Vereniging
Industrieel
Oppervlaktebehandelend
Nederland

FILIFORM CORROSION OF ALUMINIUM

Practical recommendations to reduce the potential for filiform corrosion

Vereniging Industrieel Oppervlaktebehandelend Nederland

Index

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Disclaimer: Using great care, these practical recommendations were updated to current technical standards by recognised specialists. Although the potential for filiform corrosion is minimised by applying these practical recommendations, there is always a (minor) possibility for filiform corrosion. Vereniging ION accepts no liability in such cases.

1. Introduction

Filiform corrosion is a threadlike form of corrosion occurring mainly on lacquered aluminium. The phenomenon originates in areas where there is no or inadequate lacquer, such as cut edges, punch holes, damages, and sharp edges with inadequate edge coating. By completing the various procedural steps listed in the points of focus below, the potential for the occurrence of filiform corrosion can be kept to a minimum.

1.1 General

1. Executive companies must be in possession of an adequate quality control system, such as ISO 9001 or ISO 14001. Coating companies must be Qualicoat *1) certified. Coating companies performing activities intended for coastal regions must be Qualicoat Seaside certified.

**1) The practical recommendations are based on the process descriptions and terminology in the Qualicoat Technical Specifications. Naturally, the practical recommendations can be translated to other quality systems.*

1.2 Substrate

2. Materials must be ordered in compliance with accurate specifications including:
   a) analytical perimeters restricted in comparison to broad standards;
   b) extrusion billet/rolling ingot requirements (base materials for plate materials);
   c) profile / coil requirements.
   Certain details are included in Chapter 2.

   The basis for these practical recommendations are applicable standards, including at least:
   - NEN EN 573 serie, Aluminium and aluminium alloys – Chemical compositions and form of wrought products, chemical compositions
   - NEN EN 485 serie, “Aluminium and aluminium alloys – Sheet and strip”, conditions for inspection and completion
   - NEN EN 486, Aluminium and aluminium alloys – Extrusion ingots – Extrusion ingot specifications
   - NEN EN 487, Aluminium and aluminium alloys – Rolling ingots – Rolling ingot specifications
   - NEN EN 755, Aluminium and aluminium alloys – Extruded bars, tubes, and profiles
   - NEN EN 1396, Aluminium and aluminium alloys – Coil coated sheet and strip for general applications – Specifications
   - NEN EN 12020, Aluminium and aluminium alloys – Extruded precision profiles of alloys EN AW-6060 and EN AW-6063

3. To ensure good edge coverage when coating profiles, a curvature radius of at least 0.5mm is required.

Qualicoat does not explicitly specify the rounding radius as a figure, only indicating that there should be no sharp edges. A curvature radius of 0.5mm ensures that coat thickness at the corners is no more than 15-20% of coat thickness on the flat sides. This means that, at a coat thickness of 60-80 µm, the coat thickness on sharp edges will not be more than 9-16 µm. At a lower curvature radius, coat thickness on sharp edges will be even lower. In C2 corrosion class areas (see climate map) there is no particular cause for concern, but in C4 or C5 areas, or even in C3 areas, the risk of corrosion from sharp edges is very real.

1.3 Storage

4. During continued processing, rolled and extruded semi-finished goods must be stored in such a way as to prevent corrosion or other deterioration from moisture from occurring. In addition, damage-protective measures must be taken.

5. Pre-treated materials may only be handled while wearing clean gloves.

1.4 Points of focus for coaters

Implementing pre-treatment and coating.

6. Implementation must meet required Qualicoat regulations.

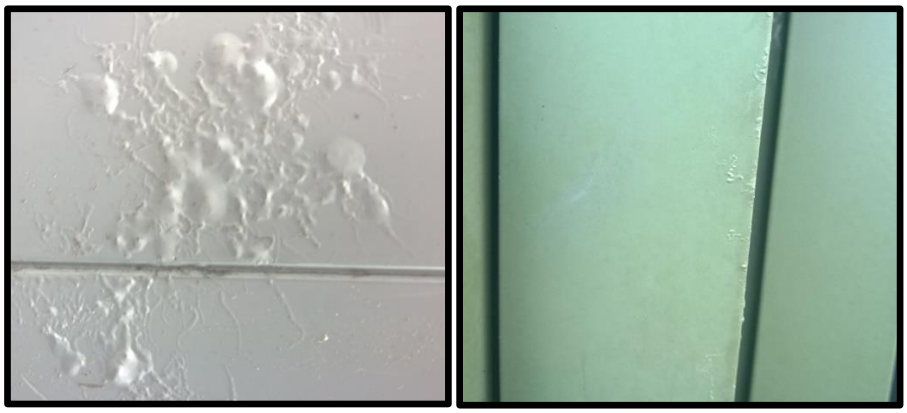
7. The storage period between pre-treatment and coating may not exceed 16 hours, unless the Qualicoat specifications state otherwise.

8. Under maritime conditions, areas C4 and C5 on the “Benelux climatological map”, a two-layer system is required/preferred with regard to corrosion protection (see Chapter 3). In such areas, the etch-rate must be at least 2 grams per m2 in compliance with Qualicoat Seaside. Note: experts recommend an etch-rate of 2 grams per m2 under all circumstances.

9. Required minimum thickness of the coating layer depends on type of powder/ liquid paint and environmental circomstancis, and is documented in the Qualicoat Technical Specifications (see VMRG Kwaliteitseisen en Adviezen, and NEN EN 1396 for coil coated materials).

   Qualicoat does not explicitly specify where and how to apply a two layer system. The two-layer systems are a “typically” Dutch approach based on experience from the 1980s and 1990s. The application of two-layer systems in C4-C5 areas is strongly recommended, specifically to achieve an adequate edge coverage. Two-layer systems are even recommended as pre-treatment for pre-anodising, where profiles with a radius at all corners of at least 0.5mm and a conversion coating can be seen as an exception.

   Perforated sheets materials must be brushed to ensure burrs and sharp points/edges are sufficiently removed from the rear. In addition, a two-layer system is also recommended for perforated plate materials with regard to edge coating.



Examples of FFC from sharp edges.

10. The application and curing cycle must be implemented in compliance with powder / lacquer supplier regulations.

11. Product exit control must be implemented in compliance with Qualicoat regulations.

12. As a supplement to traditional pre-treatment systems, aluminium can also be pre-anodised with a 4–10-micron coat thickness before applying the coating system.

    The procedure is described in the Qualicoat Technical Specifications. In addition to the strict adherence to these specifications, there are two additional points of focus:
    - Even the use of this system does not remove risks of inadequate edge coating. Ensuring the correct radius is therefore still a requirement.
    - Coat adhesion must be assured. For this reason, the Qualicoat requirements call for a conversion coat. In practice, therefore, the pre-anodising coat is nearly always considered an additional coating.

    When pre-anodising off-site, one must make use of (at least) the Qualicoat standard agreement to adequately document quality control of the full coating system from coater to anodiser.

Supplementally, since 18 December 2020, the use of traditional chrome-6-based pre-treatment is no longer a tenable option for “standard” applications. A chrome-6-based pre-treatment is currently only (legally) permitted under very specific conditions.

1.5 Points of focus for façade builders

Relevant elements include window frames, doors and windows, architectural metal facades, and coated aluminium awning components.

13. Prevent damages.

14. Only use tools and equipment suitable for processing aluminium. Tools and equipment must be sharpened at all times, and be dedicated to processing aluminium.

15. Raw edges, cuttting edges (other than mitred corners) and drill holes must be trimmed/deburred;
The machined uncoated sides must be retreated or the constructional design must allow good ventilation.

16. Contact/galvanic corrosion resulting from the use of components of other materials must be avoided by a proper design.

17. Watertight finishing of profile connections is required using an anti-corrosive, pH neutral flexible sealant or adhesive.

18. Fasteners must only be comprised of aluminium, plastics, or stainless steel. Note that, when using stainless steel fixing materials in situations characterised by exposure to an exterior climate (moisture), contact/galvanic corrosion must be avoided.

1.6 Points of focus for designers

19. Indicate the building’s intended location to facilitate calculation of the environmental impact class (see Chapter 3).

20. Document the use of details that reduce the risk of filiform corrosion, including:
    - not applying details that may lead to potential “wetting” from “inside”;
    - well-drained construction;
    - attention to potential dirt loads at engineered connections;
    - preferably ensuring that draining water does not flow across visible parts.

21. In consultation, establishing maintenance and cleaning procedures with required utilities, methods, frequencies, and means. Façade components not subject to rainfall must receive additional attention during cleaning.

1.7 Washing and cleaning

Per project/building, the façade builder must compile a maintenance plan including a start-up log, and issue this to the client upon project completion. The client will be responsible for correct façade maintenance from the point of (partial) completion.

Washing and cleaning the façade occurs in two phases:
- During construction. All contaminants, such as alkaline building materials (cement) must be removed immediately, and contaminated surfaces must be rinsed with clean water.
- Following completion, during use. Under normal conditions: at least one per year. Under aggravating circumstances: 2-4 times per year, in compliance with “Heldere kijk op onderhoud”, published by VMRG.

A pH-neutral solution must always be used when cleaning. Note that demineralised water is not pH neutral. Additionally, note that no aggressive residues remain following evaporation of the solution.

1.8 Target group

The recommendations focus mainly on aluminium components used in construction.

Updates with regard to coil coated materials are documented NEN EN 1396; Aluminium and aluminium alloys – Coil coated sheet and strip for general applications – Specifications.

For more details regarding the individual items, please refer to the following publications:
- Standards as documented in Section 1.2.
- Current VMRG quality requirements and recommendations.

- SKG BRL 2701: Nationale Beoordelingsrichtlijn voor metalen gevelelementen (national assessment guideline for metal façade components).
- “Heldere kijk op onderhoud” by VMRG.
- The latest Qualicoat Technical Specifications including update sheets.

2. Substrate

Discussion within the aluminium industry has led to the additional contents of a “Substrate” paragraph in the practical recommendations.

2.1 Composition

Chemical composition is based on EN-AW6060; an alloy used frequently, but not exclusively. In particular, alloys EN-AW5005, EN-AW5083, EN-AW6005A, EN-AW6063 and EN-AW6082 are also common.

Based on a practical experience, stricter tolerance parameters are recommended for a number of elements. The EN-AW6060 alloy is given below by way of an example.
This refers to adjustments to the elements of silicon (Si), copper (Cu), zinc (Zn) and lead (Pb).

	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Pb	Other	
										Each	Combined
Min	0.30	0.10	0	0	0.35	0	0	0	0	0	0
Max	0.55	0.30	0.03	0.10	0.60	0.05	0.03	0.10	0.02	0.05	0.15

Figures are in weight percentages; the remaining percentage is aluminium.

Note that these are recommendations by Qualicoat. The increase in recycled aluminium may cause (or start causing) deviations in elements. If this trend continues, it will be preferable/required for the installation company to notify itself of the composition of their aluminium. At the date of publication, there is an ongoing European study involving all stakeholders. The goal of the study is to assess whether higher percentages of elements can be permitted without negatively affecting coating quality, and which, if any, consequences must be imposed on aluminium not meeting this composition.

A preference/requirement for installation companies to notify themselves of the composition of their aluminium seems impending. This preference/requirement can be fulfilled in one of three ways:

- Indication by a supplier, or an investigation by the installation company (currently available).
- At the date of publication, Qualicoat 3.0 is working on a list of materials (tracing aluminium) containing aluminium composition (currently not operational).
- The EU is working on a more sustainable Europe through the Green Deal. One of the action items part of this Deal is the Digital Product Passport. This may come to include aluminium composition (currently not operational).

2.2 Base material (billets)

Billets must comply with the requirements in EN 486, specifically:

- Homogenisation.
- No casting faults, such as tears, inclusions, or internal flaws.
- With respect to traceability: each billet must be market with cast number, allow, and supplier.

If billets show exterior oxidisation or other imperfections that will negatively influence their potential for processing, the billets can be shelled.

2.3 Extrusion

With regard to controlled processing, the implementation of a quality control system, such as in compliance with ISO 9001 or ISO14001, is recommended. Pressing temperatures and conditions must be documented in quality manuals.
The aspect of the traceability of materials to billets is of great importance in this respect.
Product quality must comply with NEN-EN 12020 and VMRG quality requirements and recommendations.

3. Climate

3.1 Influence of climate on sustainability

With the exception of sunlight, climatological differences in the Netherlands are large with regard to humidity, chlorides, air pollution and the like. The interior and exterior climate largely determined the demands imposed on a system's resistance to corrosion.
The climate distribution as compiled by Centrum TNO Coatings is a good supporting basis for formulating the requirements of façade exteriors. This distribution distinguishes between macroclimate, microclimate, and mesoclimate zones.

3.2 Macroclimate

Macroclimate distinguishes between rural, urban, industrial, maritime, and maritime/industrial regions. By far the strictest requirements are to be imposed on products for clients to be used in maritime and maritime/industrial regions. Globally, this area encompasses relatively small coastal strip (approx. 10 km) with a chloride deposit of > 300 mg/m2 per day. Extreme chloride loads should be expected up to approx. 500 m from the high-water mark. This map indicates the distribution by macroclimate zones in the Netherlands.

3.3 Mesoclimate

Mesoclimate is defined as a situation where local influence plays a significant role, for example if a building is on the edge of a high-traffic route (exhaust fumes, de-icing salts), near to an industrial area, or subject to large amounts of (condensation) moisture from steam or cooling tower emissions.

Examples of mesoclimates

Zone	**Load**
Railway	Copper particulate
Livestock farm	Ammonia
Motorway	Carbon monoxide
Airport	Kerosine
Paper mill	Sulphite

The differences between mesoclimates are so great that a map of zones in the Netherlands is unworkable, nor can general requirement guidelines be formulated. Mesoclimates can be highly aggressive. A concentration of contaminant particles and condensation fluids can result in chemical compounds such as acids, creating very low (or, in exceptional cases, high) pH values following evaporation. This leads to aluminium degradation.

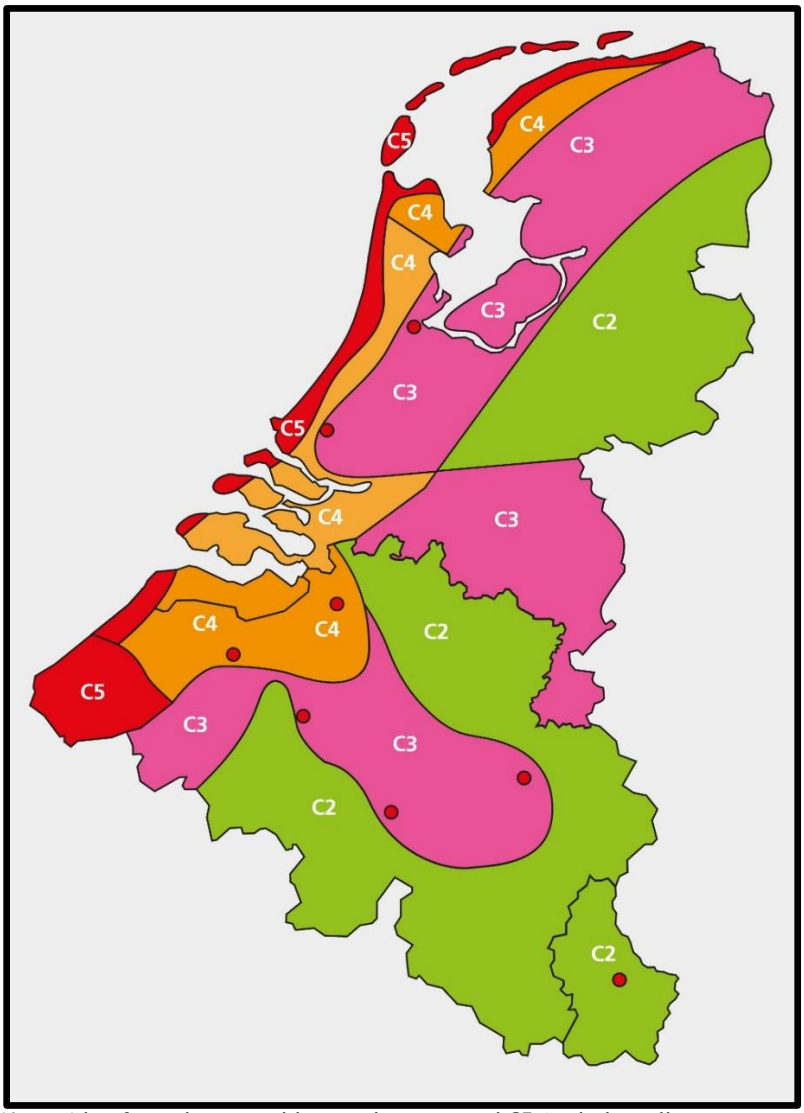
3.4 Microclimate

Microclimate is defined as the climate directly in and around a building. Most corrosion-related issues can be prevented through careful attention to the restriction of condensation and rainwater pooling to prevent the build-up of contaminants.

The client and technical consultant should inform themselves of climate circumstances on-site. Production and implementation must be aligned to relevant testing and results.

Unfortunately, it is not possible to be more specific in terms of corrosion classes in the particular zones. One must always be mindful of local circumstances. At the local level, particulate and chlorine loads may differ severely. This also applies for specific locations. For example: interior application in a pool may lead to a high corrosion class due to their higher prevailing chlorine load.

3.5 Benelux climatological map



Note: 1 km from the coastal line is characterised C5 (including all open connections to the sea).

Corrosion classification according to ISO12944 - 2019		
Class	**Specification inside atmosphere**	**Specification outside atmosphere**
C1	Indoors, in heated buildings, with a clean atmosphere, such as schools, offices and hotels	
C2	Unheated buildings where condensation can form, for example storage areas, sports halls and warehouses.	Environment with little pollution and dry climate. Mostly rural areas.
C3	Premises and buildings with high humidity and little pollution. Think of food companies and laundries.	Industrial environment and urban area with moderate SO2 pollution and low salinity.
C4	Premises and buildings with high humidity and medium pollution. Think of chemical companies, swimming pools, ports and shipyards located on the coast.	Industrial environment and urban area with pollution, not directly on the coast with moderate salt concentration, high humidity and aggressive atmosphere.
C5	Premises and buildings with (almost) permanent condensation and high pollution.	Industrial environment and urban area directly on the coast with high salt concentration, high humidity and aggressive atmosphere.
Cx	Industrial areas with extreme humidity and aggressive atmosphere.	Offshore, very aggressive atmosphere. Subtropical and tropical atmospheres.

4. Policy group composition and timeline

The practical recommendations were compiled by a policy group in 1996. This group was comprised of:

- G. de Colfmaeker — Alural / APA
- B. Govaert — Hydro Aluminium / BAA
- G. Nijhof — Hoogovens Groep / VNAI
- J. Renckens — Renckens Advies / VMRG
- P. van der Eycken — TUMS
- F. Viester — Aluminium Coating Nederland / VISEM

Further supplemented by:

- D. Boonen — Balak / VISEM
- F. Eschauzier — Hunter Douglas / ECCA

This edition of the practical recommendations was published by the Aluminium Centrum.

The practical recommendations were revised by a policy group in 2011. This group was comprised of:

- A. Hofland — Sapa Building System
- P. de Jong — Reynaers
- J. Santegoeds — Reynaers
- C. Kampen — E-max company
- K. Nilsen — Boal Aluminium
- J. Schothuis — Jonkman Coating / VISEM
- L. Smit — Kennis Centrum Gevelbouw
- W. van der Ven — Havecon Kassenbouw
- M. van de Vliet — Köhler Peutz Geveltechniek
- E. Vaders — Aluminium Centrum
- F. Viester — Coördinator

This edition of the practical recommendations was published by the Aluminium Centrum.

The practical recommendations were updated by a policy group in 2021. This group was comprised of:

- Johan van de Graaf — Damco Aluminium Delfzijl
- Ellen Vaders — Aluminium Metal Knowledge
- Frank Viester — VIAS
- Gerrit Buitenhuis — VMRG
- Remco Hermes — Scheldebouw
- Jan Willem Fidder — Schüco Nederland
- Egbert Stremmelaar — Vereniging Qual.ION/Vereniging ION

Further supplemented by:

- Gerald Oude Nijhuis — Jonkman Coating

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