The Valspar Corporation
PO Box 1461
Minneapolis, MN 55440
USA
Phone: 1-612-851-7000

www.valsparindustrialmix.com

Substrate: Zinc - Galvanized Steel TI – S 2 / USA

General Information

Zinc is produced as sheet metal for further processing or it is used as an anti-corrosion metal coating which can be applied to steel in different ways. Following appropriate cleaning, zinc can be coated with paints and lacquers according to the manufacturer's instructions. Zinc is not magnetic, and as such, when measuring any (paint) coating thickness on galvanised steel surfaces through the use of electromagnetic or magnetic measuring instruments, the thicknesses of the zinc layer and the coating layer are added.

According to the electrochemical series (see information electrochemical series) the steel is protected by the less noble zinc. Zinc corrodes like all common metals, however, a form of limited protective topcoat is created. Zinc and zinc coatings are not stable below acidic pH=5 and at alkaline effects over pH=12,5. Likewise the atmosphere has a great influence on the stability. Depending on local circumstances larger amounts of aggressive air pollutants, such as sulphuric dioxide, carbon monoxide may be present. The combined effect of moisture creates acids which react to form water-soluble zinc salts, which in turn, accelerate the degradation of the zinc (see the ISO12944 chart below).

The appearance of zinc surfaces can be silver metallic shiny, and dull grey go to matt. Depending on the steel material and the type of galvanising, zinc flowers are visible on the surface. Zinc surfaces corrode – forming white/transparent corrosion products. White rust can develop when freshly galvanised surfaces come in contact with moisture, such as rain, fog and condensation formation. White rust is not a quality defect; it is only due to improper wet storage. Fresh hot dipped components should be stored in dry well ventilated area, because after a few days a protective topcoat develops, the so-called zinc patina, which prevents white rust.

The galvanized workpieces are passivated, oiled or delivered without surface treatment so this should be performed in duplex system, carefully cleaned and prepared.
Duplex systems are composed of zinc or a zinc coating on steel and organic coating. The selection of the coating system is based on the stress and subsequent use of the component. Coating materials must not become brittle or lose adhesion by reactions with the zinc.

Corrosion rate of zinc layers (EN ISO 12944):

Corrosivity category	Typical Environments		Average Zinc mining
	Exterior	Interior	
C1 negligible		Heated buildings with clean atmospheres; Offices, schools, shops, hotels	under 0.1µm/year
C2 slightly	Low level of pollution, mostly rural areas	Unheated buildings, where condensation may occur; depots, warehouses, sports hall	0.1 till 0.7µm/year
C3 moderately	City and industrial atmospheres, moderate sulphur dioxide pollution. Coastal areas with low salinity.	Production rooms with high humidity and some air pollution; breweries, dairies, food processing plants	0.7 till 2.1µm/year

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C4 strong	Industrial areas and coastal areas with moderate salinity.	Chemical plants, swimming pools, coastal shipyards above sea level	2.1 till 4.2µm/year
C5 – I very strong (Industrial)	Industrial areas with high humidity and aggressive atmosphere.	Buildings or areas with almost permanent condensation and high pollution.	4.2 till 8.4µm/year
C5 - M very strong (Sea)	Coastal and offshore areas with high salinity.	Buildings or areas with almost permanent condensation and high pollution.	4.2 till 8.4µm/year

Popular types of zinc galvanizing steel

1.1 Hot-dip zinc coat – batch galvanizing:

Batch galvanizing is the hot galvanizing of steel parts and larger structural components. Following a pre-treatment, blanks or finished components are immersed in a hot zinc bath. This full immersion technique ensures that hard-to-reach areas, too, are fully coated, such as internal pipe surfaces and unique profile sections. Edges and corners should be rounded, hollow sections have to be in place drilled ø10 mm and more so that the liquid media can drain away completely during processing.

Procedure for the parts for batch galvanizing:

Attachment:	Parts to be galvanised are aligned at the optimum angle on devices attached to allow for a perfect galvanization.
Cleaning:	Components are cleaned in a degreasing bath. Normal degreasing agents usually are aqueous alkaline or acidic products.
Pickling bath:	To create a clean surface for the steel components a pickling bath is used. As rule, the bath is charged with diluted hydrochloric acid. Rust, mill scale and scale are effectively removed.
Rinse:	After pickling the workpieces are cleaned with plain water in two rinsing processes
Fluxing:	A flux bath is used to create a thin salt film on the surface. When the workpiece is immersed in the zinc bath the flux layer promotes the reaction between the steel surface and molten zinc.
Drying:	Galvanised steel parts are dried.
Galvanising:	The pre-treating steel parts are immersed in a 450°C hot, liquid zinc melt. Their zinc contents is accordance with DIN EN ISO 1461 at least 98.5%. During the hot-dip process and as a result of mutual diffusion, various iron-zinc layers form on the surface. When pulling the workpiece out from the molten bath a glossy, pure zinc layer has formed on the components.
Cooling:	The hot-dip galvanised components for cooling is usually air-cooled, this helps to treat defects such as: zinc runs, zinc splash.

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The Iron-Zinc-Layer has a thickness of 40-55µm, and the pure zinc coating is 30-40µm. The total zinc protective layer is about 70-86µm (DIN 50 976 at least 50-86µm).

1.2 Galvanising a steel strip – Senzimir process:

A cold-rolled steel strip (0.4 till 4.0 mm thick – 400 to 1800 mm wide) is wound into a coil. The length of a steel strip coils can be up to 3,000 m. The steel strip process consists of the continuous furnace – holding zone – cooling zone – melt bath – zinc order/distribution – cooling.
In the continuous furnace in the first stage the strip is heated at 450-650°C. Here, the oxidative purification of the material takes place, and other residues from the cold rolling process are also removed. In the reduction zone and holding, the steel strip is continuously annealed at 800°C. This process defines and adjusts the desired mechanical properties of the material. The strip is than cooled and dipped into the molten bath at a zinc temperature of 450-480°and reversed on a pulley for the return motion. A direct air jet strips excessl liquid zinc from the strip surface. The zinc coating is determined by the belt speed, and the blow-off nozzle width. After cooling, the strip is rolled into a coil for further processing. About 0.2 – 0.5% aluminium are added to the zinc bath, thus the bright glossy coating, creating a “spangle”. Bbelt speeds are up to 220 m/minutes, depending on the bandwidth.
The usual layer thicknesses of zinc coatings in this process are between 5 till 20µm. This is specified in the rule for basic weight in g/m (usually 100 to 275 g/m² on both sides, 100 g/m² correspond to approximately 7µm on one side).
Further processing of the galvanised steel strip materials will come later (punching, drilling, sawing, welding, etc.) It must therefore be expected that processing surfaces which are attached after the galvanising process, are not-galvanised. Possible corrosion of such spots must be expected. Appropriate use us of primer before the coating will prevent corrosion.

2.1 Electrolytic zinc coating / galvanising:

The components to be treated are immersed in a zinc electrolyte, whereby the component functions as a cathode in a solution. Pure zinc parts are used for the anodes. With this type of zinc coating, the zinc coat develops acc. to strength and duration of the electric current. Zinc is deposited as a film on the whole workpiece. Normally a zinc coating measures 10-20µm. Stronger film thicknesses up to 50µm are possible. Workpieces which are uniformly galvanised keep their original hardness, they can be bent easier because they have no inter-metallic alloy coatings such as hot dip galvanised materials. Passive layers are formed up to 120°C. As with galvanised components any contact with acids and alkaline conditions should be avoided as they promote corrosion. After cleaning, yellow and blue passivated substrates can easily be (spray) painted.
In the automotive industry among other zinc coatings from 2,0 till 7,5µm can be applied for the protection of corrosion on steel sheets. The metal surface is then contacted with several lacquer coats with thicknesses ranging from 60 to 130µm.

3.1 Zinc spraying – electric arc (mechanical zinc plating).

In the zinc spraying process, a zinc wire is melted by flame or electric arc. Here, the liquid zinc is applied onto the blasted / cleaned surface by compressed air. The still liquid zinc forms a porous layer on the surface, providing similar corrosion protection as a galvanised object. In contrast to hot-dip galvanising the material is subjected to low thermal stress and is not deformed in the process. However it should be noted that folds, hollow sections and hard-to-reach areas are not fully zinc coated or even not at all.
If the zinc coating reaches a thickness of about 100µm, the zinc coating it will absorb an unusually large amount of primer or paint material. Users should calculate for a greater amount of primer or paint.

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4.1 Zinc laminated coating.

In a spray or dip-spin method, small zinc and partially aluminium flakes are applied to the workpiece and baked at 250-350°C, commensurate with the specific use of the final product. The layer thickness is in a coating operation only 4-5µm and the protective layer is porous. For this reason, the process is normally carried out twice.

Preparation of a zinc surface

Careful preparation by removing dirt, grease, oil deposits, corrosion products and old coatings will contribute to improve the adhesion.

For cleaning surfaces the zinc ammonia alkaline wetting agent can be used. Prepare 10 litres of water with 0.5 litres of aqueous ammonia (ammonium hydroxide 25%) and 1 capr dishwashing liquid as a wetting agent in a container. The cleaning liquid is to be used with a cleaning pad/abrasive pad as Scotchbrite (not steel wool) applied to the zinc surface to be cleaned and sanded thoroughly forming a wet foam. After a short exposure the surface is thoroughly cleaned with water.
Similarly, appropriate cleaning fluids can be used. Observe the manufacturer's instructions. Steam cleaning with special conditioning agents is also suitable for cleaning. After rinsing the surface with water, it should be well dried, with special attention to tight spaces, gaps and voids. Otherwise is there a danger of renewed corrosion and damage to the coating.

One type of jet blasting is **"sweeping"**. This technique will prepare the zinc surface to be treated in a smooth and careful manner. Caution when using this beam blasting technique: Use of a non-metal abrasive, a blasting pressure of 3-4 bar, a beam angle of 30-45°, in a distance of 0.3 – 0.5 meters.

Warning: Sweep blasting may damage the zinc surface!