Aspects Affecting the Image of Hard and Functional Anodizing
Examples of new and latest developments
Criteria's for a quality label

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"Hard Anodizing" is not really specified. A reasonable fundament is the international standard ISO 10074 (in combination with other ISO standards) – but there a plenty of individual specifications for special technical and functional applications (e.g. in aerospace, military and automotive industry). The technological requirements and customers demands are much higher and more complicated than for architectural application (by way of comparison bulk production).

The experience shows that a review of an ISO standard is very slowly going - existing quality label organisations are not experienced in such functional applications like for Hard Anodizing. A scientific background of members in a quality label committee is essential – now we are on the way to understand what was developed by empirical findings in the past. We still have to honor the inventors of the past which collected a lot of know-how. And well-founded experience as well as scientific and theoretical knowledge is necessary to deliver a judgement for new criteria's or the meaning of new developments – and the beneficial effects on surface quality.

Some examples of the latest and new developments may set new "benchmarks" for surface quality (details will be presented):

- New and/or improved abrasive test
- New and/or improved polymer aluminium oxide composite finishes
- New non-destructive hardness test
- New decorative finishes e.g. "kinetic satination"

A quality label organisation should be able to set and to organize critical checks to find criteria's to distinguish between good and necessary "surface quality" for a variety of applications – flexible enough not to hinder new developments and new demands (a possible proposal will be explained). All factors affecting the quality of hard anodizing (or anodizing for functional applications) must be listed in a ranking of relevance.

The following text was worked out by P.G. Sheasby and me in view on the architectural application of anodized materials. Most of the proposals we made have already influenced the QUALANOD-Specification – and this specification is predominantly worrying about corrosion. But, with anodic coatings (and with the metal Aluminium in comparison to steel) we have not really corrosion problems, we have problems with the decorative appearance and the performance in general for a variety in applications especially with "hard and functional/technical anodizing".

In the field of architectural applications the job is simplified by the use of only one alloy for profiles, AlMgSi0,5, 6060, and two for sheets and panels, AlMg1, AlMg3. In case of hard and functional/anodizing we have to handle plenty of alloys: especially the 5000, 6000 and 7000 series.

In a general conspectus the following text and statements are still valid and the meaning of some parameters and aspects affecting the quality are even more relevant in hard anodizing:

The quality and performance of anodic oxide coatings is of increasing importance, as, with the current competition from other finishes and materials, it is the appearance and performance of anodic finishes that is their main selling point. Their performance is dependent on many factors, the relative performance will depend on the anodizing system used for their production and the processing conditions used. Many processing factors will affect anodic film quality and they can be delivered into the following three groups:

1. **Electrolyte composition**

   Acid concentration
   Aluminium content
   Additives present
   Bath contamination

2. **Physical parameters**

   Electrolyte temperature
   Electrolyte agitation
   Jigging arrangement
   Handling and load transfer arrangements

3. Electrical parameters

Anodizing current density
Current type and control
Electrode material and arrangement
Electrical contacts

Of these factors it is those that control the balance between film growth and anodic film attack that are particularly important. **Thus anodizing electrolyte temperature, electrolyte agitation and anodizing current density are especially critical, and small changes have a major influence.** The danger is in producing films which have been too heavily attacked during anodizing, with the result that the oxide structure is weakened and the outer surface of the film softened. Thus high anodizing electrolyte temperatures, low anodizing current densities and low levels of electrolyte agitation are particularly dangerous. Correct control of these parameters is especially important when producing thick films, and when using relatively acid electrolytic colouring processes (for example acid copper and tin baths). Jigging method and arrangement is also critical and any methods leading to a relatively wide spread of anodic film thickness within the load will be likely to give variable anodic film quality.

In general the key to achieving satisfactory and consistent anodic film quality is to set the anodizing parameters at the correct levels and then to maintain them within as narrow a range as possible. Improvements in the equipment available and better understanding of the effect of operating practices helps this consistent quality level to be achieved.

Achieving satisfactory quality does not only mean the achievement of acceptable test results but also means that the required appearance and performance are achieved. In colour anodizing in particular, with the competition from other finishes and materials, colour uniformity and appearance can be vitally important factors. Such factors are affected by anodizing parameters, and by the colouring system used.

Because of the importance of these considerations a Quality Label Committee should look again at the recommendations in its specifications and made certain changes in order to ensure that satisfactory anodic film quality is achieved. In the following the relation to anodic film quality will be discussed and shown more detailed:

Electrolyte Composition

- Acid concentration

  Acid concentration is only critical at high anodizing temperatures. High acid concentrations lower the anodizing voltage required (about **0.04V / g/l of H_2SO_4**), but high acid concentrations also give greater drag-out and higher acid consumption.

- Aluminium content

  Very low Aluminium contents increase the sensitivity of the film to high bath temperatures. Increasing Aluminium content raises the anodizing voltage required (about **0.2V / g/l of Aluminium**).

- Additives present (such as oxalic acid)

  Oxalic acid does not attack the anodic films as sulphuric acid does, and should not be taken into account when considering acid strength. Oxalic acid allows up to 4 °C higher electrolyte temperature without disadvantage of surface quality.

  High oxalic acid contents above 10 g/l have no advantage and increase cost.

- Bath contamination

  Chloride in the anodizing electrolyte can cause pitting during anodizing and has been found to adversely affect exposure performance.

  It is highly to recommend not to use tap water in the anodizing tank.

Physical Parameters

- Electrolyte temperature

  Anodizing electrolyte temperature is the single most critical factor affecting anodic film quality and excessive temperatures caused through poor control, poor agitation or poor jigging are responsible for the bulk of anodizing quality problems.
  Temperature control needs to be improved.

- Electrolyte agitation

  Agitation by means of pump circulation of the electrolyte is not sufficient to maintain proper temperature control in the bath. Agitation is a vital factor in the control of the electrolyte temperature close to the work and any areas of poor agitation will lead to poor anodic film quality in these regions.

- Jigging arrangement

  Jigging is a major factor in film quality variation largely as a result of putting too much work in the bath. Work should be arranged on this jigs in such a way that anodic film thickness variation over the load is minimized. Work jigged very densely or multiple lines of work without intermediate cathodes will lead to increase film thickness variation.
  Central cathode systems between the lines of work are Recommended.

- Handling and load transfer arrangements

  Work left for long times in an acid rinse is a cause of film attack.

Electrical Parameters

- Anodizing current density

  The danger area in terms of quality is the use of low current densities to produce thick films. High current densities require good agitation, but are less likely to give quality problems. High current density will tend to increase film thickness variations over the load.

- Current type and control

  It is very important that the correct current density is applied and therefore that the true current is being measured on the equipment.
  Automatic current density control units are recommended.

- Electrode material and arrangement

  Aluminium electrodes require the lowest operating voltage, and are recommended.
  (The use of lead lined tanks without shielding, where there is a high cathode to anode ratio, can lead to film thickness distribution problems.)

- Electrical contacts

  Cross section of Jigs: Aluminium supporting jigs submerged in the electrolyte shall have a cross section representing more than 0.2 mm^2/amp. Larger sections are required for titanium which has higher resistance (the conductivity of Aluminium is more than 10 times higher than the one of titanium).
  Pressure on the contacts shell be sufficiently high to prevent oxidation of the points of contact and any movement of the parts during electrolysis – and agitation (!).