

## Introduction

Normally, galvannealed steel sheet has a very uniform matte-grey appearance, as is shown in Figure 1.



**Figure 1: Normal appearance of galvannealed steel sheet**

The color may be slightly lighter or darker, reflecting a respectively lower or higher percentage of iron in the coating.

At times, the users of galvannealed sheet complain about localized dark stains on the surface of a galvannealed coating. Often, these stains have a dark grey to black appearance. The dark stained areas usually transition to a lighter grey around their periphery, but at times, there is anything from a straw colored to a dark purple hue around the edges.

Dark areas can range in size from small to large (less than 1 inch to many inches in diameter), be rounded or very irregular in shape, be uniformly dark or exhibit variable darkening, or show a gradation in darkness as they transition to the unaffected areas.

Figure 2 shows two photographs of galvannealed coatings with areas of dark stain and the transitioning to a normal grey appearance.

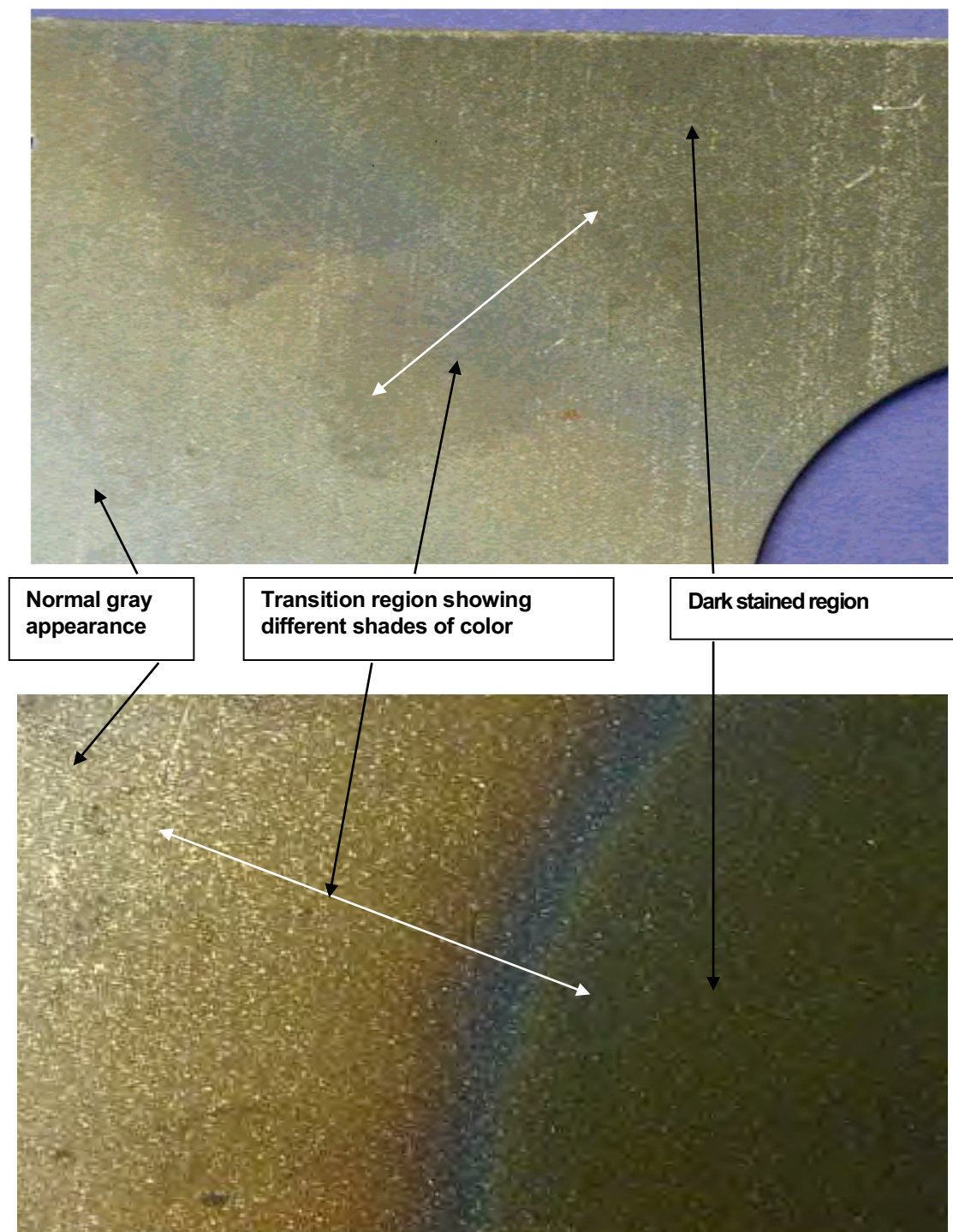


Figure 2: Dark stains on galvanized steel sheet

## Source of Dark Staining on Galvanneal

Regardless of the color or shape, there is one primary cause for darkening. This is the **presence of moisture**, either from intrusion during storage and shipping or from condensation within the coil during transit and storage.

With galvanized sheet product, if moisture gets trapped between the adjacent wraps in a coil, or between sheets in a lift, the usual result is “white rust”. Most users of galvanized sheet have encountered this phenomenon. The white color is that of the corrosion products (primarily zinc hydroxide) that form when moisture corrodes the zinc in the absence of free air circulation. Typically, white rust is present as a flocculent, loose powder. For a detailed discussion of white rust, please refer to GalvInfoNote 3.2.

For galvannealed sheet product, corrosion of the coating also occurs if the coil or bundle of sheets gets wet and has no way of drying. Instead of forming white rust, the first appearance change is the formation of an adherent oxide that is most often dark grey to black in color. The iron in the coating is thought to be the main reason for nature of this corrosion product – the result of localized galvanic coupling on the Zn-Fe surface alloy layer. The stain does not form as a loose powder, but is a thin, often adherent continuous film. Its dark grey to black color is associated with the light absorbing characteristics of the thin film of corrosion product. If the sheet stays wet for long periods and large amounts of corrosion product form, the stain may begin to exhibit the same flocculent white corrosion product that is observed on storage-stained galvanized sheet. It has also been observed in the case of skin passed galvanize that storage stain due to condensation can appear as a dark, not white, stain. Tests have shown such stain to be zinc oxide. The dark color is thought to be the result of the light reflecting properties of a skin passed galvanized surface (see GalvInfoNote 3.2, p. 3).

## Why is Galvannealed Sheet Susceptible to Dark Staining?

The primary reason that the dark corrosion film is seen more than perhaps expected on galvannealed sheet is because this product is often shipped “*dry – no oil and no surface passivation (chemical treatment)*” to the customer. There is no rust-inhibitive oil applied at the exit end of the galvanizing line, nor is the surface passivated with a clear chromate treatment to minimize white rust.

The reasons for shipping without any type of corrosion inhibiting surface film are:

1. Chemical treatments may interfere with obtaining good paint adhesion. Since galvanneal is intended to be painted, most customers do not want to be concerned about the possible adverse effect on paintability due to a surface passivation film.
2. Many customers do not want to be concerned about removing the rust-inhibiting oils present on the surface, which is necessary, because as with a passivation film, oil can also interfere with paint adherence. Excellent cleaning methods are required to get rid of all the oils, especially since the galvannealed surface is somewhat rough and porous. If the oil is not totally removed, paint blistering can occur during baking of thermally cured paints. If the paint is air-drying, the presence of any oils between it and the galvannealed surface can lead to premature separation of the paint during service.
3. During any subsequent zinc or iron phosphating treatments that the product may undergo, chromate passivation treatments will prevent the proper deposition of the phosphate compounds onto galvanneal (and galvanize) surfaces.
4. Passivation treatments interfere with the spot welding of galvannealed (and galvanized) steel parts. The presence of the chromate poisons the copper based electrodes, causing a severe drop-off in the life of the electrode tips and degradation of spot weld quality.

## Recommendations

1. As the susceptibility of galvanized sheet to exhibit dark grey to black surface discoloration is caused by the intrusion of water during shipping or storage, or condensation of moisture onto the sheet surfaces, it is extremely important to keep the product dry. For example, when coils are shipped during the wintertime and become cold, there is potential for condensation to occur within the coils if they are immediately placed in, say, a 70°F warehouse. If the material is then allowed to sit for a period of time before use and no attempt is made to remove the condensation, black stains may form. Extreme care is therefore needed to prevent the corrosion reaction that produces dark surface stains. Precautions must be taken when shipping, especially during wintertime. If transit times will be long, heated trailers/rail cars should be used. Packaging must be good. Good storage conditions at the customer's plant are important. Also, inventory control is important to assure that any specific coil is not allowed to remain unused for a long time. Refer to GalvInfoNote 3.2 for more information on protecting against storage stain and protecting against condensation that can sometimes occur within climate controlled storage.
2. Consider ordering the product "oiled", and then utilize good cleaning practices that employ staged alkaline cleaning. The presence of rust-inhibitive oil will dramatically extend the shelf life of galvanized sheet, and help prevent storage staining.
3. In some instances, cooperative work amongst the steel producer, surface treatment supplier, and paint company has allowed the customer to paint over the surface passivation film applied at the exit end of the hot-dip coating line. If passivated galvanized can be successfully painted, then the probability of dark storage stains developing is dramatically reduced.
4. If dark stains are present on a galvanized sheet, it does not necessarily mean that paint adhesion will be "poor" for all applications. Typically, the dark stain corrosion product that is formed is a thin adherent zinc oxide film on the surface of the galvanized coating. Paint trials are recommended to determine if the dark stain does indeed adversely affect paint adhesion. If not, it may then be possible to use the stained galvanized product.

If this salvage method is tried, it is important to be not only be sure that the dark stained oxide on the surface of the galvanized sheet is adherent to the galvanized coating, but that the paint has sufficient hiding power to prevent "show through". If the amount of storage stain is severe and the dark corrosion product is not adherent to the galvanized coating, it is often better to not use the product for a painted application unless the surface is subjected to aggressive cleaning.

## Summary

The dark stains that are at times visible on galvanized sheet are caused by the same wet storage conditions that cause white rust on galvanized surfaces. Since galvanized sheet is often shipped "dry, no oil, no surface passivation", it is very important to control the shipping and storage of this product. Often, if storage stains are present and the stain is a thin, adherent film, the product can still be used for the intended application. Paint adhesion tests should be conducted to assure that the mechanical adhesion and appearance of the paint is not adversely affected over the stained areas.

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