# Wet storage staining on galvanized steels

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The atmospheric corrosion rate of zinc is determined by the physical and chemical properties of the 'oxide' film formed on its surface during the corrosion process.

Zinc is very reactive metal. It exhibits a low atmospheric corrosion rate in non-marine environments only because a continuous passive film forms on the surface. This passive film is essentially zinc carbonate which forms following a series of sequential reactions, initially involving atmospheric oxygen, then water and finally atmospheric carbon dioxide.

A key part of the passive film formation mechanism is that the surface needs to dry in air in order to develop and maintain this passive layer. It is during the drying part of a rain cycle that the zinc carbonate passive film develops. Atmospheric wet-dry cycles are therefore necessary for zinc to develop passivity. It is the formation of this passive film that results in the dulling of zinc coatings over time, and the reduction in corrosion rate with time.

When galvanized steel becomes wet while in coil form, or as packed tube, storage staining can result. Storage stain (white rust) is simply the chemical compound zinc hydroxide which forms when zinc is in contact with moisture. The zinc hydroxide has a voluminous white appearance that has resulted in it being commonly referred to as 'White Rust'.

The surface does not convert to a zinc carbonate passive film because the tightly packed sheets or tubes are not freely exposed to carbon dioxide-containing air, so the protective zinc carbonate film never gets a chance to form. Since the corrosion reaction continues to proceed as long as the surfaces are wet and starved for oxygen and carbon dioxide, a large accumulation of zinc hydroxide can form.

The extent of the damage is primarily dependent on the exposure time to moisture, the temperature that is experienced during storage, and the presence of accelerating corrosive agents such as chloride-containing salts. However, due to the significant volume increase from zinc metal to zinc hydroxide, the extent of corrosion may appear more serious than it actually is. In fact, most white rust can be easily removed with no significant long term damage to the underlying zinc coating.

All stages of the supply chain from manufacturer to end user have a role in avoiding white rust formation. The following is a summary of common issues and prevention measures.

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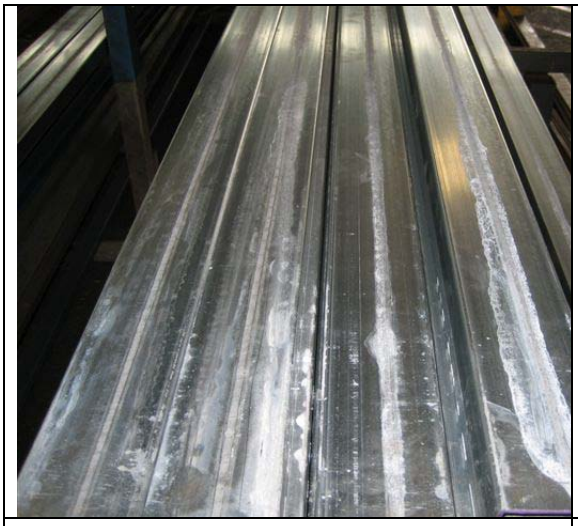
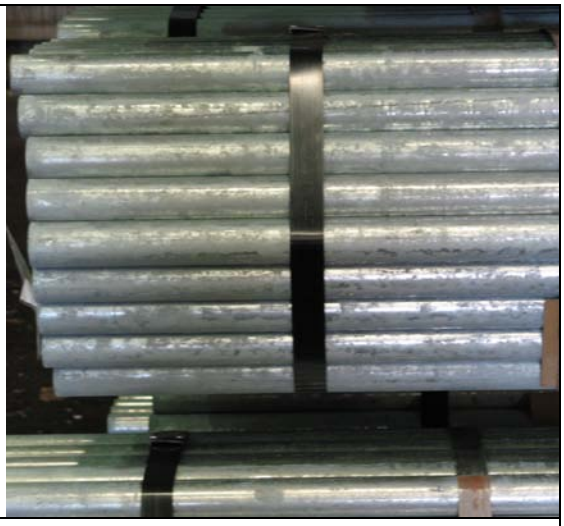
|  |  |
| *White rust on galvanized tube. In this case the pack had been wet in transit and the tubes were not separated and dried. The inside of the pack remained wet for an extended period, resulting in localised white rust.* | *White rust on imported galvanized pipe. In this case, pipe was packed into a container using wet dunnage prior to sea transport. The high humidity within the container resulted in white rust over the entire pipe surface.* |

Galvanizers always apply some form of white rust prevention to freshly galvanized products, usually a passivation treatment. Passivation treatments aim to stabilise the reactive zinc surface through the formation of a passive film. Historically, passivation treatments involved hexavalent chromium, which is now being phased out in favour of less hazardous silane or trivalent chromium treatments. Some manufacturers also apply a thin organic top coat over the passified surface.

It should be noted that passivation treatments reduce the reactivity of the zinc surface, thereby lowering the propensity for white rust formation, but won't prevent white rust formation in the event of improper storage. For example, tubular products in pack form are extremely sensitive to white rust formation as capillary action can draw moisture to the middle of a pack where it will remain wet for extended periods. Wet packs of galvanized must be opened and allowed to dry to prevent white rust formation.

Bulk transport involves transport of full truck loads of bundled product delivered from one location to another. Transport is often across large distances and changing weather conditions. As galvanized product in pack or coil form is highly sensitive to water damage, water ingress must be prevented. Key measures required during bulk transport include:

1. Always tarp the load. Tarps should be applied in such a manner to prevent the ingress of water from rain and/or road spray;
2. Apply secondary cover, such as light-weight plastic, during exposure to inclement weather;
3. Keep tarps dry and do not apply a wet tarp to a load;

4. Only use dry/seasoned timber (or timber with rubber surfaces) dunnage;
5. Do not load wet product; and
6. Be aware of the potential for condensation during sudden temperature changes and high humidity. The use of a desiccant to absorb condensation is strongly recommended for long haul journeys and containerisation.

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| *Inadequate tarping during local transport is a major cause of wet galvanized product and associated white rust.* | *Covered prairie wagons provide excellent protection from water ingress* |

Dry storage of bulk galvanized product is particularly important to avoid white rust. For example a wet pack of tube in storage can remain wet for days, weeks or even months before being opened. Under these circumstances white rust is unavoidable.

Warehouse maintenance and vigilance are required to identify and remedy leaking roofs before they cause damage to product. Common causes of white rust during warehouse storage are:

1. Leaking roof particularly from skylights, smoke vents and internal box gutters;
2. Water ingress from broken louvers and open doorways during high winds and storms; and
3. Condensation, either dripping from the underside of a steel roof or forming directly on the galvanized products. The Australian Building Codes Board[2] has published an informative handbook in order to provide additional information, detail and advice relating to the management of the risk of condensation in buildings.

*Condensation on the impermeable foil sarking and steel purlins*

Sometimes it is not possible for a distributor or end-user to store bulk galvanized product in a warehouse and so exposure to the elements is unavoidable. Under these conditions galvanized products with a polymer coating will exhibit greater resistance to white rust than those with a passivated coating. Best practice for bulk tubular products stored externally is to keep the pack raised from the ground and separated with dunnage to prevent packs being placed on wet soil or decaying vegetation and to provide free access of air to all parts of the surface.

The packs should be inclined and oriented to prevent water collecting on the surface. Ideally, spacers should be placed between the individual layers of tube to eliminate contact between zinc surfaces and prevent crevices for moisture entrapment. It is important that resinous wood not be used for dunnage or spacers as the resin itself can initiate staining. Wood used should be seasoned/dry and untreated with preservatives or fire retardant chemicals. Galvanized sections should never be stored in contact with cardboard or other paper products, cinders, clinkers, unseasoned timbers or treated pine.

In the event of white rust forming, the affected objects should be removed from the high moisture environment and arranged so the zinc coating can dry rapidly. Removing the free water with a clean, dry cloth prior to air drying can reduce the amount of white rust that forms. Once dry, most stains can be easily removed by brushing with a stiff nylon brush (scotch-brite) and if required by rubbing with a rag soaked in methylated spirits.

If a nylon brush will not remove the white rust, a cleaning product should be used. Applied with a nylon brush, there are several off-the-shelf products that are effective in removing white rust. White vinegar is a common cleaning product often recommended by galvanizers for white rust removal and will successfully remove light to moderate white rust without damaging or dulling the surface. Other proprietary solutions such as Henkel Deoxidine 624 or CLR Clear can also be used.

Severe white rust is characterised by very heavy hydroxide deposits and individual tubes or sheets may be stuck together. The areas under the oxidised area may appear almost black or show signs of red rust. A coating thickness check after first removing the white rust deposit will determine the extent to which the galvanized coating has been damaged.

Remediation would first involve the removal by power tool cleaning to a class 1 surface of the affected area. Following cleaning, the corrosion protection should be reinstated by the application of at least two coats of Organic zinc-rich primer complying with AS/NZS 3750.9, with each coat having a Dry Film Thickness of at least 50 microns. When colour matching is required, Galmet DuraGal Silver paint may be applied over the zinc rich paint.

References


1. GalvInfoNote 3.2, Rev 1.1 Mar-09
2. Information Handbook: Condensation in Buildings, The Australian Building Codes Board


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