



Coated steel or aluminium piecework must withstand a variety of environmental influences. GSB Quality Seals provide internationally accredited product assurance.

Editorial

**Quality Coating -
The right solution for every location**



Since its conception in 1977, GSB International - Quality Association for Piecework Coating of building components - has continued to strive for excellence in quality coatings of Steel and Aluminium

building components in accordance with the most up to date technical standards and in close cooperation with acclaimed research and development institutes. The key focus of GSB activity is aimed at offering practical and effective solutions to building contractors, architects and metal construction companies to meet the very specific and individual demands of any location.

The latest revision of the Quality Regulations and introduction of new weathering categories is one of the best examples of the achievements by GSB (please refer to page 4 of this info letter). In the prevention of Filiformcorrosion the harsh climatic conditions in coastal areas place particularly high demands on both the coating and pre-treatment systems, where the pre-anodising process, which we have pleasure of introducing in this info letter has proved particularly effective.

GSB International is proud to be your reliable partner in all areas relevant to the coating of building components. Our Quality Label represents both quality assurance and ultimately peace of mind.

Harald Knufinke,
Honorary Chairman

Latest Developments in the Prevention of Filiformcorrosion

The first Quality Regulations developed by GSB in 1977 consisted of a mere nine pages. The latest revision of the current Quality Regulations which were sanctioned by the General Members' Assembly in May 2009, feature 60 pages. The fact that their content is now six times more comprehensive bears witness to the continuing and ongoing technical advances and their incorporation into the Quality Regulations through the GSB Technical Commission.

The quality of the product known as „coated piecework“ is essentially determined by the following three criteria, which are the pre-treatment, the coating material and the diligence of the coating process at the coating plant.

It should be noted that the surface treatment of Aluminium should not be seen as a stand alone process, but instead must always be considered taking into account the different viewpoints of surface chemistry on the one and metallurgy on the other. Whilst metallurgy focuses on the production process, design and mechanical properties, surface Chemistry is much more concerned with specific surface properties such as appearance and corrosion protection.

Generally, it is always preferable to view the entire production chain as a holistic process starting at the foundry to part and further preparation up to the surface treatment as a final step.

GSB International continually strives to take an appropriate holistic approach which I would like to demonstrate to you using the issue of Filiformcorrosion (FFC) and its prevention as an example.

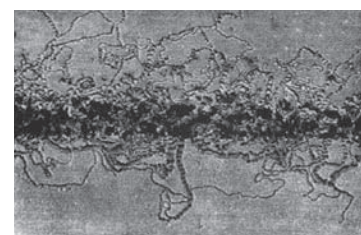
What is Filiformcorrosion?

Filiformcorrosion occurs at the interface of metal and coating and shows itself in a fibril like pattern. As a rule this is caused by a "defect" as a result of mechanical damage, edge alignment or disturbance to the organic coating or top coat. The main culprits are Chlorides together with humidity levels between 60 and 85 % whereby moisture and Oxygen promote the migration of a local anode at the interface of the coating or pre-treatment processes and the metallic substrate. This can be clearly seen in the "fibril development" on the Alumatter internet website, item 1 on the table of literary references.

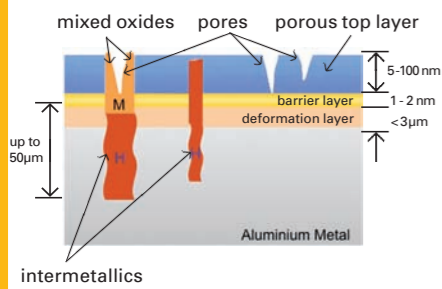
Pure Filiformcorrosion manifests itself in an external attack of the surface whereby the coating is undermined, lifted and ultimately splits away. A deep running attack can only be seen in combination with other forms of corrosion like pitting.

Since when do we know about Filiformcorrosion?

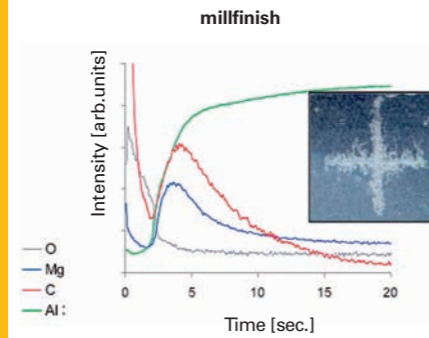
It is widely believed that Filiformcorrosion is a form of corrosion particular to coated Aluminium which first occurred to a building in the Netherlands in 1985, and since then has kept many research



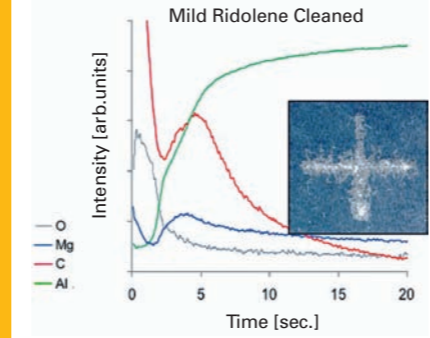
Pic. 1: FFC at the rolled edge of coil coated Aluminium in 1964



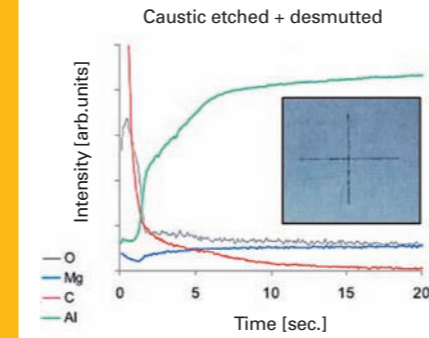
Pic. 3: Diagram of the natural oxide layer



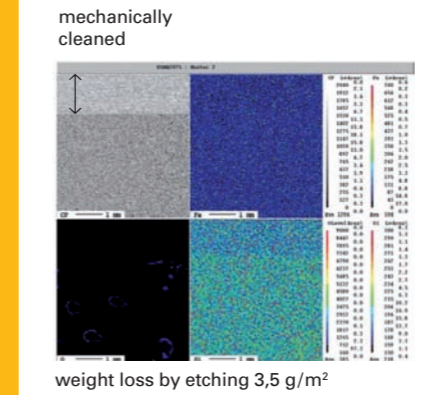
Pic. 4: GDOES – Analysis and surface image of rolled blank sheet, clear lacquered and tested at 80% rel. humidity and 40°C. *



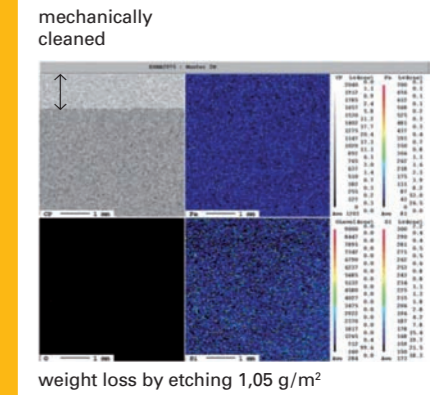
Pic. 5: GDOES – Analysis and surface image of mildly alkaline degreased sheet, clear lacquered and tested at 80% rel. humidity and 40°C. *



Pic. 6: GDOES – Analysis and surface image of etched and deoxidised sheet, clear lacquered and tested at 80% rel. humidity and 40°C. *



Pic. 7: Distribution image showing the elements of oxygen, iron, silicon in a profile section after etching with weight loss of 3,5 g/m².



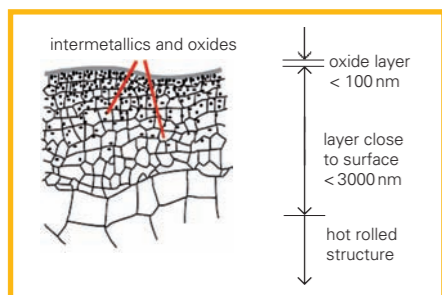
Pic. 8: Distribution image showing the elements of oxygen, iron, silicon in a profile section after etching with weight loss of 1,05 g/m².

institutions busy. However, as early as 1953 Van Loo – see reference (2) – describes Filiformcorrosion in the book titled „Corrosion“ by NACE, which can equally occur in Zinc, Iron, Steel and Magnesium. Picture (1) shows a photograph of FFC taken in 1964 on coil coated roll shaped Aluminium, caused by cracks in the coating at the rolled edges.

What is the actual cause of Filiformcorrosion?

Any distortion of Al materials involving raised temperatures (such as hot rolling and extrusion process) changes the surface properties by building „disturbed micro-crystalline layers close to the surface“. Such deformed micro-crystalline layers were first described in 1996 in a dissertation by H. Leth - Olsen at the NTNU Trondheim as a cause of Filiformcorrosion of lacquered Aluminium coils.

Fishkis and Lin (3) have published a diagram of these sensitive surface areas (shown in pic 2), but the formation of micro-crystalline deformation layers is



Pic. 2: Diagram of the deformation layer according to Fishkis and Lin (3)

not simply a question of the purity of the alloy, as some literature would suggest.

In the late eighties the Eloxal façade of a building displayed signs of Filiformcorrosion at Al99.7Mg. This case involved a high gloss rolled anodic oxidised sheet, which was insufficiently degreased and etched to retain its high gloss finish. The Fe-content was 0.08% with neither

Copper nor Manganese being detected in the alloy. This would indicate the surface pre-treatment as a determining factor rather than the composition of the alloy.

The susceptibility to Filiformcorrosion of chromated and lacquered extruded profiles made from alloys AA 6060/6063 was examined by Nordlien e.a. (4) and it was found that these alloys proved to be highly resistant to Filiformcorrosion, provided that sufficient metal was removed prior to chromating. Cases which showed high levels of Filiformcorrosion during testing could be attributed to the fact that this was restricted to sensitized surface areas that occurred during thermo mechanical processing of the alloy and were not sufficiently removed during the chemical pre-treatment.

How can Filiformcorrosion be prevented?

At this point it seems to be sensible to reiterate the tasks of the pre-treatment process, however well known they might be. The natural oxide layer of Aluminium (shown as a diagram in image 3) is not suitable as a coating surface, as more often than not it is contaminated by foreign substances, which are preventative to the adhesion of the coating. As a result, the main purpose of the pre-treatment is to adequately prepare the surface to specification, to passivate the active metal and thereby to aid adhesion and assist in the prevention of corrosion.

The natural oxide layer is removed by etching and is subsequently replaced by a chemical (amorphous Chromate process or Cr-free passivation) or electro chemical (pre-anodising) Oxide layer which acts as a barrier to moisture that is able to penetrate any organic layer. It therefore follows that the quality of the coating is directly related to the quality of the pre-treatment process. Even the

highest quality coating material will not be able to compensate for compromises and/or mistakes which occurred during pre-treatment.

Residual insular deformation layers which are present between the oxide layer and metal matrix are electrochemically active and are therefore likely to make the surface susceptible to Filiformcorrosion. Only the complete removal of the deformation layer effected by a combined process of degreasing, alkaline etching and acid finishing treatment (deoxidation) or removal by degreasing and acid pickling with sulphuric acid containing fluoride as described by Scamans and Afseth (5) facilitates unhindered establishment of a chemical barrier through chromating, Cr-free pre-treatment alternatives or pre-anodising as shown by the same authors with GDOES analysis in pics 4, 5 and 6 (Glow Discharge Optical Emission Spectroscopy) of resulting depth profiles of sheet surfaces of the alloy Al Mg 4,5 Mn following various pre-treatments and their appearance after an application of clear lacquer and testing in a climatic chamber at 80% rel. Humidity at 40°C. The depth profile analysis shows the concentration of Oxygen (O), Magnesium (Mg), Carbon (C) and Aluminium.

The intermediate layer (Oxygen decreases whilst Aluminium increases) of the blank rolled sample (pic. 4) displays clusters of Magnesium and Carbon with corrosion testing resulting in Filiformcorrosion.

The mildly alkaline degreased sample (pic. 5) still shows traces of this intermediate layer of Magnesium and Carbon and once again corrosion testing does result in Filiformcorrosion. Only the alkaline etched sample (pic.6) that has undergone an acid finishing treatment (deoxidation) shows the complete removal of the intermediate layer and no signs of Filiformcorrosion after corrosion testing.

This result may lead to the somewhat premature conclusion that the occurrence of Filiformcorrosion is directly related to the levels of removal during etching. However a number of tests commissioned by GSB in 2002 have shown that satisfactory as well as poor corrosion test results have occurred with high as well as low levels of weight loss by etching. The various chemical properties of the Aluminium Matrix and different existing intermetallic phases are the likely explanation – during the degreasing and etching processes the difference in the solubility of the various components result in a sort of layer that is known to technical experts as “etching smut” and can only be removed in a combination of alkaline and acid cleansing or by an acid pickling degreaser with added fluoride. If pickling or etching levels are too high, the “easier to dissolve” Aluminium Matrix is removed whilst the “more difficult to dissolve” intermetallic Phases remain on the surface as smut and can be partially wiped off.

This behaviour is documented in pics 7 and 8 on extruded profiles of alloy AlMgSi (EN AW 6060). The images show the distribution of elements Iron (Fe), Oxygen(O) and Silicon (Si) measured with an electron beam micro probe and the relevant electron backscattering image (Cp). A part quantitative surface distribution of the elements is assessed in a wavelength dispersive x-ray analysis (WDX).

The varying coloured zones represent element clusters ranging from black (= barely present) to blue and green up to red (= high presence). One specific area which has been mechanically cleaned shortly before the analysis (about 2cm at the top edge of the individual images) serves as a comparable untreated surface.

Pic. 7 shows the distribution of elements in a profile segment with a level of removal by etching of 3,5 g/m² whilst

- With respect to alloy composition and production process:**
- Natural oxide layer: < 100 nm
 - Microcrystalline deformation layer: ca 1000 to 3000 nm
 - Solid cast phase: ca 1000 to 10000 nm
 - Intermetallics: ca 100 nm
 - Chromatizing layer: ca 15 to 30 nm
 - Cr – free passivation layer: < 10 nm
 - Preanodizing: 3000 to 8000 nm (1 nm = 10⁻³ µm = 10⁻⁶ mm = 10⁻⁹ m)

Pic. 9: Surface dimensions

the segment in pic 8 shows a removal of 1,05 g/m². Pic 7 shows an increase in the distribution of Silicon on the surface in comparison to the polished area (top quarter of the individual image), whilst pic 8 clearly presents an even Si-distribution across the entire surface. One can therefore only conclude that specific and individual circumstances need to be considered.

An Si-increase will hinder the build up of the Chromat layer as well as the flawless application of a Cr-free passivation, which can be proven con-

clusively if one looks at the surface dimensions which are dependent on the composition of the alloy and the production process of the part finished product (see pic 9).

Residual intermetallic phases can barely be covered by a Chromat layer or an alternative Cr-free passive layer whilst the anodised Oxide layer created during the pre-anodising process has the ability to engulf the intermetallic phases and de-activate their electrochemical activity.

GSB AL 631 Quality Assurance

Research commissioned by GSB International has shown that 1000 hours of Filiformcorrosion testing in accordance with DIN EN 3665 is comparable with the results of approximately 10 years of Hoek van Holland weathering. Further examination has revealed that alongside pre-anodising as a pre-treatment prior to organic coating, conventional chromating processes or alternative Cr-free pre-

<p>MASTER Approved Coated Aluminium ★★ Sea Proof</p>	<p>PREMIUM Approved Coated Aluminium ★★★ Sea Proof</p>	<p>Sea Proof duration of test: 1000 h length of fibril l_{max} ≤ 2 mm frequency of fibril H number of fibrils/10 mm filiform corrosion coefficient F = H x l ≤ 0,4 no defects on the surface</p>
<p>MASTER Approved Coated Aluminium ★★ Sea Proof Plus</p>	<p>PREMIUM Approved Coated Aluminium ★★★ Sea Proof Plus</p>	<p>Sea Proof Plus duration of test: 1000 h length of fibril l_{max} ≤ 2 mm frequency of fibril H number of fibrils/10 mm filiform corrosion coefficient F = H x l ≤ 0,15 no defects on the surface</p>

Pic. 10: Filiformcorrosion test criteria for GSB approved categories of Sea-Proof and Sea Proof Plus

treatment systems are equally effective in the prevention of Filiformcorrosion. Filiformcorrosion testing in accordance with DIN EN 3665 is recommended, whereby after 1000 hrs the average fibril length must not exceed 2mm and the Filiformcorrosion factor F which is a product of average fibril length and frequency must remain below 0.4.

As the test period of 6 weeks does not facilitate each individual production batch to be tested, GSB Members whose results meet these requirements after unannounced testing will be licensed to use the GSB quality standards „Sea Proof“ or the quality standard of „Sea Proof Plus“ if a Filiformcorrosion factor F of below 0.15 has been met.

It goes without saying that the appropriate choice of coating material for Aluminium construction components

and its ability to meet the specific climatic requirements must be considered of equal significance in the assurance of long lasting protection against corrosion as well as the maintenance of aesthetic appearance.

* Source: G.M. Scamans et. al. Alcan International Ltd. Banbury ASST 2000 Manchester

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2. [Van Loo et. al. „Filiform Corrosion“, Corrosion – NACE – Vo I. 9 (1953) 277-283]
3. [M. Fishkis, J.C. Lin: Wear 206 (1997), 168].
4. [J. H. Nordlien, J. Defrancq, W. Züst, M. Benmalek, R. Stuckart: Materials and Corrosion Band 51 Edition 7, pages 473 – 480; (Online release: 12 Jul 2000)].
5. [Geoff M. Scamans, Andreas Afseth, ASST 1997, 2000, 2003]

Author: Axel Blecher, GSB International – Chairman of the Technical Commission, Schwäbisch Gmünd

GSB Members' Assembly in Berlin: Introduction of new coating classifications

Around 120 delegates from all over Europe attended this year's GSB International Members' Assembly in Berlin on 11th and 12th May. Whilst the agenda included a number of significant lectures and presentations, the focal point of the meeting was the introduction of new classifications of coating standards as well as the recommendation for revised weathering categories.

As a result the GSB Quality Regulations GSB AL 631 now include the new weathering categories of „Country Side“, „Industrial“, „Sea Proof“ und „Seaproof Plus“. Incorporating the latest technology the distinctions are aimed at simplifying the selection process of suitable pretreatment and coating systems for metal construction companies and architects in accordance with the specific demands placed by the relevant location of individual projects.

At the same time the new classifications of „Approved Coater“, „Master Coater“ and „Premium Coater“ were introduced to the Quality Regulations alongside a revision in the design of the Quality Labels. The proposed changes to the Quality Regulations were accepted by a large majority vote and are effective from the beginning of July 2009.

Please contact the GSB Head Office for further information.

In Memoriam



Jo Verstappen, Technical Director of the company Weert Groep/NL, died suddenly on 15th April 2009 at the age of 67. Since 1999 Jo Verstappen had held the position of Chairman for the Steel Sector and was a Member of the GSB Board. From 2007 to his death he was Deputy Chairman of the GSB Board and active in a number of national and international organisations such as the European General Galvanizers' Association (EGGA).

In Mr Verstappen the GSB has lost not only a valued colleague but also a dear friend, who will always be remembered with fondness and honour.



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