TECHNICAL NOTE
Mottled Appearance

Issue 1, April 2017

Preface

This document is intended to inform readers about potential surface conditions resulting from batch hot dip galvanizing through the provision of visual and written guidance. AS/NZS 4680 provides guidance in the area of allowable surface conditions after galvanizing, however identification of a non-conforming surface condition of a galvanized article will depend on the stated end use of the product and the extent and nature of the damage to the coating. This document is not intended to replace guidance provided by an expert, such as a galvanizer or accredited hot dip galvanizing inspector, who may be consulted when issues with the surface condition arise.

Description

Mottled appearance consists of a dull grey circular type pattern around areas with a shiny finish. It may occur as a localised patch or extend over the entire surface of an article. The surface condition can appear in conjunction with other surface finishes, such as shiny or dull appearance and spangled areas (see *Dull Grey Appearance* and *Spangle*). Mottled appearance is also referred to as:

- Mechanical scale pattern
- Web pattern
- Spider web pattern
- Cellular pattern

Cause

A mottled finish occurs due to a partial presence of zinc-iron alloy layers at the surface of the galvanized coating in the form of a dull grey circular pattern. The alloy layers reach the surface following their continued growth during the galvanizing process, which can be caused by:

- Using steel in Category B in Table 9.1 of AS/NZS 2312.2, with a silicon content between 0.14% and 0.25% or steels with a phosphorous content above 0.035%, as they are more reactive and more likely to result in a mottled appearance. While a mottled finish can occur on steel in Categories C and D, it is less common.
- Cooling articles slowly after galvanizing, allowing the reaction between the zinc and steel to continue after leaving the molten zinc

Prevention

The risk of mottled surface finish occurring can be minimized by:

- Choosing a steel in category A in Table 9.1 of AS/NZS 2312.2, with silicon and phosphorous contents smaller than 0.04% and 0.02% respectively where possible
- Designing the article for fast and even cooling where possible

If it is vital that the product has a similar initial finish, this must be advised prior to galvanizing and preferably prior to fabrication. This will allow the galvanizer to provide guidance regarding the chemical composition of the steel and fabrication process that will lead to the desired result.

Effect

The finish appears as a circular dull grey pattern on the surface of the galvanized article, seen in Figures 1-5. The appearance resembles a spider web or scales and is purely an aesthetic condition, with the corrosion protection of the article unaffected. Over time, the overall appearance will become uniform as the coating weathers with exposure to the atmosphere.

Acceptability

A mottled appearance is acceptable when galvanizing to AS/NZS 4680 if the coating thickness is above the minimum specified. AS/NZS 4680 gives the following information on the initial appearance of a galvanized article:

- Special requirements for the surface condition of an article requiring arrangements with the galvanizer prior to galvanizing (See Note 3 of Clause 7 of AS/NZS 4680)
- Steels of certain compositions or different cooling speeds potentially causing the article to become partly or wholly grey in colour, which is acceptable provided it has adequate adhesion (see Note 6 of Clause 7 of AS/NZS 4680)

Responsibility

Mottled appearance can be caused by:

- The steel manufacturer, when steel is provided with a susceptible chemical composition
- The designer, when normal cooling isn't possible due to the design of the article
- The galvanizer, when the part has been unnecessarily slowly cooled

Remedy

The initial appearance of the galvanized coating can be modified by:

- Spraying small areas that are aesthetically displeasing with silver spray to provide a **temporary** colour match. Most silver sprays do not weather in appearance with the galvanized coating and will remain shiny after the dull grey zinc patina has formed
- Stripping the coating and regalvanizing may help to reduce the mottled appearance in some cases, but will usually need to be discussed with the galvanizer and incur cost to the customer when the initial coating complies with AS/NZS 4680

Examples

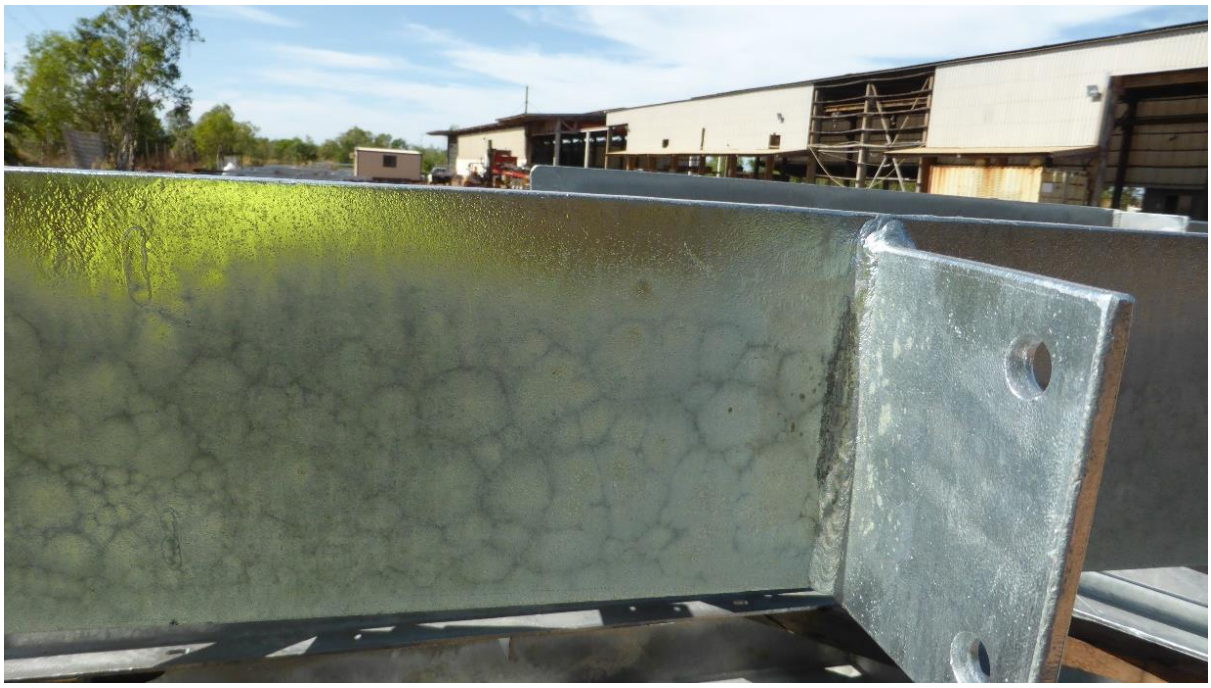

Figure 1: The dark circular pattern of a mottled appearance is visible, with the dark sections being regions of iron-zinc alloy layers on the surface.

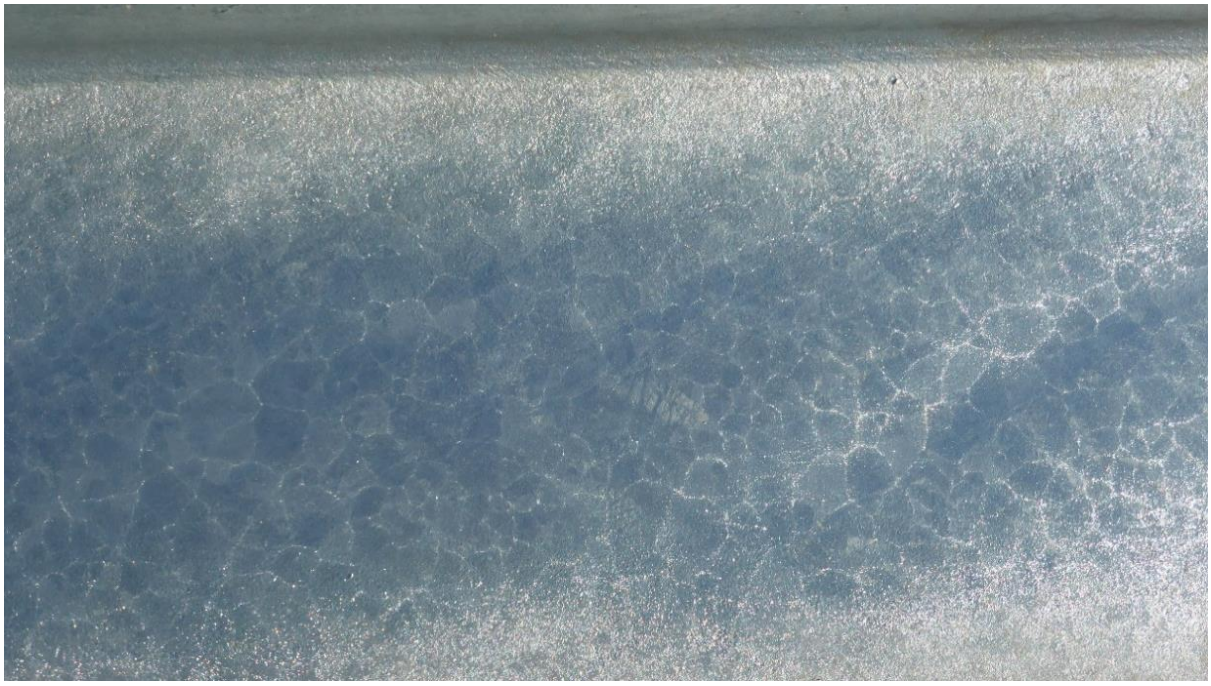

Figure 2: A close up of a mottled appearance, showing the difference between the shiny and dull regions.

Figure 3: Mottled appearance on a pipe, most likely due to the steel chemistry.

Figure 4: The scale like mottled appearance evident on a circular article.

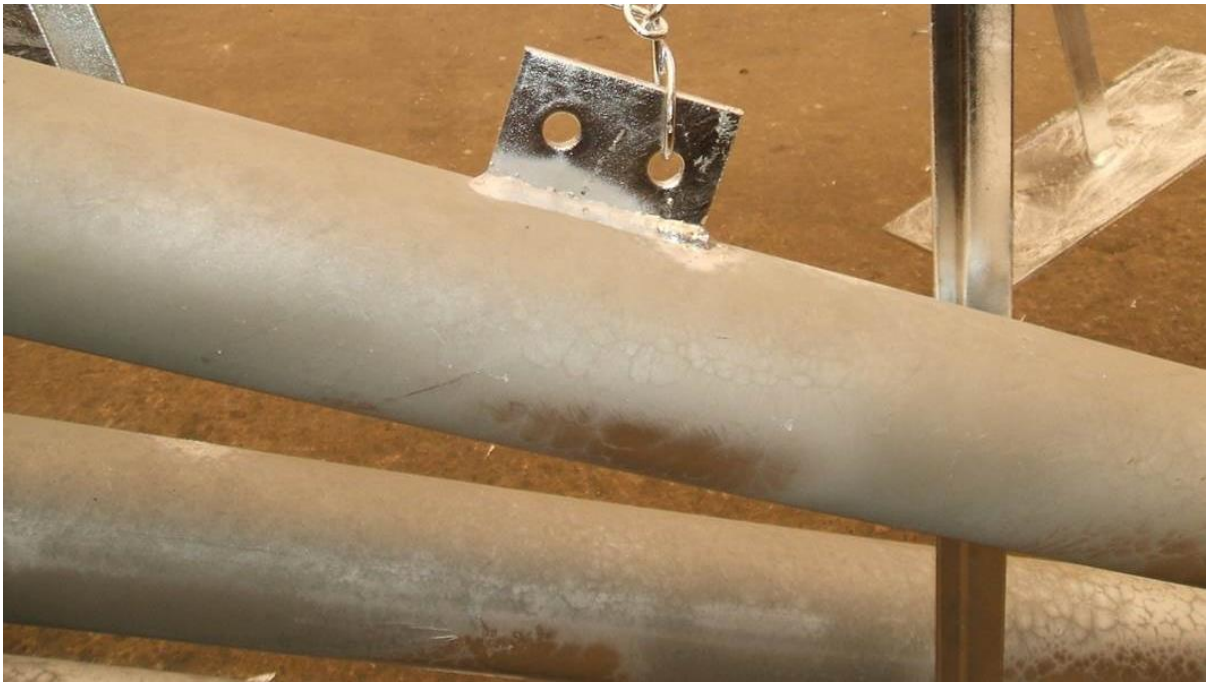

Figure 5: A mottled appearance has occurred in some regions on the pipe in combination with a dull coating (see *Dull Grey Appearance*).