of anodized aluminium for architectural applications are interested that the initial appearance of the anodized aluminium will be retained to a great extent, with maintenance as necessary, over the design lifetime of the component. Since its inception, Qualanod has been involved in monitoring investigations of the weathering of anodized aluminium with the first being a 20-year study that ended in 1985.

The appearance can change due to:

- superficial cosmetic degradation of the anodic coating (not the aluminium metal);
- colour change;
- pitting corrosion of the aluminium under the anodic coating (only after the anodic coating has been locally penetrated).

The sections below describe these effects in more detail and explain how they relate to the quality of the anodized aluminium. In particular, the importance of coating thickness loss from good quality coatings is discussed and relevant outdoor exposure data is presented.

2. SUPERFICIAL COSMETIC DEGRADATION

Superficial cosmetic degradation is due to chemical and/or physical processes caused by exposure to the weather that take place at the immediate surface of the anodic coating. They result in unsightly effects such as blooming, chalking, staining, resmutting and iridescence. Some of these effects are related to “sealing quality” and “anodizing quality” and can arise within the first year of exposure on poor quality products. Weathering bloom, resmutting and iridescence can occur on good quality products particularly in polluted atmospheres where in-service maintenance and cleaning has been inadequate (see Qualanod Specifications section 3.1.5 “cleaning and maintenance”). However, remedial cleaning treatments can be applied that will restore the finish to its original appearance without significant loss of coating thickness.

3. COLOUR CHANGE

Colour-anodized aluminium can change colour during service depending on the nature of the colorant and the conditions of exposure to sunlight and water. Many dyestuffs can change colour within a few years outdoor exposure. However, certain dyestuffs are very resistant to fading and have been demonstrated as suitable for architectural applications if applied correctly. Electrolytic colouring produces lightfast deposits in the anodic coating.

4. CORROSION

It should be noted that the aluminium alloys used on buildings, including ones suitable for anodizing, do not fail structurally due to corrosion unless there is a design flaw, for example a situation where the aluminium metal is in contact with copper and galvanic corrosion can occur. This is explained in more detail in "Aluminium products in the building and construction industry" published by the Gesamtverband der Aluminiumindustrie eV (GDA).

The anodic coating protects the aluminium substrate against pitting corrosion which manifests itself as localized dissolution of the metal. Note that although pits might be visible, they remain small and do not significantly propagate, which is why structural failure does not occur. Aggressive chemicals from the environment have to reach the metal surface before pitting can commence. This requires the dissolution or penetration of the anodic coating at each site of a pit. The degree of protection provided by the anodic coating on anodized aluminium in a given environment depends primarily on the coating thickness. It is largely independent of sealing quality. Good quality anodized aluminium will lose coating thickness progressively over time and, eventually, pitting corrosion will take place. Of course, any assessment of how much pitting is unacceptable is subjective depending on the expectations of the observer (Figure 1).

ISO 7599: 2010 specifies the classification of coating thicknesses and gives guidance on the choice of coating thickness. However, the advice is very general because performance can be highly dependent on specific location, its micro-climate and topography, and the orientation of the anodized part on the building and with respect to the prevailing wind.

5. DATA RELATING TO THE LIFETIME OF GOOD QUALITY ANODIZED ALUMINIUM

As described above, the key factor affecting the lifetime of properly maintained, good quality anodized aluminium during service in a particular environment is the rate of thickness loss. This section summarizes data on the thickness loss of anodic coatings during exposure to the weather.

Tables 1 to 5 include data from the technical literature. These were obtained from the exposure of test pieces at outdoor exposure test sites. The results may be summarized as follows.

1. The lowest rate of thickness loss was about 0.05 µm/year for 25 to 30 µm thick coatings exposed for about 17 years. These data involved detecting an average thickness difference of 0.85 µm, which is not significant unless large numbers of measurements are made.
2. The highest rate of thickness loss was 1.2 µm/year for a 19 to 25 µm thick coating exposed for 5 years in Sheffield in the 1970s. The industrial part of Sheffield was very polluted by the steel industry until its substantial closure in the 1980s.
3. Urban environments caused a loss of about 0.2 to 0.4 µm/year.
4. Marine environments caused a loss similar to urban environments or lower.
5. The rate of thickness loss decreased with time (Table 5). Another interpretation is that the rate of loss after a given period of exposure was proportional to coating thickness at that time. Thus, after exposure for a given time, the final thickness of a thicker coating will never be less than that of a thinner coating (Table 4).
6. The data predicts that if all other factors are equal, the lifetime of thicker coatings will be longer than that of thinner coatings.

There is little information in the technical literature about coating thickness loss on buildings. The difficulty is discovering the initial thickness of the coating when very many years have elapsed since production. One method is to measure the coating thickness of a single profile on both the outside and the inside of the building. Faller and Sautter (1983) reported data from two buildings in Bonn, which showed that after 17- and 20-years' service, there was negligible thickness difference between the inside and the outside. Data from the Bonn test site which might have had a different micro-climate from that of the buildings, showed a loss of 1.0 to 4.8 µm over comparable periods. The lower value may be consistent with the results from the buildings.

Robin Furneaux, 3rd August 2011

Figure 1: Anodized aluminium extruded panels (150 x 75 mm) originally with 5, 15 and 25µm coatings after weathering at Sheffield from 1979 to 1999 showing the extent of pitting attack (R.C.Furneaux, ATB Metallurgie, 43, 84 (2003))

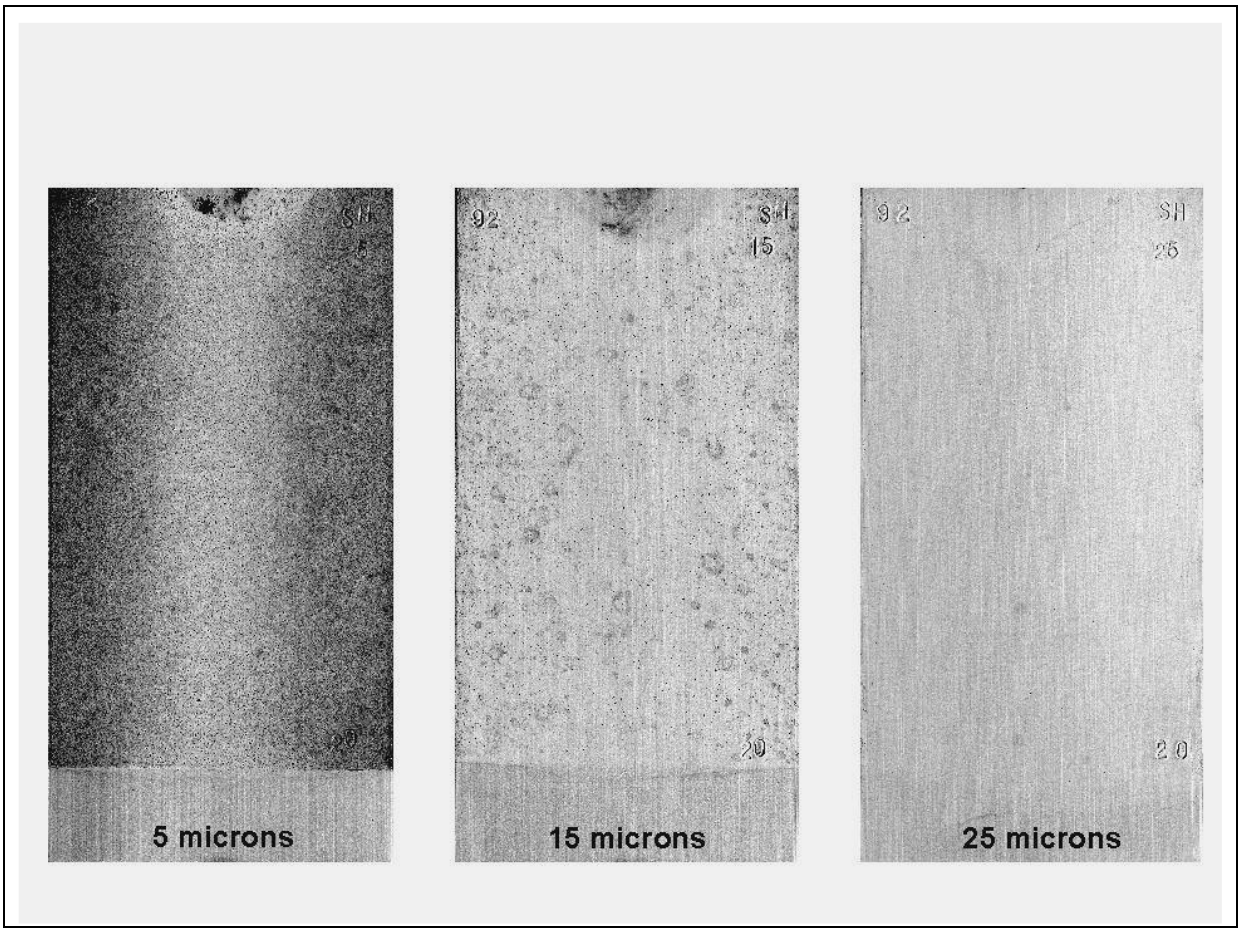

Table 1: Review of early work (F.E.Faller & W.Sautter, Aluminium 59, 117-122 (1983))

Reference	Location	Exposure time (years)	Initial coating thickness (µm)	Thickness loss (µm/year)	Range (µm/year)
Speiser 1975	Aesch	9	25	0.1	
	Banbury	9	25	0.3	
	Basel	9	25	0.4	
	Bonn	9	25	0.4	
	Genoa	9	25	0.35	
	Kingston	9	25	0.35	
	Ljubljana	9	25	0.75	
	Manchester	9	25	0.45	
	Mexico City	9	25	0.1	
	Neuhausen	9	25	0.5	
	New Jersey	9	25	0.55	
	Osaka	9	25	0.85	
	Ostend	9	25	0.4	
Knutsson 1976	Bohus Malmön	5	19-25	0.4	0-0.8
	Finspång	5	19-25	0.4	0.2-0.7
	Sheffield	5	19-25	1.2	0.6-1.4
	Stockholm	5	19-25	0.4	0.2-0.6
Oelsner 1976	Duisburg	10	15-35	0.8	0.5-1.4
	Hörnum (Sylt)	10	15-35	0.5	0.2-0.7
Witt 1979	Duisburg	4.5	20	0.5	
Baker 1973	New Kensington	18	25	0.3	0.2-0.4
Cochran 1967	New Kensington	8-11	3-28	0.3	

Table 2: The effect of location, exposure time, finish and coating thickness (F.E.Faller & W.Sautter, Aluminium 59, 117-122 (1983))

Location	Exposure time (years)	Initial coating thickness (µm)	Thickness loss (µm/year)
Bonn (mild industrial)	8	16-25	0.29
	8	19-25	0.25
	17	5-10	0.12 - 0.21
	17	20-30	0.06 - 0.24
Duisburg (strong industrial)	8	16-25	0.50
	8	19-25	0.41
Westerland / Sylt (marine)	8	16-25	0.44
	8	19-25	0.59
	15	5-10	0.13
	15	8-9	0.10
	15	20-30	0.35 – 0.43

Table 3: The effect of location and coating thickness for 10 years exposure (F.E.Faller, Aluminium, 62, 345-349, 432-436 (1986))

Location	Initial coating thickness (µm)	Thickness loss (µm/year)
Duisburg	10	0.2
	15	0.2
	20	0.3
	25	0.15
Hamburg	10	0.3
	15	0.3
	20	0.25
	25	0.3
München	10	0.1
	15	0.05
	20	0.05
	25	0.2
Westerland	10	0.15
	15	0.15
	20	0.15
	25	0.15

Table 4: The effect of location and coating thickness during exposure from 1964 to 1980 (B.R.Ellard, Proc. Anodizing Workshop, Aluminum Anodizers Council 1998)

Location	Initial coating thickness (µm)	Thickness loss (µm/year)	Final thickness (µm)
Banbury (rural)	15	0.05	14
	25	0.05	24
	30	0.1	28
Bristol (urban)	15	0.2	12
	30	0.2	27
Leeds (urban)	15	0.25	11
	20	0.25	16
	25	0.3	20
	30	0.3	25
Manchester (urban)	15	0.25	11
	20	0.3	15.5
	25	0.35	19.5
	30	0.3	25.5
Portsmouth (marine)	15	0.15	13
	30	0.15	27.5
Sheffield (industrial)	15	0.55	6.5
	20	0.55	11
	25	0.65	14.5
	30	0.65	14.5

Table 5: The effect of initial coating thickness on the rate of thickness loss during exposure at Sheffield from 1979 to 1999 (R.C.Furneaux, ATB Metallurgie, 43, 84 (2003))

Initial coating thickness (µm)	Thickness loss over two years exposure (µm/year)	Thickness loss over ten years exposure (µm/year)	Thickness loss over 20 years exposure (µm/year)	Final thickness after 20 years (µm)
5	0.25	0.05	(0.15)	5.5
15	0.65	0.6	0.3	7
25	1.1	0.7	0.6	15.5