Practical Guidelines

Causes and Prevention of Blistering on Factory-Coated Hot-Dip Galvanized Steel Components

These guidelines were developed with the participation of the following experts:

Company	Name
Amprion GmbH	Jan Daniel Wenzel
Bayernwerk Netz GmbH - E.ON Group	Annika Maierhöfer
Chemische Industrie Erlangen GmbH	Jürgen Büttner
Geholit + Wiemer Lack- und Kunststoff-Chemie GmbH	Dr. Frank Bayer
RWE Power AG	Stephan Müller
Schleswig-Holstein Netz GmbH - E.ON Group	Steffen Kupke
TenneT TSO GmbH	Martin Salfer
Westnetz GmbH - E.ON Group	Jürgen Wierz

Content

1 Introduction

In practice, the factory coating of hot-dip galvanized components with water-borne coating materials can lead to blistering in the fresh coating often. This phenomenon often occurs with a time delay. Blistering is caused by an interaction of the following factors:

- Steel grade
- Hot-dip galvanizing, incl. surface preparation
- Coating material
- Coating and drying process

2 Causes and factors of blistering

The following causes are known:

- Outgassing from the zinc coating
  Zinc films contain micropores, cavities and voids that can contain hydrogen. The hydrogen is produced among others by pickling (HCl) and becomes trapped in the zinc film during the galvanizing process.
  Surface preparation (sweep blasting) and subsequent coating cause the gas to escape which can result in blisters under the coating.

- Reaction of water from the coating with zinc and/or ammonium chloride in or on the hot-dip galvanized coating
  If residues of hydrochloric acid or flux ($ZnCl_2$ / NH_4Cl) have not been correctly removed, they become trapped in the zinc film. When they react with water from the coating materials, acid is formed. The acid reacts with the zinc and releases hydrogen gas which can result in blistering and coagulation.

This is mainly due to excessive film thickness of the coating and unfavourable drying conditions. High wet film thickness retains water on the surface for a longer period of time. Cold components, high humidity and/or stagnant air slow down the flash-off process, resulting in a longer reaction time between the water and the zinc surface which promotes blistering.

3 Measures during hot-dip galvanizing

- Pickling and rinsing
  After pickling the components must be rinsed thoroughly to ensure that no hydrochloric acid residues enter the subsequent process stages. The rinsing fluid must be replaced regularly to maintain salt content, conductivity and PH value within an optimal range.

- Use of flux
  The flux ($ZnCl_2$ / NH_4Cl) must not become trapped in the zinc film.
  This requires a dry flux film to be present.

- Galvanizing procedure
  Before removing the components, the surface of the zinc bath must be skimmed completely to prevent zinc ash or particles from depositing on the surface.

- Quenching and cooling water (if permitted by the client)
  The water in the quench and cooling tanks must be changed regularly to prevent the carry-over of salt contamination.

- Formation of white rust
  To prevent the formation of white rust, the components should be stored in a dry and properly ventilated environment for a sufficient period of time after galvanizing to allow a passivating zinc carbonate film to form.

4 Measures before application of the coating material

- Outgassing of the galvanized coating
  In this case, trapped gas can be expelled from the cavities and pores of the hot-dip galvanized coating by tempering the galvanized components at temperatures of approx. 50–80 °C before applying the coating material. This also reduces the reactivity of the zinc surface. The coating material must then be applied while the component temperature is falling.
- Reaction of water from the coating with zinc chloride and/or ammonium chloride in or on the hot-dip galvanized coating
  In this case, the galvanized components should be thoroughly washed with clean water (e.g. high-pressure washing) before further surface preparation (sweep blasting).
  This measure removes soluble salts on the surface such as zinc chloride or ammonium chloride.

5 Measures during application of the coating material

When applying water-borne coating materials, make sure that no excessive wet film thicknesses are applied (e.g. by selecting the appropriate nozzle size and regularly monitoring the wet film thickness).

Excessive film thickness as well as low temperatures and/or high relative humidity during the drying process are counterproductive and must be avoided.

The following climatic conditions accelerate drying and prevent or minimize the risk of blistering:

- Drying the freshly coated components in a moderate indoor climate (approx. 20–30 °C) or forced drying at higher temperatures (approx. 50–80 °C)
- Low humidity (relative humidity < 60 %)
- High air circulation/air movement

If blistering occurs despite observing the target film thickness and optimized application and drying conditions, applying the total film thickness in two application steps can solve the problem:
Applying an initial continuous thin film ("mist coating").
After this relatively thin film has dried in a shorter period of time, the zinc surface is inhibited/passivated. If no blistering occurs within this thin film, there will be no blistering during the subsequent application of the remaining film thickness to reach the required total film thickness.

6 Repairing the coating in the event of blistering

Should blistering occur despite all measures, the blisters in the affected areas must be removed using suitable tools (knife, scraper etc.) and subsequently recoated.