HOT DIP GALVANIZING GUIDE
for designers, technicians and customers

Bordignon Group
Total Quality Company
Zincheria Seca
Zincheria Valbrenta
Zincheria S.A.
DMW Logistic
Over the years, this regularly updated guide has become a major consultation tool for designers, technicians and customers. A commitment of all the personnel of Zincheria Valbrenta, Zincheria Seca and DMW Logistic.

A major contribution to the growth of the culture of hot-galvanized steel.

Giuseppe Bordignon
President

Bordignon Group
Total Quality Company
HOT DIP GALVANIZING FOR ENVIRONMENT SUSTAINABILITY
Steel is the most recycled building material. In Europe, its re-use achieves levels of 87%. Once removed, large galvanized steel sections, such as motorway barriers, are completely recycled.

ZINC IS A TOTALLY RECYCLABLE NON-FERROUS METAL
In the galvanizing process, no material is lost, unlike spray applications or other types of coating. What is more, zinc ashes (surface oxidisation of galvanizing bath) and zinc bottom dross (mix of zinc and iron deposited in the tanks) is in part recycled by the same galvanizing facility or transformed for various applications such as additives for rubber, cosmetics and electronic components.

ZINC RESERVES
Zinc is the 27th most common element in the earth’s crust and abundant quantities exist in the world. Thanks to the discovery of large deposits, global reserves have increased considerably.

ZINC IS LIFE
Zinc helps us to lead an active and healthy life style. Among all the vitamins and minerals, zinc produces the most marked effect on our entire immune system. Zinc improves our memory and our mind and also reduces tiredness and changes in mood. Zinc is essential for favouring the growth of new-born babies, children and teenagers.

GALVANIZED STEEL, AN ESSENTIAL INSTRUMENT IN LIFE CYCLE THINKING
Hot dip galvanizing provides long-term protection against corrosion without maintenance, even in the harshest environments. New community policies consider hot dip galvanized steel as a primary material in green procurement guidelines and in the transparency processes adopted in Life Cycle Assessment. It is a crucial instrument for the implementation of an Integrated Product Policy, and the main operating instrument of “Life Cycle Thinking”.

Zinc is environment friendly
How to obtain a top-quality galvanized product.

INTRODUCTION

The document was produced to enable designers to achieve top-quality hot dip galvanizing process standards. This is made possible by optimizing the suitability of structures to the galvanizing process. To achieve this goal, it is most important to bear in mind both the design phase and the choice of steel. This way, critical situations which lower the quality standard of the structure itself are reduced to the utmost.

WE ALSO GALVANIZE LARGE SIZES

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WE ALSO GALVANIZE LARGE SIZES
Weight: up to 28 tonnes - Length: up to 19 m

Our tank is 16.5 m long, 2.8 m wide and 3.4 m deep.
This dimensional ratios permit treating large parts (max galvanizable lengths: 19 m with weight of up to 28,000 kg) with high quality standard.

1A Corrosion
Metals are the result of the transformation of oxides and salts, present in nature, by means of mechanical operations that convey them to a higher energy state.
One of the best ways of combating corrosion is to coat the metal with a sacrificial material able to react more slowly to corrosion and protect the underlying metal.

2A Hot dip galvanizing
Hot dip galvanizing is a process that permits the formation of a zinc coating on steel objects through a hot dip process.
This type of protection permits the formation of a layer of intermediate zinc-iron alloy with greater hardness and strength properties than those of iron.

<table>
<thead>
<tr>
<th>PHASE</th>
<th>FORMULA</th>
<th>CONTENT</th>
<th>CRYSTALLOGRAPHIC STRUCTURE</th>
<th>DENSITY (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ζ Zeta</td>
<td>Zn</td>
<td>max 0,003</td>
<td>Body-centred hexagonal</td>
<td>7,14</td>
</tr>
<tr>
<td>δ Delta</td>
<td>FeZn₁₃</td>
<td>5,7 - 6,3</td>
<td>Monoclinic</td>
<td>7,18</td>
</tr>
<tr>
<td>η Eta</td>
<td>FeZn₁₀</td>
<td>7,0 - 11,5</td>
<td>Body-centred hexagonal</td>
<td>7,24</td>
</tr>
<tr>
<td>γ Gamma</td>
<td>Fe₅Zn₂₁</td>
<td>21,0 - 28,0</td>
<td>Face-centred cubic</td>
<td>7,36</td>
</tr>
</tbody>
</table>
PRODUCT DESIGN

3A Vents and drains

The first thing to be addressed is making the vents and drains. When designing hollow bodies, big enough holes must be made, in the right positions, to allow the flow of both air and zinc inside the cavity so as to obtain a coating even inside the product.

SHEET 1:
Alternative projects for making holes in profiles fastened to base plates

VENTS

SEZ A-A

DRAIN HOLES

SEZ B-B

SEZ B'-B'

SEZ B''-B''

NOTE:
The vent and drain holes on each side of the product should be diagonally opposite. The best option should be established by mutual agreement between the designer and the galvanizer.
The tubes with ends closed by plates must have openings which are at least equal to 1/15 of the tube section. By way of example, the table shows some examples relating to the size and number of holes required to ensure correct galvanization.

All holes with the diameter less than 8 mm, tend to clog due the zinc density.

<table>
<thead>
<tr>
<th>SQUARE AND RECTANGULAR TUBES</th>
<th>HOLE DIAMETER mm</th>
<th>ROUND TUBES</th>
<th>HOLE DIAMETER mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 x 50</td>
<td>14</td>
<td>42</td>
<td>10</td>
</tr>
<tr>
<td>50 x 100</td>
<td>20</td>
<td>88</td>
<td>22</td>
</tr>
<tr>
<td>100 x 100</td>
<td>30</td>
<td>100</td>
<td>26</td>
</tr>
<tr>
<td>100 x 150</td>
<td>36</td>
<td>139</td>
<td>36</td>
</tr>
<tr>
<td>100 x 200</td>
<td>42</td>
<td>165</td>
<td>42</td>
</tr>
<tr>
<td>150 x 200</td>
<td>50</td>
<td>177</td>
<td>46</td>
</tr>
<tr>
<td>200 x 200</td>
<td>60</td>
<td>193</td>
<td>50</td>
</tr>
<tr>
<td>200 x 300</td>
<td>70</td>
<td>244</td>
<td>62</td>
</tr>
<tr>
<td>200 x 400</td>
<td>80</td>
<td>323</td>
<td>82</td>
</tr>
<tr>
<td>300 x 400</td>
<td>100</td>
<td>406</td>
<td>104</td>
</tr>
<tr>
<td>400 x 400</td>
<td>120</td>
<td>457</td>
<td>120</td>
</tr>
<tr>
<td>500 x 500</td>
<td>150</td>
<td>500</td>
<td>130</td>
</tr>
<tr>
<td>500 x 700</td>
<td>180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600 x 800</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>800 x 1000</td>
<td>260</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Example of part where the central crosspiece was without vent hole.

If the job is not perfectly performed, problems like this could arise.
**3B Reinforcement elements and head plates**

*Important:*
The pictures show technical solutions for allowing adequate zinc drainage.

*Important:*
avoid “dead” areas when zinc could stagnate.

Examples of assembled elements provided with the proper chamfered angles for the right air and zinc exhaust.

Ware must be weld end-plates make the necessary holes to allow a complete drainage of zinc/air.
If an internal diaphragm is used to stiffen a hollow body, make sure the reinforcement corners are well chamfered. In the case of larger hollow structures, ensure that the reinforcement element, beside the chamfered corners, also has a central hole.

Drainage holes must be seen from outside for any pipes to permit a visual check.
3C Superimposed plates

**Important:** the coupling of two flat surfaces must include at least one air vent because the presence of humidity inside this could lead to explosions in the galvanizing tank, creating safety problems for the operators.

Example of plates coupled with circular welding, where the contained inner humidity, by transforming into steam, has caused an explosion with consequent part deformation.

**Important:** in case of bad drilling, the holes will be made in our facility by using an oxyacetylene flame due to the difficulty of using a pillar drill or other specific equipment on an assembled product. Consequently, if you have any doubts concerning the designing of products suitable for galvanizing, please contact our Technical Department.
3D Anchor points

Remember to provide lifting and anchor points as the galvanizer will have to lift and rotate your construction. If the part is less than 2.8 m high, just one anchor point will be enough, otherwise longer parts require two points.

EXAMPLES OF BINDING

NO

On these parts the mark of the wire remains after galvanizing.

YES

The hole permits anchoring the part and reducing the contact surface. This means the mark will also be reduced after galvanizing.
THE CHOICE OF STEEL

4A Chemical composition of steel

Steel is an alloy made up mainly of iron (Fe) and carbon (C) and other elements, the quantity and type of which intervene in the formation and growth of the zinc protection layers. In metallurgy, it is known how silica (Si) and phosphorus (P) are elements normally added to the steel to obtain certain mechanical properties. At the same time, these elements act on the reactivity of the galvanizing process: high concentrations produce layers thicker than normal but which are very fragile. Elements that produce the same effects are, for example, sulphur (S), manganese (Mn), chrome (Cr), nickel (Ni), niobium (Nb), titanium (Ti), vanadium (V). These elements considerably increase the reaction speed of the zinc with the steel and block the normal formation of protective layers. Nevertheless, at normal concentrations, the effect is completely negligible.

From the point of view of the galvanizing process reactivity, steels, which require coatings with high quality standard characteristics, are split into four categories, distinguished by different percentages of silica and phosphorus.

FIGURE 1: Graphic representation of the classes of steels for galvanizing according to UNI EN ISO 14713-2:2010 standard
TABLE 1: Characteristics of the classes of steels according to UNI EN ISO 14713-2:2010 standard.

<table>
<thead>
<tr>
<th>COATING CHARACTERISTICS</th>
<th>UNI EN ISO 14713 STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category A</strong></td>
<td></td>
</tr>
<tr>
<td>Si ≤ 0.04%</td>
<td></td>
</tr>
<tr>
<td>P &lt; 0.02%</td>
<td></td>
</tr>
<tr>
<td>For cold rolled steels</td>
<td></td>
</tr>
<tr>
<td>these characteristics</td>
<td></td>
</tr>
<tr>
<td>are seen when the</td>
<td></td>
</tr>
<tr>
<td>composition of the</td>
<td></td>
</tr>
<tr>
<td>steel satisfies the</td>
<td></td>
</tr>
<tr>
<td>formula: Si + 2.5 P ≤</td>
<td></td>
</tr>
<tr>
<td>0.04%</td>
<td></td>
</tr>
<tr>
<td><strong>Category B</strong></td>
<td></td>
</tr>
<tr>
<td>0.14 &lt; Si ≤ 0.25%</td>
<td></td>
</tr>
<tr>
<td>P &lt; 0.035%</td>
<td></td>
</tr>
<tr>
<td><strong>Category C</strong></td>
<td></td>
</tr>
<tr>
<td>0.04 &lt; Si ≤ 0.14%</td>
<td></td>
</tr>
<tr>
<td><strong>Category D</strong></td>
<td></td>
</tr>
<tr>
<td>Si &gt; 0.25%</td>
<td></td>
</tr>
</tbody>
</table>
AESTHETIC EFFECTS PRODUCED BY THE CHEMICAL COMPOSITION OF STEEL

The photographed aesthetic effects depend on the chemical composition of the material supplied by the customer, which cannot be changed during galvanizing.

Two parts identical in shape but with different chemical composition galvanized at the same time.
4B Rolling defects

If the material is not correctly rolled, a very rough surface could ensue caused by the lifting of iron flakes.

(A) Rolling defect on the plate.
(B) Regular galvanizing on the tube.

On part (A) Coupled material showing a rolling defect. On part (B) galvanizing is regular.
PROBLEMS AFFECTING GALVANIZED PARTS

5A Colour stains or wording on parts

The use of marker pens, paints or anti-spray products containing silicones or oils creates a protective film that prevents the acid from cleaning the surface and welding joints properly. In this case, galvanizing will appear irregular and the part will therefore have to be restored or reworked.

EXAMPLES OF ROUGH MATERIAL WITH WORDING
5B White and grey stains

If white or grey stains appear on the product surface, these are mainly excess zinc oxides and hydrates which form in particularly damp conditions during transport or storage. These stains dissolve naturally by means of exposure in the environment and do not affect the galvanizing function. If necessary, to ensure better appearance, the stains can be brushed off. Recent galvanizing standards concerning corrosion indicate that the formation of any damp-retention stains that form during storage in damp environments does not represent a ground for the non-acceptance of the product.

5C Welding joints

The zinc coating adheres to the welding joint as it does to the rest of the steel. In some cases, the different chemical composition of the welding areas could result in different thicknesses and appearances.
THE REFERENCE STANDARD FOR HOT DIP GALVANIZING

6A Coating properties

The standard to which our company makes reference is UNI EN ISO 1461 “Hot dip galvanized coatings on fabricated iron and steel articles”. The standard provides all information concerning the galvanized material specifications.

COATING PROPERTIES

1. APPEARANCE
The formation of lighter or darker grey areas (e.g. the cell design of dark grey areas) or a lack of surface uniformity must not lead to rejects.
Stains caused by storage in damp environments (white or dark products due to corrosion, mainly zinc oxides formed during storage in damp places after galvanizing) must not lead to rejects, as long as the thickness of the coating is greater than the minimum specified thickness.
No zinc clots and ashes must be allowed when these could affect the use for which the hot dip galvanized article is intended or its resistance to corrosion. When special requirements exist (e.g. when the zinc coating has to be painted), a sample must be produced on request.

2. THICKNESS
Coatings applied by hot dip galvanizing are intended to protect iron and steel products from corrosion. The duration of the period of protection against corrosion by the coating (both grey and light colour) is proportionate to the thickness of the coating.
In case of extremely aggressive conditions, coatings can be requested with greater thicknesses than those specified. More consistent coating specifications must be subject to an agreement between the galvanizer and the customer.

Minimum coating thicknesses on non-centrifuged samples.

<table>
<thead>
<tr>
<th>ARTICLE AND THICKNESS OF MATERIAL</th>
<th>LOCAL COATING THICKNESS (minimum) μm</th>
<th>AVERAGE COATING THICKNESS (minimum) μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel &gt; 6 mm</td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>3 mm &lt; Steel ≤ 6 mm</td>
<td>55</td>
<td>70</td>
</tr>
<tr>
<td>1.5 mm &lt;= Steel ≤ 3 mm</td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>Steel &lt; 1.5 mm</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>Iron castings ≥ 6 mm</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>Iron castings &lt; 6 mm</td>
<td>60</td>
<td>70</td>
</tr>
</tbody>
</table>
6B Corrosion resistance of hot dip galvanized steel

<table>
<thead>
<tr>
<th>Code</th>
<th>Corrosivity class</th>
<th>Aggressivity environment</th>
<th>Average consumption of zinc (µm/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Inside: dry</td>
<td>Very low</td>
<td>&lt; 0,1</td>
</tr>
<tr>
<td>C2</td>
<td>Inside: occasional condensation Outside: rural area exposed internal land</td>
<td>Low</td>
<td>0,1 to 0,7</td>
</tr>
<tr>
<td>C3</td>
<td>Inside: high humidity, light pollution Outside: Internal lend area or urban area, coastal temperate</td>
<td>Medium</td>
<td>0,7 to 2</td>
</tr>
<tr>
<td>C4</td>
<td>Inside: swimming pools, chemical plants, etc. Outside: Industrial area or internal land, coastal urban area</td>
<td>High</td>
<td>2 to 4</td>
</tr>
<tr>
<td>C5</td>
<td>Outside: Industrial area with high humidity or coastal area high salinity</td>
<td>Very high</td>
<td>4 to 8</td>
</tr>
<tr>
<td>Im2</td>
<td>Sea water in temperate regions*</td>
<td>Very high</td>
<td>10 to 20</td>
</tr>
</tbody>
</table>

* it means immersion in sea water in the temperate regions of Europe. These conditions for zinc, are less aggressive than in tropical marine waters where the corrosion rate is higher.

To predict the corrosion rate of the zinc layer we must refers to the UNI-EN-ISO 14713 which provides information on the average annual loss of coating thickness, after identifying the category of corrosivity, or aggressiveness of the environment. The following table shows the values of average annual loss of thickness of the zinc as a function of six different environments of exposure.
Projects completed
Projects completed
WORKING AROUND THE WORLD

Bordignon Group
Total Quality Company
zincherie.com