CORROSION TYPES
CHAPTER 4
6) FILIFORM CORROSION

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5 ) Filiform corrosion:

Filiform corrosion is a type of localized corrosion that is often associated with aluminum and magnesium alloys that have an organic coating. This type of corrosion has occurred on other coated metals such as zinc, iron and steel. Filiform corrosion tends to occur at high humidity, e.g. greater than about 75% and temperatures at or slightly above room temperature. The corrosion appears as thread-like filaments under the coating. The corrosion products cause the coating to bulge giving the surface the appearance akin to that of a lawn riddled with mole tunnels. The filaments proceed from points where the coating is no longer continuous. Numerous coating systems are susceptible. Condensates containing halides, sulfates, carbonates, or nitrates have been associated with filiform corrosion. Damage to the metal tends to be limited but the effect on appearance tends to be detrimental.
Filiform corrosion occurs under surface layers such as paint. It depends on the relative moisture of the air and the quality of the surface treatment preparation prior to coating. **Filiform corrosion has the appearance of thin threadlike attacks progressing along the surface beneath a surface layer.** The mode of attack is similar to pitting corrosion in that the front of the attack is supported by moisture which penetrates the surface layer and becomes depleted of oxygen making the area anodic. Filiform corrosion mainly has an **aesthetic effect**, but the corrosion products formed may cause deformation in narrow crevices or delimitation of surface treatment.
The mechanism of filiform corrosion is shown in the figure below:-

The mechanism has a number of characteristics that are similar to Crevice corrosion, e.g. differential aeration and hydrolysis of metal ions resulting in increasing acidity in the region of dissolution. This type of corrosion has the following characteristics.
1) The coating allows oxygen and water to migrate through it.

2) The concentration of dissolved oxygen becomes highest at the back of the head near the region of the tail. This region becomes the cathode.

3) Oxygen becomes depleted at the head. This region becomes the anode.

4) Corrosion is driven by the potential difference between these regions, a potential difference which can rise to several tenths of a volt.

5) Metal ion formation and dissolution proceeds at the head while oxygen is reduced closer to the tail.
Thus, the worm-like or thread-like structure that is formed has two parts that participate in the corrosion process, the front of the head in which metal dissolves and the region behind the head in which oxygen is reduced. Farther back is an inactive region in which metal oxide and metal hydroxide have formed a precipitate. Hydrogen bubbles can be formed if the head becomes very acidic. The propagating head region continues to move under the coating into new areas leaving behind a thin trail of corrosion under the coating. The threads can measure less than 1 millimeter across. Multiple threads or worms can appear under the coating. When two propagating heads meet, the propagation tends to stop. When a propagating head approaches the inactive tail it tends to be deflected. The corroding alloy can affect the appearance of the filament.
For example, filiform corrosion of aluminum or magnesium can result in a whitish precipitate forming in the tail. Filiform corrosion of iron can result in a head containing a greenish fluid (Fe(II)) and a tail containing a redish precipitate (Fe(III)).

The occurrence of filiform corrosion has been reported to be decreased by the following approaches:

- Application of more than one layer of a coating.
- Use of a chromate containing conversion coating or primer on aluminum.
- Use of a zinc containing primer on steel.
- Reducing the relative humidity or maintaining a low relative humidity when storing items made of susceptible alloys.
According to one recent investigation, a reduction of the Cu content in the aluminum alloy below 0.3% reduces filiform corrosion substantially. The use of an inhibiting primer or a conversion coating can also be effective. However anodizing used as a pre-treatment seems to be the best solution.