Instructions for material selection, structure preparation, and quality hot-dip galvanizing

1. Connection with Other Standards

Elements must be prepared for galvanizing in accordance with the standard:
SRPS EN ISO 14713-2:2020 Protection against corrosion of iron and steel in structures
Zinc coatings — Guidelines and recommendations for corrosion protection of iron and steel structures — Part 2: Hot-dip zinc coating.

Metal-Cinkara d.o.o. performs hot-dip galvanizing by immersion in accordance with the standard:
ISO 1461:2022 Hot-dip galvanized coatings on fabricated iron and steel articles — Requirements and test methods

Structure Dimensions

The maximum dimensions of the structures are limited by the size of the galvanizing bath:

L x W x H = **13750** x **1700** x **3200** (mm)

The maximum weight of a structural element can be 10,000 kg.

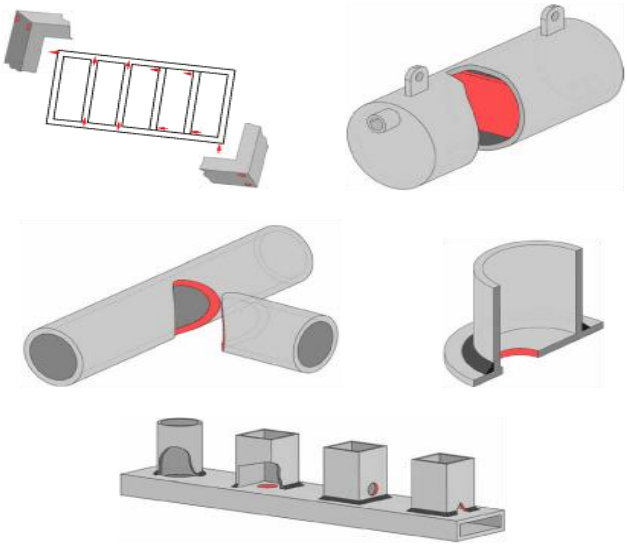
2. Appearance (Cleanliness) of Elements and Structures for Galvanizing

There must be no residues after sandblasting (steel shot, dust) inside pipes and corners of the structure.va za zavarivanje, parafina, katrana i ostataka prethodnih površinskih zaštita.
U cevima i uglovima konstrukcija ne sme biti ostatka nakon peskarenja (čelične kuglice, prašina).

3. Openings

Each element or structure must have openings (drilled holes, cutouts, etc.) in accordance with ISO 14713-2 (2020) standard for:

a) Air outlet and zinc inlet from closed pipes and corners. These openings must be located at the extreme upper and lower points, directly adjacent to the weld location.



Images 1, 2, 3 - Examples of opening layouts on pipe structures

All technological openings on the pipe structure must be visible. If the structure has **invisible (hidden) openings** for zinc entry and air exit, **hot-dip galvanizing is not allowed**.

Instructions for material selection, structure preparation, and quality hot-dip galvanizing
Structures **with hidden openings** **will not be accepted for processing** at the Metal Galvanizing plant.

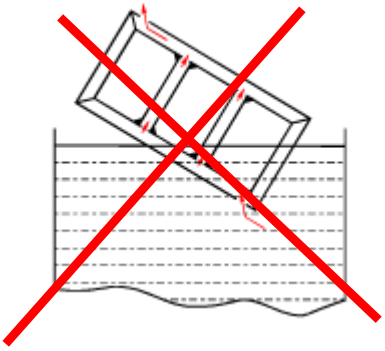
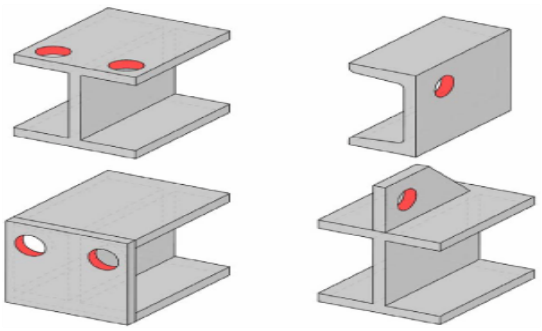


Image 4 – **Invisible (hidden) openings** on the pipe structure are **not allowed**

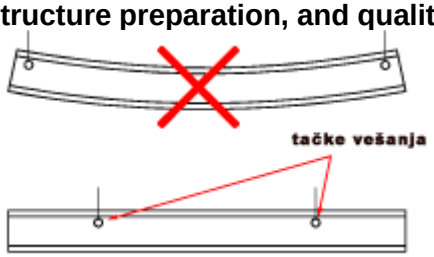
The smallest opening sizes are presented in Table 1:

Steel pipes - measurements in mm			**Smallest □ opening in mm**
○	□	▭	Openings at both ends of the pipe must be immediately adjacent to the weld location.
15	15	20 x 10	6
20	20	30 x 15	8
30	30	40 x 20	10
40	40	50 x 30	12
50	50	60 x 40	16
60	60	80 x 40	20
80	80	100 x 60	20
100	100	120 x 80	25
120	120	160 x 80	25
160	160	200 x 120	32
200	200	260 x 140	32

b) Hanging
The structure can be hung from specially welded lugs designed for this purpose. For simple elements up to 2500 mm in length, a single hanging point is sufficient, located at least 20 mm from the edge. For longer structures and elements, two or more hanging points are required,positioned at least 1.5 m from the edge to prevent bending of profiles longer than 8 m.



Images 5-6: Hanging holes for I and U profiles



Images 5-6-1: Hanging holes for a long profile

c) Ventilation

Ventilation holes (ventilators) must be made in closed surfaces between two plates that are fully welded together to prevent explosions during galvanizing. The hole can be made in just one plate or through both.

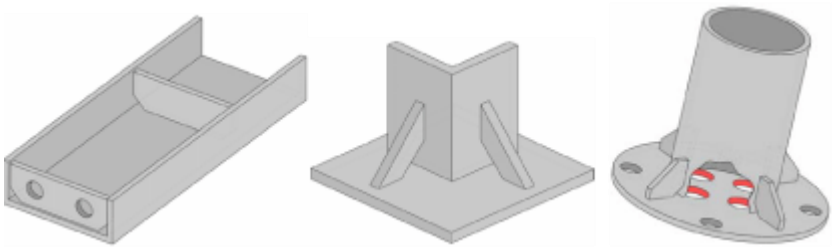


Image 7 – Ventilation of ribs and plates on U and I profiles

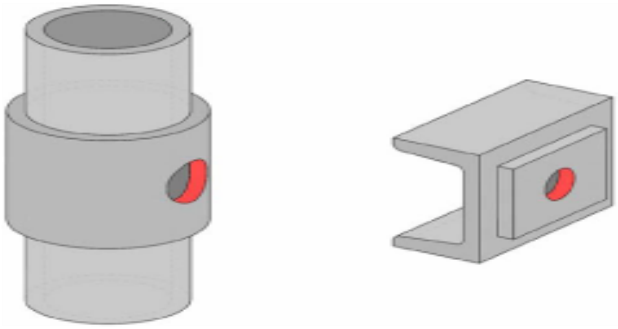


Image 8 – Ventilation of closed shapes

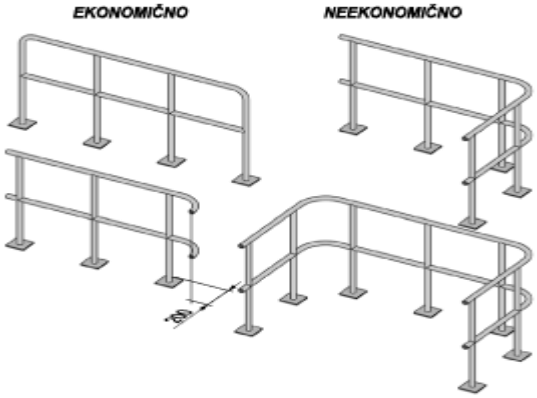


Image 9 – Cost-effective design of fences for galvanizing

4. Joints and Connections

When joining two plates, there is a risk of acid leaking later from cavities due to incomplete zinc filling. Joints must be watertight and free of debris and welding droplets. Electrodes should contain as little silicon as possible. Riveted joints must not be made with rivets of non-ferrous metals.

Soldered joints:

Soft soldered joints cannot be galvanized. Hard soldered joints need to be tested..

Threaded joints:

Threads (nuts, bolts) must be re-cut after galvanizing; therefore, it is better to account for the zinc coating thickness (50 – 200 µm) in the tolerances beforehand. Prior to galvanizing, it is also possible to protect bolts and nuts with a special coating.

Hinges and Other Sliding Elements

These parts (e.g., round tubes or profiles within the assembly) must be supplied separately by the client and assembled only after galvanizing. When designing, tolerances for the zinc coating thickness must be considered. Hinged parts fitted onto the same structure with a single hole must be oriented in the same direction or be open on both sides.

5. Cold Forming and Forging

The sheet surface must be free of scratches or patterns caused by cold forming. Such defects become very visible after galvanizing (coating roughness). Various edges on pipes must be removed completely (no remaining needles, chips, or filings). Cold forming after galvanizing damages the coating, especially on elements with a wall thickness greater than 1 mm, since these have a thicker coating with poorer flexibility. Forged elements are recommended to be sandblasted.

6. Thermal Deformations

Structural elements contain various stresses from rolling, welding, straightening, and cold forming processes. Under the influence of the high temperature of molten zinc, these stresses are released, leading to deformations.

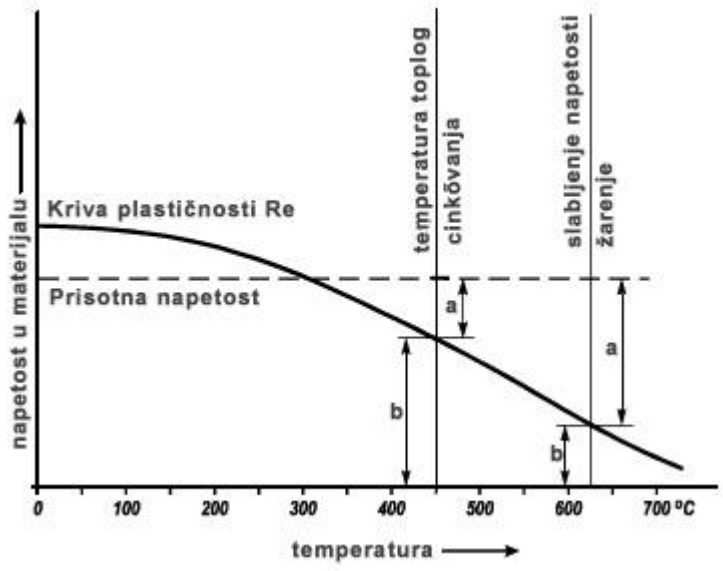


Diagram 1 – Dependence of material stress on temperature

Instructions for material selection, structure preparation, and quality hot-dip galvanizing

The extent of deformation depends on:

- the magnitude of internal stresses,
- the heat absorbed in relation to the position of the structure's neutral axis,
- the cross-section:

a) symmetrical or asymmetrical structure,
b) open (U- and T-profiles) or closed structure (tubes).

Internal stress decreases during heating by amount a (plastic deformation occurs), while internal stress of magnitude b remains.

The most common examples of thermal deformations occur in:

- thin sheets of larger dimensions,
- structures where sheets of different thicknesses are welded,
- grids fixed in a frame or individually,
- longer tubes or profiles – levers.

Deformations can be avoided or reduced by the following methods:

- fastening with bolts instead of welding,
- symmetrical welding as close as possible to the neutral axis and only as much as necessary,
- pre-annealing to relieve stresses in the material,
- pre-stressing the structure,
- inserting reinforcements made of the same material and with as uniform thickness as possible,
- embossing crossed or pyramidal shapes with a height of 20–30 mm and bending the sheet – doming,
- suspending the structure at multiple points to prevent bending (if the shape of the structure allows).

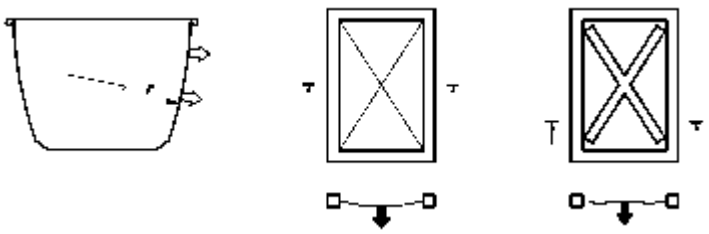


Image 10 - Methods of reducing thermal deformations.

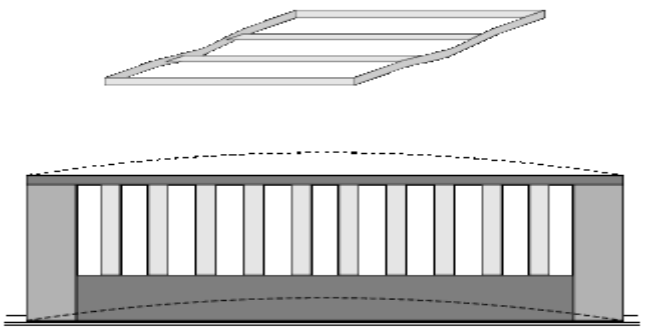


Image 11 - Potential deformation of longer elements

7. Closed Structures

Such structures are galvanized only on the outside (batteries, boilers, heat exchangers). The client must provide a declaration of pressure-tightness testing at 200 kPa. The interior is vented with a vent hole of at least 10 mm diameter to allow moisture—which at 450 °C can reach pressures up to 20 MPa—to escape. This prevents the risk of explosions. Closures must be suitable for 450 °C. Due to buoyancy in these structures, loading is necessary (7.2 kg load per 1 liter of enclosed air). Every closed structure must be designed to allow submersion with a weight to overcome pressure.

8. Structures with Louvers

The spacing between louvers should be greater than 4 mm due to the surface tension of zinc, which limits its flow. Louvers should be as thin as possible, and their material must not contain silicon beyond permitted limits.

Requirements Regarding Material to be Galvanized

9. Chemical Composition

The chemical composition of steel decisively affects the thickness, appearance, and quality of the zinc coating. Silicon has the greatest influence, so steels must not contain silicon.

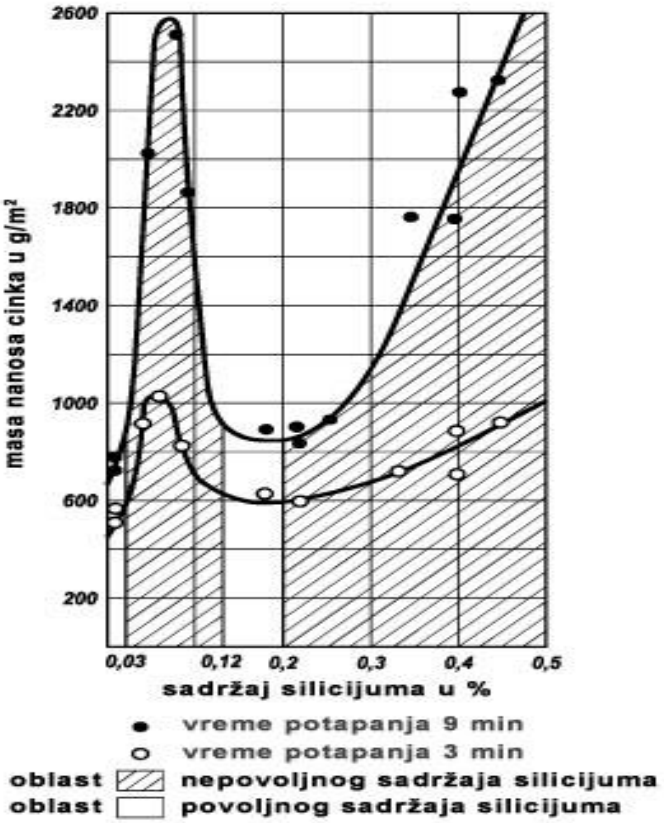


Diagram 2 – Dependence of zinc coating thickness on silicon percentage

Instructions for material selection, structure preparation, and quality hot-dip galvanizing

Favorable silicon content ranges (in %):

a) 0 < Si < 0.03
b) 0.12 < Si < 0.20

The most critical range is:
0.03% ≤ Si ≤ 0.12% (Sandelin range).

If the silicon content is below the Sandelin range (0.03%), the phosphorus content becomes very important. The following empirical formula must then be met:
Si (%) + 2.5 × P (%) < 0.09%

The content of other chemical elements is less critical but should preferably be within the following limits:

C<0,2%
P<0,045%
S<0,05%
Cu<0,5%
Mn<0,5%

Content outside these parameters can severely degrade the coating's appearance (grayness, roughness, adhesion)

10. Steel Surface Condition

Steel must not have the following defects:

- double gauge,
- dents visible as longitudinal lines,
- weld slag inclusions,
- contamination from dirty emulsions and impurities (oxides).

The surface of cold-rolled sheets must be bright and slightly rough, never polished, with surface quality grade P-3 (free of oxide layer, pickled). Defects after galvanizing will affect the zinc coating, causing it to become dark gray with uneven thickness, roughness, and possibly flaking.

11. Non-Ferrous Metals and Gray Cast Iron

Non-ferrous metals must not be galvanized. Gray cast iron must be sandblasted before galvanizing to remove oxide, sand, impurities, and graphite from the surface. Gray cast iron with 1.7–4.5% carbon is very difficult to galvanize because during pickling in hydrochloric acid, carbon diffuses to the surface, preventing adhesion of the zinc coating. There is a risk of cracking after galvanizing gray cast iron.

12. Coating Thickness

The zinc coating thickness must comply with ISO 1461:2022.

Table 2: Zinc Coating Thickness on Non-Centrifuged Elements

Material and Wall Thickness	Local Coating Thickness (minimum value a)	Mean Coating Thickness (minimum value b)
Steel≥ 6mm	70	85
Steel ≥3mm do < 6 mm	55	70
Steel≥1.5mm do<3mm	45	55
Steel<1.5 mm	35	45
Gray cast iron≥ 6mm	70	80
Gray cast iron< 6 mm	60	70
(a) Local coating thickness is the average thickness obtained from a number of measurements on a reference area using magnetic methods or an individual value obtained gravimetrically. (b) Mean coating thickness is the average of local thicknesses over a large product or all products in the control sample.		

NOTE: Table 2 is for general use; special standards may vary. Thicker coatings or additional requirements can be agreed upon outside this standard.

13. Repair of Uncoated Areas

The total uncoated surface area to be repaired may not exceed 0.5% of the total surface of an individual element. A single uncoated spot may be up to 10 cm^2. Repairs are permitted by thermal zinc application or by suitable zinc powder-based coatings that meet quality requirements.

14. White Rust

White rust results from the formation of zinc hydroxide on freshly galvanized elements, particularly on surfaces exposed to water (moisture) where oxygen and carbon dioxide access is limited. White rust is not subject to claims.

15. Palletizing and Transport

Elements sent for galvanizing must be properly palletized to prevent mechanical or chemical damage to the structure or zinc coating during external and internal transport. Metal pallets must be surface-protected. Palletizing must allow transportation of elements into the galvanizing facility using pallets.