Designing manual and contract galvanizing guide 2nd edition

NAGÉV CINK LTD. & NAGÉV IPARI LTD.

Preface to the second edition

The first edition of this publication had been issued for customers, designers, professionals and those who are interested, four years ago, in 2012. That was a revolutionary innovation at that time, since the deeper insight of the profession and the characteristics of hot galvanizing were known in details by a closed circle only. We believe we had been following a good strategy at the launch of our hot galvanizing plant in Ócsa, when we put together a professional guide in a briefly summarized form, and then provided it for our customers. In this publication we shared such information that made the process of galvanization more easily implementable during the possible later work - with special consideration of the aspects of the designing of steel structures - and thus the outstanding galvanizing quality was guaranteed.

We experienced that our customers busily studied our previous publication, and we acknowledge with appreciation that as a result of our publications popularizing this profession - more and more people got back to us that they would need detailed information in one or another section, perhaps they would even like to gain knowledge about some other, previously not covered areas as well.

In the preface of this present publication of ours we gladly inform you, that this new issue has been created based on the feedback and suggestions received in the meantime. The guide has been complemented with a comprehensive, overall picture of the entire galvanization technology for our existing and in-future-customers – including the selection of surface protection method, the most important milestones of the designing process and first of all the crucial, major steps of the galvanization technology. We concern the entire process from the point when the designed structure is put into production, until the point when the galvanized steel structure is shipped.

We hope that many of our readers shall find the previously missing or only partly available information, and also hope that our customers' professional knowledge will expand, and the certain steps of our course of business and the reasons behind them will be understood.

I wish good health - in the name of my workmates, too - and many successful mutual galvanizing for all of our existing and future customers!

János Nagy Antal
NAGÉV CINK Ltd. and NAGÉV IPARI Ltd.
Owner, managing director

Attention!
Directive MSZ EN ISO 14713-2 and standard MSZ EN ISO 1461 contain general information. The construction of the steel structures to be galvanized usually does not require special solutions, only some important rules must be kept, which originate from the characteristics of the technology. These are simple, easy to understand and apply. The **proper selection of the steel raw material** for the to-be-galvanized products, their appropriate **structural construction** and correct **manufacturing technology** guarantee the excellent quality of the product and reduce the cost of production.

The information in this guide was compiled by NAGÉV GROUP with the greatest care and based on the most up-to-date experiences. The goal of our company is to promote the job of the designers and manufacturers of the hot galvanized steel structures. At the same time we do not take any responsibility for any damage or loss coming from the use of the designing guide. Multiplication of the information contained in this publication can only be carried out with the written consent of the NAGÉV GROUP

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1. The selection of optimal steel quality for hot galvanizing to achieve aesthetic and economic coatings

The non-alloy carbon steels, poorly alloyed steels and cast-irons are suitable for hot galvanizing, while alloyed steels and steels high in sulfur content are not. The optimal steel quality for hot galvanizing must be stated right at the point of the order of the raw material of the steel structure. It does not mean surplus cost and does not limit usability. If the manufacturer of the steel structure does not know the quality of a given steel, then it should ask for a test-galvanization before procurement (production) - in order to clarify galvanizability. Coatings compliant with standard EN ISO 1461 form on the surface of the steels. Within certain solidity groups of the hot galvanizable steels there are some steel types that have silvery-shiny and the most economically efficient coatings, while on other quality steels thicker and grey, perhaps grid-patterned coatings will form. This phenomenon is first of all in relation with the silicon (Si) and phosphorus (P) content of the steels.

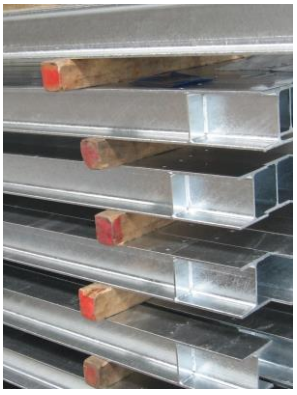
- **Aesthetic and the most economically efficient** coatings form in the case of the use of steel quality groups „A", „C" and „D" according to the table below (compliant with standard EN ISO 1461's specifications).
- **Thicker, grey** zinc (galvanized) layers form on the surface of the structures made of steel quality groups „B" and „E" (compliant with standard EN ISO 1461's specifications).

Expected appearance of the coating	**EN 10025-2,-3,-4: 2004** (points 7.4.3 and 7.2.4)			**EN ISO 14713-2: 2009**	**Expected thickness of the coating** (µm)*
	Si (%)	*Si + 2,5 P (%)*	*P (%)*		
(A) Shiny, silvery	**≤0,03**	**≤0,090**	**-**	**Si ≤0,04% és P<0,02%**	**50-150**
(B) Grey, dark grey	-	-	-	0,04%<Si≤0,14%**	250-600
(C) Shiny, silvery	**0,14≤ és ≤0,25**	**-**	**≤0,035**	**0,14%<Si< 0,25%**	**100-250**
(D) Shiny, silvery	**≤0,35*** **	**-**	**-**	**-**	**100-250**
(E) Grey, dark grey, stained	-	-	-	Si>0,25%	200-600
*Average value, which depends on the thickness, construction and surface quality of the steel structure.					
**In the case of specially alloyed (*Technigalva*) baths, coatings will become a lot thinner (80-150 µm)					
*** Only in the case of specially alloyed zinc melts (must be conciliated with the galvanizer)					

Grouping of hot galvanizable steels

Optimal coating
(steel group A)

Non-optimal coating
(steel group B)



Optimal coating
(steel group C,D)

Non-optimal coating
(steel group E)

If - because of strong corrosive effects (category C4, according to ISO 9223 and ISO 9224), and/or because of an extremely long (>60 years) protection period - a thicker than usual zinc coating is necessary, such a steel quality must be chosen from the table above which result in the appropriate thickness of coatings (quality groups C and D).

When we look at the ready galvanized surface, if it is made of different parts, it is easy to determine whether it was made of the same quality of steel or different quality steels from the hot galvanization point of view. Typical differences are when some parts show homogenous, shiny/reflective appearance, while others look

matte, grey or even show the shades of grey. If the appearance of the visibly originally separate parts within one structure show significant difference after hot galvanizing, then the chemical composition of the different-looking parts is different, too. We draw the attention of the designers and structure builders to the fact that galvanized surfaces massively fluctuating in appearance may mean different coating structure and thickness as well. This, however, does not mean that their corrosion-proof feature significantly differ from each other, but their life expectancy will be different because of the thickness differences.

We stress it furthermore, that some structure manufacturing operations and surface preparation procedures also have an impact on the material of the structure. We would like to point out the elements cut with flame, plasma and laser, during the treating of which on the cut edge and right next to it the alloy-composition of the original raw material changes as an effect of cutting heat, i.e. the forming zinc layer has different characteristics than the one forming on the surfaces farther from the treatment area. This deviation may appear in the thickness of the zinc layer and in the different appearance of the galvanized surfaces (according to the standard it's not allowed to mark measurement points for reference layer thickness at these points).

2. Surface condition of the products to be hot galvanized

Before delivery for hot galvanizing the thick grease, oil, non water soluble paint, tar, lacquer, slag coming from welding, silicon spray, etc. residues must be removed. These can be terminated with such surface-cleaning methods (e.g. grain scattering, burning off) which are not available in the galvanization plant. Products in "commercial condition", rusty or slightly scaly can be hot galvanized flawlessly, following surface pre-treatment in the factory. The solid and thick hot-rolling scales on the surface of the freshly produced, hotly rolled commodities may lead to quality problems, so it is practical to remove them by grain scattering. When selecting the commodities, it is recommended to avoid massively, laminarly rusty ('blind rusty') raw materials. Welding together very rusty/oxide and slightly rusty parts should be avoided, because these require significantly different pre-treatment (acidic steeping) time, and may lead to quality defects, coating deviations.

It's important to add a remark to the procedure of grain scattering, that its application slightly increases the surface of the structure. Its result usually does not cause a spectacular difference in terms of appearance, however, it is important to note that if the homogenous appearance of the zinc layer is a customer preference, it is practical to use grain scattering on each of the structure parts. The drawback of the procedure is that it increases the thickness of the forming zinc coating by min. 10-15%.

The hot galvanizing plant will inspect the inner surfaces of the structures only if specifically requested by the customer, regardless of the fact that otherwise the inner surfaces of the given structure are important or not. In many cases the contamination remaining in the inner cavities softens during the galvanization process and it "swims out" from those inner cavities, frequently contaminating the visible outer surfaces, too. At the acceptance of materials by the galvanizing factory there is no inspection for residues possibly remaining in the inner surfaces such as: chemicals, alluvium, chips, grain scattering (or sandblasting) residues, dust etc. So the galvanizing company does not take the responsibility for the later coming quality issues originating from these.

In the case of hot galvanizing of *moldings*, special care must be taken in order to make the forming zinc coating smooth, incessant and flawless. Because there can be molding material residues (form sand and other contaminations) burnt in the surface of the work pieces, which cannot be removed in the hot galvanizer. Therefore these must be cleaned off the surface of the work pieces by sandblasting or abrading before the delivery to the galvanizing/coating plant.
On slivered surfaces a zinc coating of different color and thickness may form than on other parts of the piece. If *fitted surfaces* (e.g. wedge track, bolt track, fitted screws) are to be hot galvanized, one has to take the thickness of the forming coating into consideration even at designing.

If, at certain surfaces *zinc coating is not necessary* (for example threaded parts), then the part to be protected should be covered with a paint of appropriate quality or with some other coating that cannot be marinated in the galvanizer or with a layer of plastic.

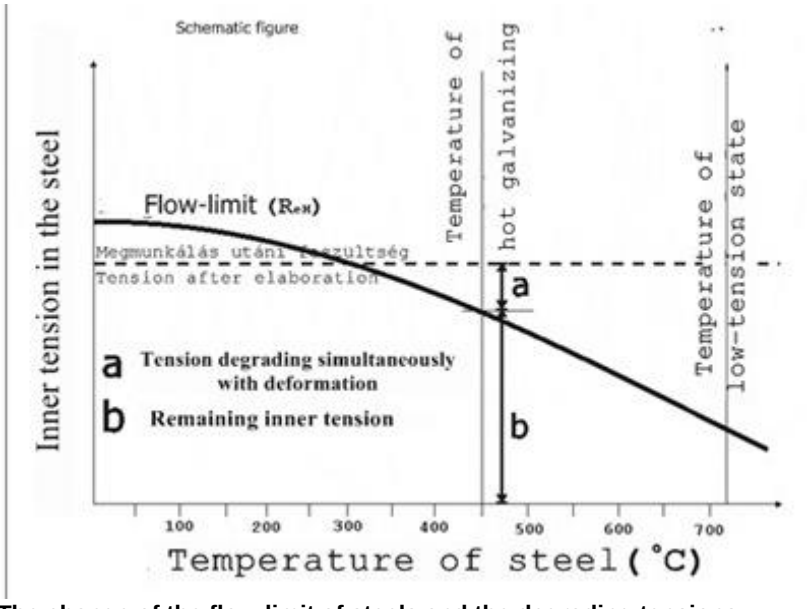
A frequent error is that a contamination of unknown origin can be found on the structures delivered for galvanizing. On the welded structures it is most frequently the charred or burnt remains of the applied drop separator material (spray) burnt as a result of the welding heat. This residue is attached very strongly to the steel surface. As the surface cleaning capacity of the galvanizing plant is limited, and in the case of some contamination ineffective, it is very important that on delivery of the structures to be galvanized the hot galvanizer receives information - besides the procedures applied during the structure manufacturing - about the

chemicals and processing aids used as well. The contaminations brought in to the preparation line of the plant on the structures to be galvanized in some cases may cause the expensive update of the pre-treatment technology.

The steel structure delivered for hot galvanizing must not contain a previously galvanized part or element, or any other non-steel sub-unit (e.g. rivets, soft solders). Certain marker paints, crayons, stickers and the residues remaining after the removal of these result in discontinuities in the coating. The removal of these markings and surface contaminations cannot be guaranteed with the pre-treatment technology of the galvanizing plant.

3. Avoiding deformations and the technological slots

During the manufacturing of the steel structures tensions of different direction and size develop in the material structure. In this process the drawing tensions forming during welding are dominant. The tension peaks that reach the flow-limit of the steel, get degraded, meanwhile local material flows evolve which accumulate and may lead to a deformation.



The change of the flow-limit of steels and the degrading tensions

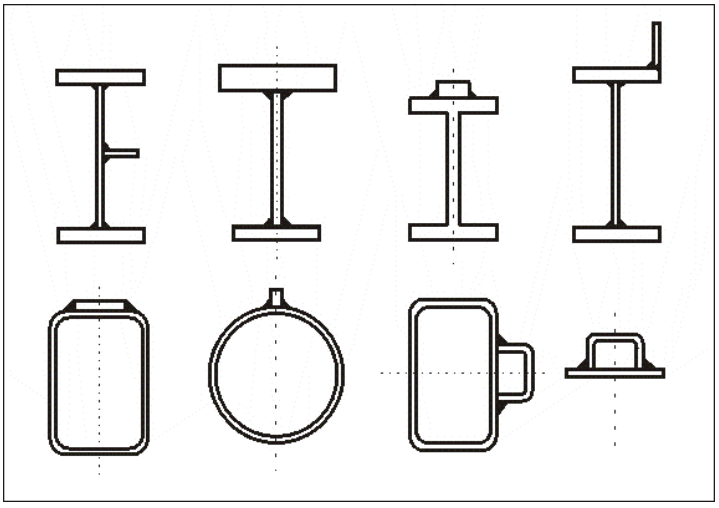
The formation of the coating – in the case of normal temperature galvanizing – takes place at about the temperature of 450°C. Since the flow-limit (ReH) of steels significantly decreases with the increase of temperature, those tension peaks that already reach the reduced flow-limit at the temperature of hot galvanizing, get degraded (a) and dissolve in deformations. The tensions evolving in the matter structure (primarily drawing tensions) during the manufacturing of products are forming because of the different steps of elaboration, processing (rolling, bending, heat treatment, *mainly welding,* thermic chopping, splitting etc.). With the decrease of the flow-limit of the steel, at the temperature of hot galvanizing, some of the inner tensions originating from production still remain (b). Deformations, which are harmful from the use perspective of the products, can be mostly or fully eliminated by appropriate design and production measures.

It also must be mentioned that the size and number of the technological slots created on the structures sunken into the galvanizing tub, as well as the three-dimensional design of the structure, are determining factors of the applicable sinking/diving speed. It's not hard to imagine that if the speed of sinking is low, there is a significant temperature difference between the already sunken and still untreated parts of a structure, which may lead to too high tensions or perhaps to the deformation of the structure. At the heating up of the steel structure from °C 20 to °C 450 one must calculate with approximately 5 mm/m thermal expansion in all directions of space, then with the same amount of volume decrease at cooling down. Therefore our colleagues struggle to create technological slots of minimum 8 mm diameter, proportional to the inner volume, on the delivered products.

3.1. Design of product cross-sections

From the technological implementation point of view, among the most favorable ones are the rod-like elements. The manufacturing and galvanizing of these products is usually simple, there are no real difficulties involved, but some important aspects must be taken into consideration.

Selection of symmetric cross-sections:
A harmful extent of deformation can evolve not only in more complicated structures, but - in some cases - also in very simple rods. Because of the above-mentioned it is practical to strive even during the design and production of steel structures that the distribution of manufacturing tensions should be symmetrical to the two mutually perpendicular axis in the cross-section of the product. When the tension distribution is not desirable, the deformed element must be aligned directly after the production of the steel structure (so before galvanizing). Based on the before said, the design of product cross-sections symmetric to at least two axis is practical. In this figure some *not recommended* constructions can be seen.

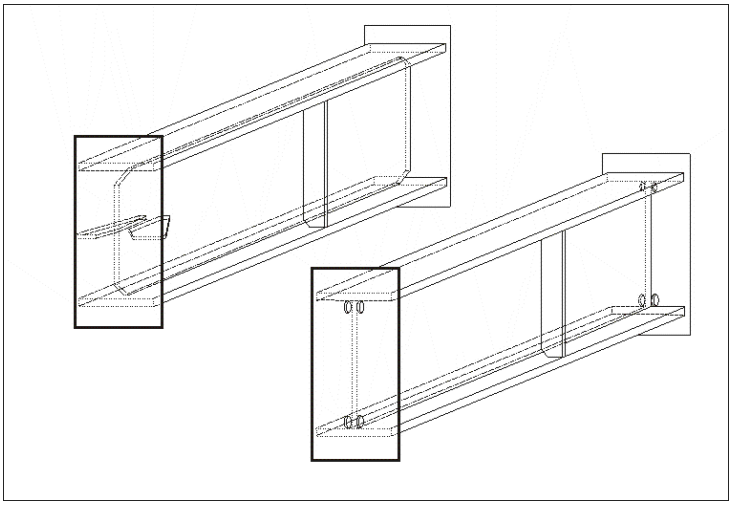


Not proper rod cross-sections

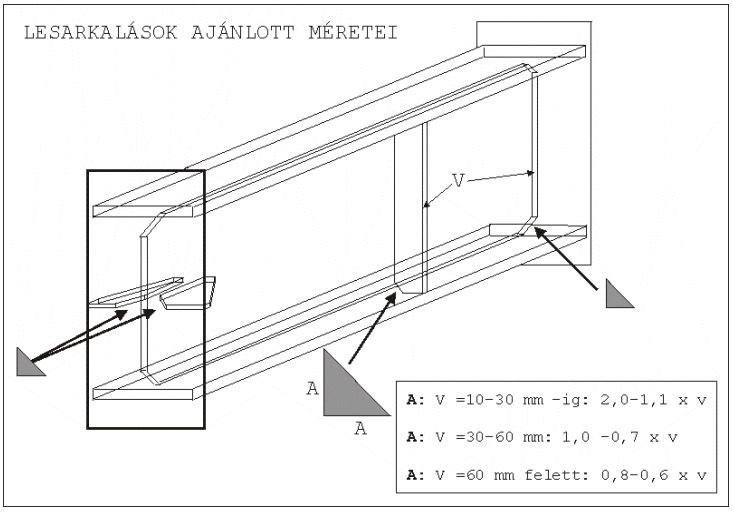
If the structural solutions seen in this figure or similar ones are utterly unavoidable, then the application of screw fittings is reasonable instead of welded joints. In this case the elements, parts are galvanized one by one, and then they are assembled with screws to one finished product. If separate, two- or three-dimensional pieces are designed, principles similar to the above should be followed, i.e. the symmetry to two mutually perpendicular axis in the complex cross-sections of the products must be ensured.

3.2. Creation of technological slots

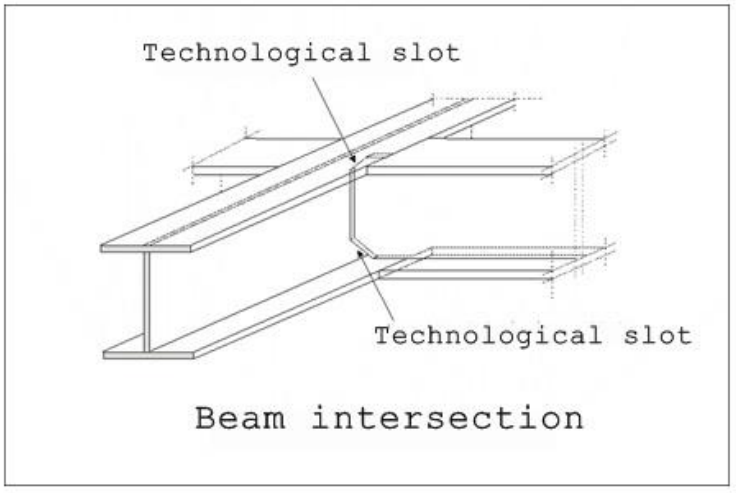
One of the biggest advantages of hot galvanizing is that we provide equal protection against corrosion on both the *outer and inner surfaces* of the structures. During the technological treatment the treating liquids and the zinc must be in contact with the not visible surfaces of the work pieces as well. In order to make these surfaces completely metal-clean the liquids must get in, while the gases, the air and the roughages must perfectly get out of the inside of the closed segments. In order to avoid air bubbles, so-called *air-outlet slots* must be installed to optimal places and in appropriate size and number. At the horizontal and vertical bracings of the plate-girders, at the mounting-, and keel joints care must be taken about the boreholes of desired position and bevel-edges of appropriate size.



Build up of plate-girders



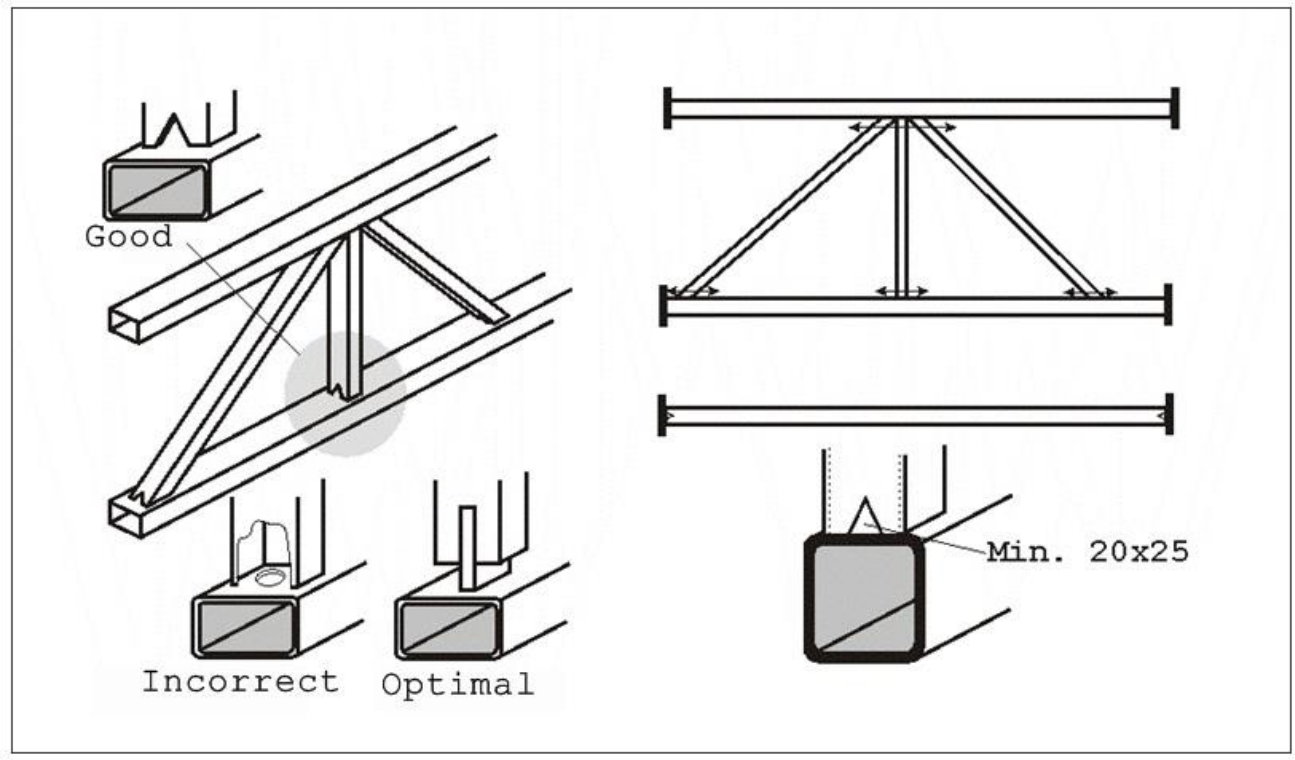
Bevel-edges and recommended sizes



Joining of plate-girders

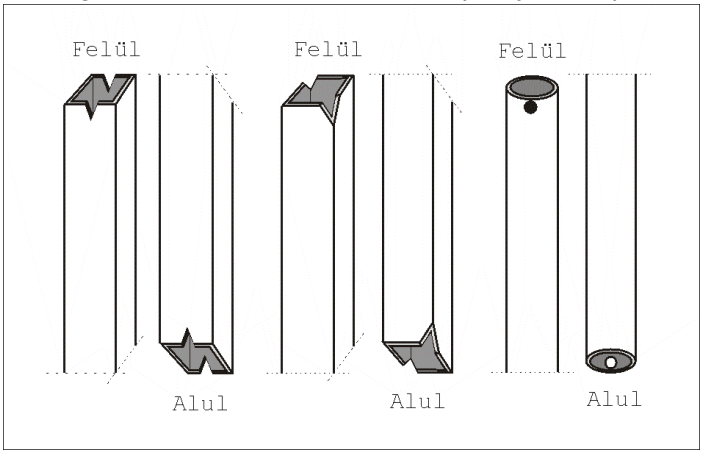
During the operation of lifting the work pieces out of the liquids all the liquid must flow out, thus so-called liquid pockets cannot remain anywhere in the structure because it causes material loss and quality issues. Therefore *outlet holes* of appropriate size, number and position are to be applied, which should be placed tangentially with the inner surfaces (there should not be any so-called liquid sills). Care also must be taken that *the technological slots* made in advance during the manufacturing process *should not be welded*.

The *spots* of the necessary technological slots are always determined by the method of hanging (hot galvanizing). The *size and number of slots* must be determined by the size of the closed spaces of the work piece. The objective is to achieve that the piece dives into the melt zinc as soon as possible, and that there are no after-flows at lifting out. These general requirements above are not only true for structures manufactured from closed segments, but also at the building up of stay slats forming delimited spaces, corners, in any position. Therefore, recommended bevel-edging methods are shown in the figure below.



Elaboration of closed-segment constructions

In several cases we can find gridded steel structures at which one must be very careful with checking the existence of technological slots. Water possibly remaining in the closed spaces may exerts a pressure of several hundred Bars, when it suddenly turns to fume in the galvanizing (zinc) bath, thus, with a sudden *explosion* can destroy not only the structure itself, but it also means a hazard for the employees working on site (point 3.6.). As long as the regulations on the slots are not kept, not only air sacs, zinc and fluid residues , but also slag adhesions will deteriorate the quality of the product.

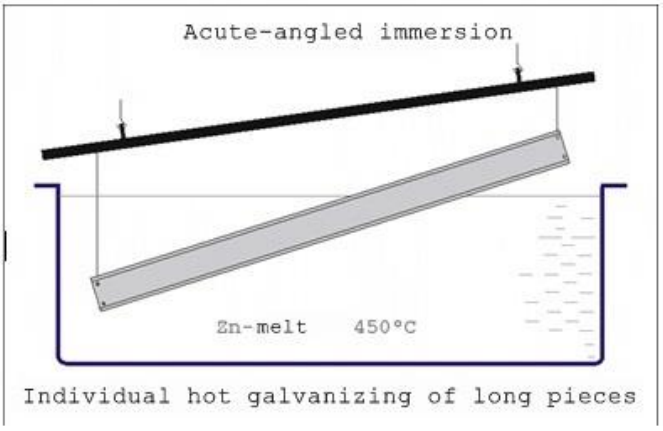


Slot formation of a two-dimensional closed-segment structure ("felül" means above, "alul" means below)

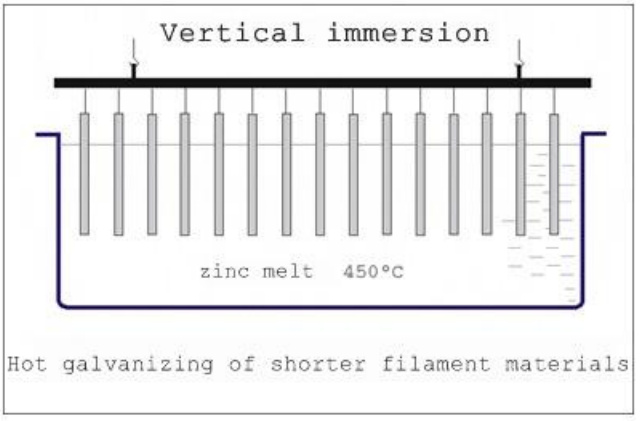
In the case of three-dimensional (spatial) formation, and the case of closed segments at each corner, while with pipes by 90 degrees at the ends is necessary the formation of technological slots. In the case of any doubt we recommend to ask for the advice of NAGÉV experts.

3.2.1. Position and size of technological slots

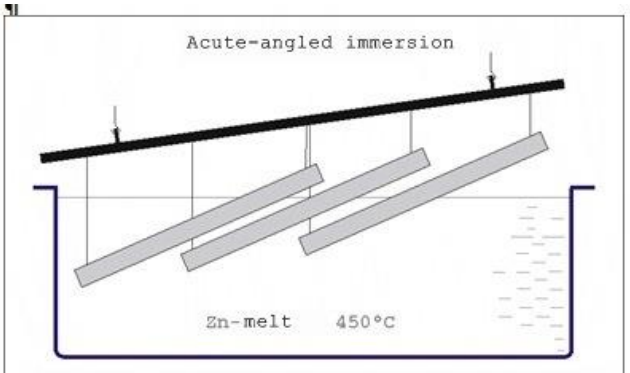
Because of the earlier mentioned reasons it is obvious that the existence, size and positioning of technological slots have a crucially important role. The slots serving as the outlet of air and gases should be positioned to the top corner points of the closed space, in the plane of the diving, sinking into the zinc bath, while the liquid outlets should be positioned to the bottom corner points of the closed space. *The spot/place of the slots is in each case* determined by the *hot galvanizing (hanging) position* of the given work piece. If this cannot be determined in advance, contact must be established with the experts of the hot galvanizing plant. Hanging positions depending on the size of the products are presented in the following figures.



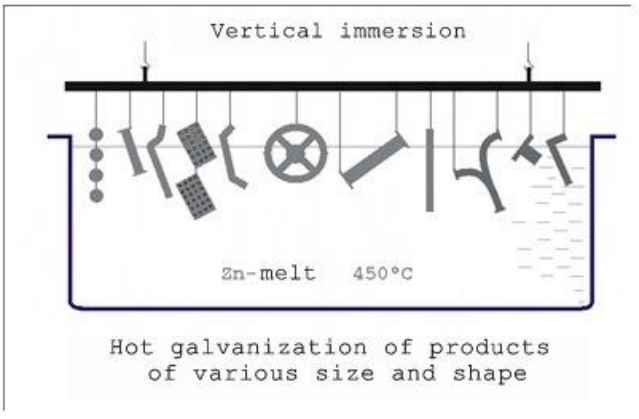
Individual hot galvanizing of long pieces



Hot galvanizing of shorter filament materials



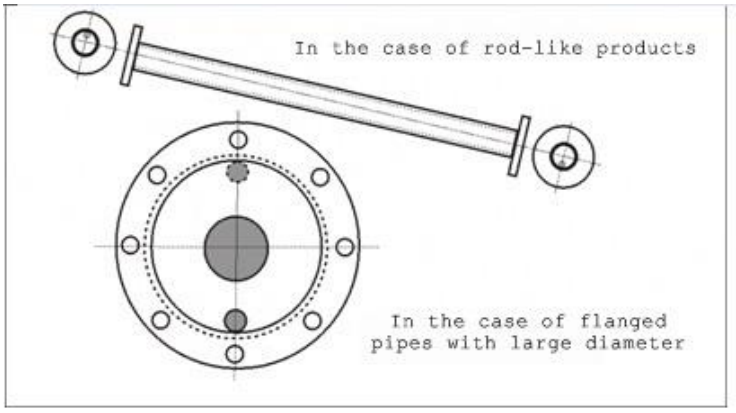
Hot galvanizing of longer filament materials



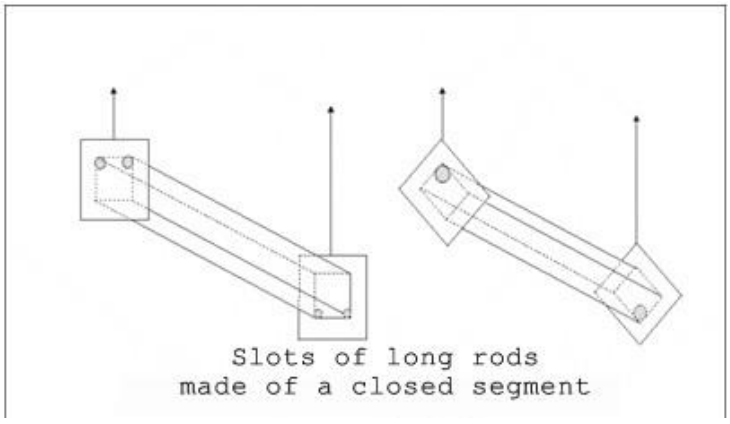
Hot galvanization of products of various size and shape

Various girding methods for hot galvanizing

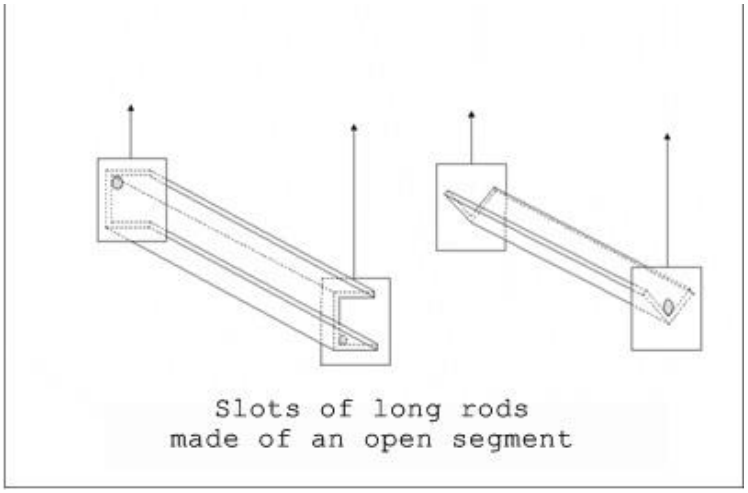
If, because of the static characteristics of the structure, or by ay other considerations technological slots cannot be formed/made at the ideal spots and in ideal amount from galvanizing point of view, then the designer must in each case contact the galvanizing plant *before* the manufacturing of the structures for technical consultation.



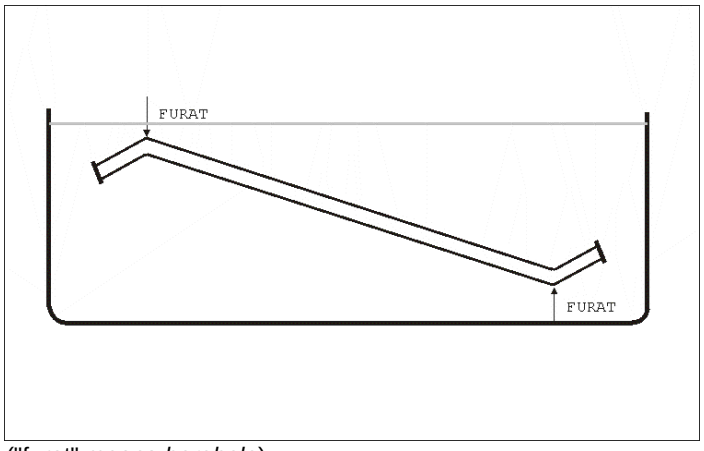
Technological slots at the bottom and top spots (pipes)



Technological slots on the square segments

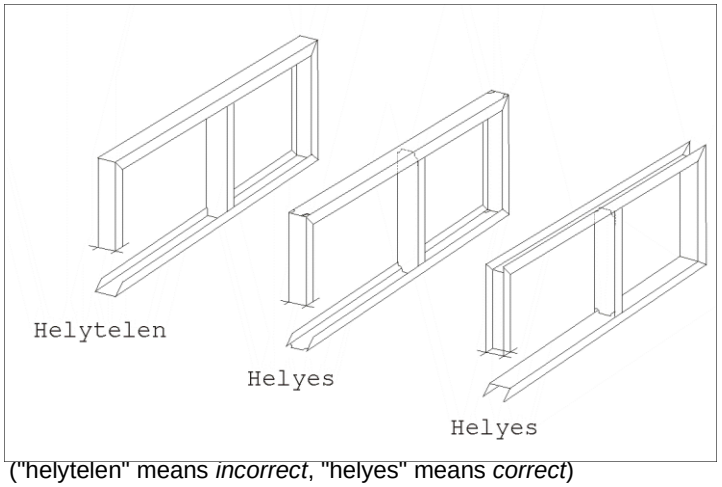


Technological slots on the open segments



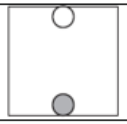
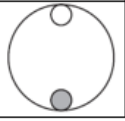
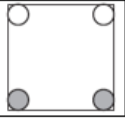
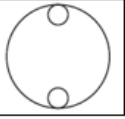
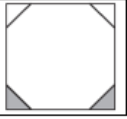
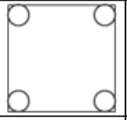
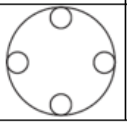
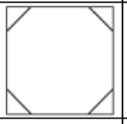
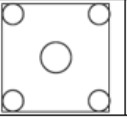
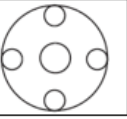
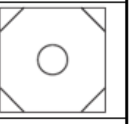
("furat" means *borehole*)

Technological slots at the bottom and top spots



("helytelen" means *incorrect*, "helyes" means *correct*)

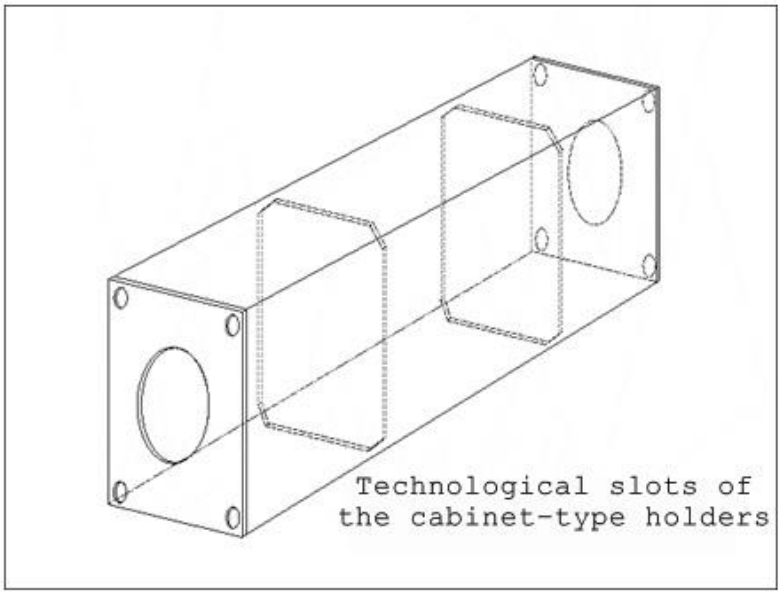
Technological slots on frames (open segments)

Recommended size and location of vent and drain holes for hollow sections (EN ISO 14713-2)			Number and location of holes or crops at each end of the hollow section										
			Galvanizing direction	1-1 hole	1-1 hole	2-2 hole	2-2 hole	4-4 hole	4-4 hole	2-2 crops at corners	4-4 crops at corners	4 holes of 15mm + 1 central hole	4 holes of 15mm + 1 central hole	4 crops at corners of 25mm + 1 central hole
Section cross-sectional shape and dimensions (mm)														
Round	**Square**	**Rectangular**		**Diameter of hole (mm)**						**Size of crop (mm)**		**Diameter of central hole (mm)**		
15	15			10	10									
20	20	30x15		10	10									
30	30	40x20		12	12	10	10							
40	40	50x30		14	14	12	12			10				
50	50	60x40		16	16	12	12	10	10	13				
60	60	80x40		20	20	12	12	10	10	15	12			
80	80	100x60		25	20	16	16	12	12	20	15			
100	100	120x80		30	25	20	20	14	15	25	20			
120	120	160x80		35	30	25	25	20	20	30	25			
160	160	200x120		45	40	35	30	25	20	40	30	35		
200	200	260x140		60	50	40	35	30	25	50	35	50	40	
300	300	350x250				60	55	45	40	75	55	80	70	75
400	400	450x250				80	75	60	50	100	75	110	100	110
500	500	600x300				100	90	75	65	125	90	140	125	135
600	600	700x400				120	110	85	75	150	110	170	150	165

Sizes of technological slots

Besides position **the size** and total number **of the slots** is at least that much important. The primary reason for their importance is that the immersion could be done as fast as possible, while the lifting is with optimal speed, and also that the slag could swim up to the surface of the metal melt. The duration of the product's stay in the metal melt is an important expense factor for the customers, and usually it is to be reduced to minimal. This means that the reasonably biggest number and diameter of holes, indentions and bevel-edges must be placed on the structures.

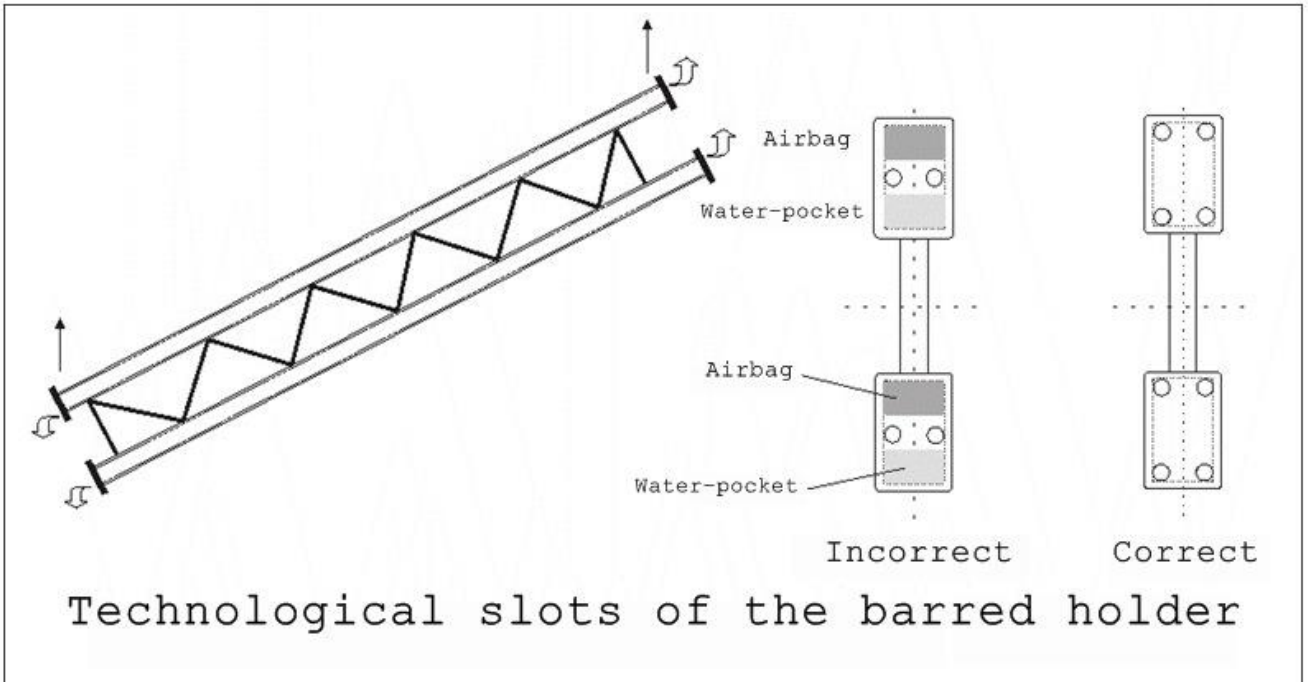
The necessary holes (slots) in the case of cabinet-type holders



In the case of *too small, not appropriate amount or wrongly positioned technological slots,* the customer must take the following disadvantageous consequences into account:

- Because of the too slow immersion and lifting out, a very thick zinc coating forms on the surfaces, which is less aesthetic and causes significant surplus costs.
  During lifting posterior zinc runs may form on the piece, which causes quality issues (defects) and surplus costs.
- Because of the too small air outlet slots slag adhesions remain in the corners of the products, which deteriorate the quality of coating and cause surplus costs.

The air- and liquid outlet slots serve the full emptying of the entirely or partially closed spaces (complete flushing). This condition can only be met if the air outlet serving the opening of the given closed space is at the highest point of the suspension plane of the product, and the fluid outlet slot is at the deepest point of the suspension plane.



Method of hanging/suspension and the position of technological slots

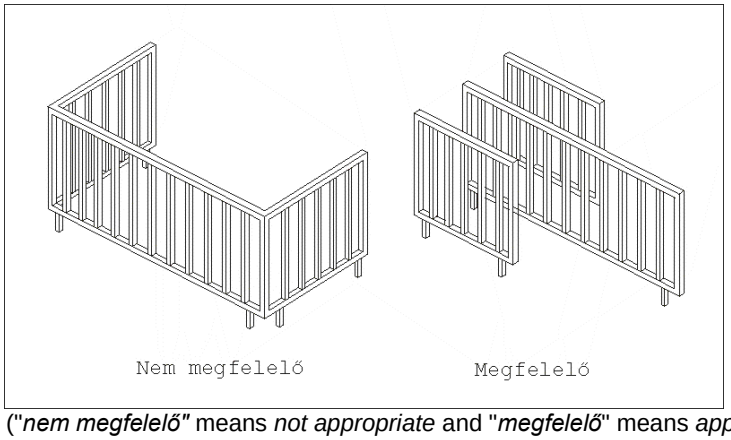
Our experience is that the steel structure manufacturers frequently fall into the trap of combining the creation of technological boreholes inevitable for galvanizing and the slots necessary for the suspension of structures. In

some of the cases it can be carried out, though, furthermore, our co-workers strive to realize, implement the intention of the manufacturers, bit it is not always possible. It may occur that the formation of the technological slots is adequate but they are not suitable for use to the suspensions, or that even the number and/or position of the suspension spots made on the structure are not suitable, either. The boreholes for the suspension/hanging of the products should be such a size so that the hanging steel wires - of the necessary thickness and strength to be able to hold the mass of the products - could be easily threaded and lifted from the tub following galvanization (minimal borehole diameter: 8mm).

In the near surroundings of the hanging spots, following galvanization, there is residue or a small extent of discontinuity of coating, in the case of outer surfaces the galvanizing plant repairs it the standard way. If galvanizing brings similar results on the inner surfaces, then it must be indicated in advance if the defects of the inner surfaces should be repaired as well.

3.2.2. Spatial structures, rails and fences

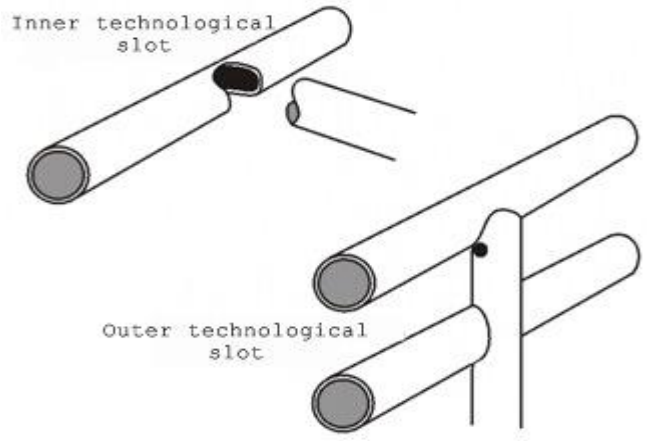
Spatially expanding steel structures, such as fences and rails, are frequently on the palette of hot galvanizers. When dealing with these, besides the technological slots, extra care must be taken about the appropriate parts to be galvanized. The parts having several planes preferably should be disassembled to elements (partial planes). The arched parts (units) should preferably be avoided. If this is not possible, the placing of surplus, extra technological slots is crucially important. The place of these depends on the galvanizing position of the given structure part (section 3.2.1.).



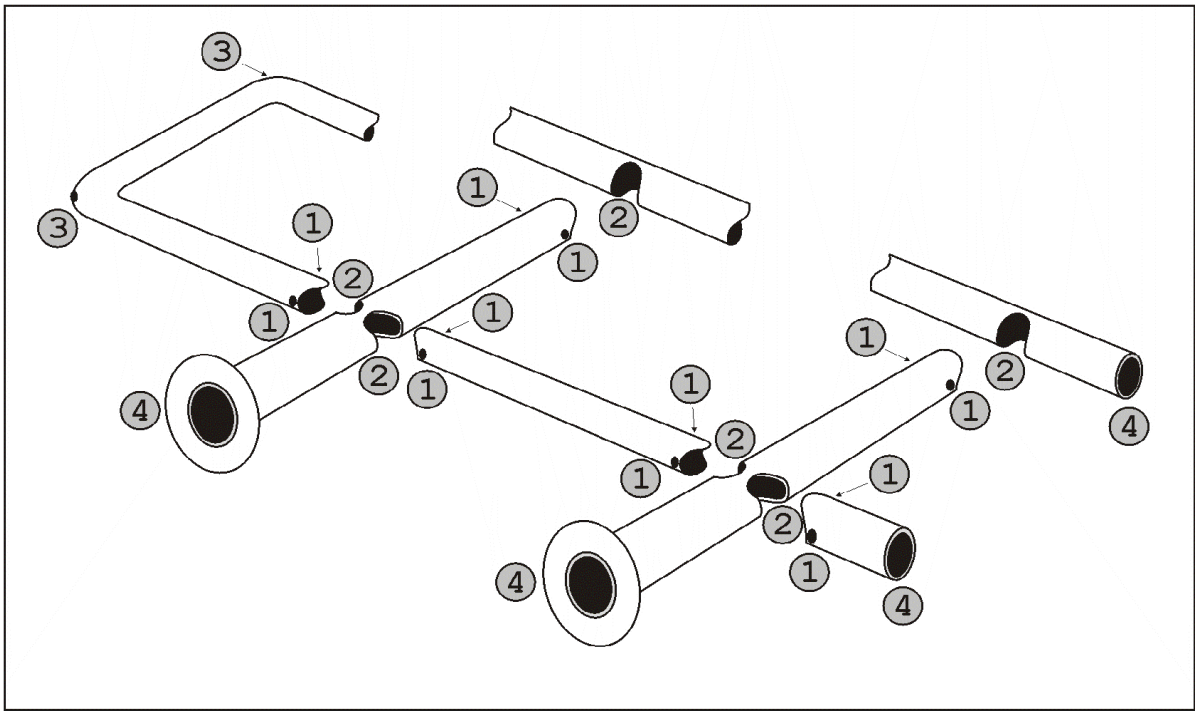
("*nem megfelelő"* means *not appropriate* and "*megfelelő*" means *appropriate*)

Galvanizing units of fence elements and rails

The superb quality galvanization of the spatial structures is a professional challenge, therefore the productivity parameters of the galvanizer plant may deteriorate and as a consequence of this, the amount of raw material used also increases. The galvanizers try to put across these changes towards the customers. Among other reasons this is why our colleagues try to convince our customers and the designer about the fact that they should design and create their spatial structures with modular or mountable solutions for hot galvanizing.



Possible technological slots for rails

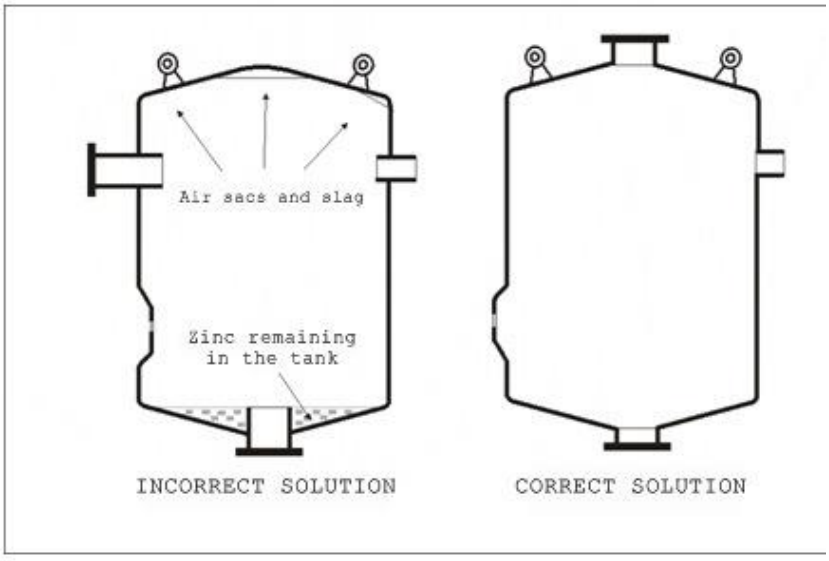


Technological boreholes and slots on a pipe rail

In the figures above we present two versions of technological preparation. In the first figure the principle of inner and outer technological slots can be seen. At the inner slots the in- and outflow of fluids, gases and slag can be ensured by the design of free pipe ends, while in the case of outer boreholes, slots drilled at the end of the pipes are required. In the next, so-called "exploded figure" slots marked "1" show the boreholes of the lateral surface of the pipe (smallest borehole size: 10 mm), while slots marked "2" with full cross-section ensure almost limitless liquid flow-in and gas flow-out (that is when the nicest and best quality product can be expected). Boreholes marked "3" present the technological slots of the bent rail ends, where holes of at least 13 mm diameter are necessary. Mark "4" shows the free rail ends which are the best slots from the technology point of view.

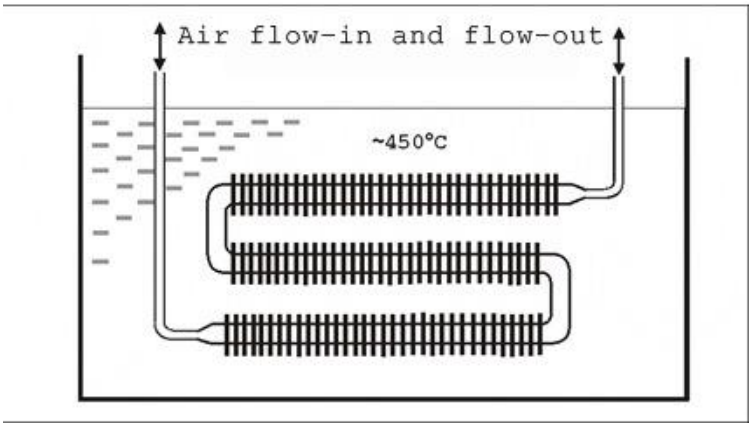
3.2.3. Design of tanks and heat exchangers

Because these pieces in most of the cases have large inner spaces and relatively small openings, special care must be taken about the placing of the appropriate technological slots. When choosing wrong solutions the appearance of airbags (air sacs), slag adhesions and zinc residues must be taken into account in the inner (internal) spaces and layer-defects on the external surface.



Liquid outlet and air/gas outlet slots on tanks

There is, however, a group of products with large internal spaces, of which only the external surface has to be hot galvanized. These equipments are the heat exchangers. In this case the work pieces full of air must be enforced to stay under the surface of the metal bath, which operation requires a lot of attention, careful designing and skill. In order to prevent the hazard of explosion these kind of structures, equipments must be equipped with appropriate technological studs, which at each immersion reach above the level of the liquid, so above the metal melt. The equalization of the air pressure takes place through these openings/slots.



Design, formation of heat exchangers

The formation of gas-solid, flawless welding seams is outstandingly important at manufacturing. In the case of these constructions, in many cases supplied with a mass of metal lamellas, the application of proper steel quality is of utmost importance (section 1), because they have huge surfaces, so even with an optimal steel raw material, their zinc uptake will be high. On the products made of the inappropriate steel quality - parallel with significant surplus expenses - the coating will be less aesthetic and too thick.

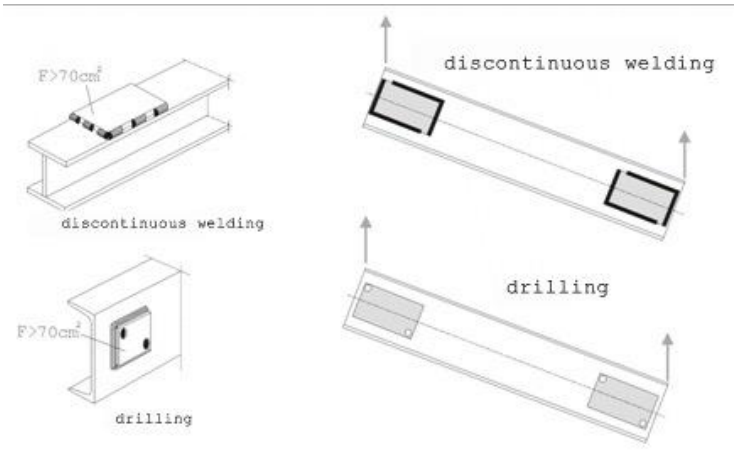
The tanks and heat exchangers are structures presenting a challenge from the hot galvanizing point of view. The conciliation between the designer and the galvanizing plant is in each case necessary - perhaps even before designing. These structures require completely unique and tailor-made hot galvanizing technique, with special regard to the different requirements, the appearance, slag-free surfaces and parts differentiated from

the aspect of layer thickness. The loading and shipping of finished, galvanized structures for the sake of high quality long-lasting coatings make some further considerations necessary.

3.2.4. Application of overlapping surfaces

It is a general principle, that the application of overlapping surfaces, which form with insoluble bounds, should preferably be avoided.
The moisture, contamination stuck between the surfaces, on the temperature of the metal bath in the small space turns to steam and gas, and can cause not only the harmful distortion of the structure, but it also means a danger of accident.

In the case of the application of overlapping surfaces the use of screw-fitting is more practical. If this is not possible, then by drilling through the entire or just the upper surface, or by making discontinuous welding seams can the damages be avoided. The spots of boreholes and discontinuous welding must always be created according to the position of galvanizing.



Constructions of the overlapping surfaces

If their application is unavoidable, then the regulations contained in the next table must be kept.

Size of the overlapping surface	Necessary solutions
There should be no fitting gap between the overlapping surfaces. The surfaces must be clean and free of moisture!	
> 70 cm^2	Gas-solid surrounding welding of the entire surface.
70 – 1000 cm^2	2x ≥12 mm diameter borehole diagonally, opposite to each other near the corners or 2x ≥ 25 mm long discontinuity in welding near the corners
1000 – 2500 cm^2	4x ≥12 mm diameter borehole diagonally, opposite to each other near the corners or 4x ≥ 25 mm long discontinuity in welding near the corners
> 2500 cm^2	≥12 mm diameter borehole diagonally, opposite to each other, starting from the corners per 300 mm continuously or ≥ 25 mm long discontinuity in welding starting from the corners per 300 mm continuously

Galvanizing-technical regulations for overlapping/overlapped connections

In the case of "overlapping" surfaces (discontinuous seams, drilled plates) there is the risk of posterior corrosive damages (rusty liquid flow-out). In such a case the slots not jammed with zinc must be coated with a galvanizing paste of at least 90% zinc content, in 2-3 mm thickness.

Because of the aforementioned reasons, the overlapping means not only a technological and quality risk, but also an occupational safety one. Chemical (acid) fumes, molten zinc spilling out, but in an extreme case they can even lead to explosions. Here it may be noted that, an above-mentioned serious event in each case causes downtime for the galvanizing plant, because of the obligatory inspection and drawing up minutes. Furthermore, the prevention of the possible personal injuries or technical damages must be carried out, and then the plant must be restarted. From the above mentioned it's easy to see that the overlapped structures mean an enhanced risk factor for the galvanizing plant and the employees working there, so its application should preferably be avoided during the building/design of the structure. The designers and manufacturers should in each case take into account that the galvanizing plant carries out the hot galvanizing only if the appropriate quality technical documentation is provided.

3.3. Incorporation of elements with great thickness difference

The exposition (immersion) time applied during hot galvanizing usually depends on the encasing size of the work piece, the size of the empty spaces and the thickness of the walls. The organizing principle is that the entire cross-section of the product should take over the roughly ºC 450 temperature of the zinc melt. This basically means that the time demand of the stay of the element with the highest wall thickness and weight in the melt shall determine the length of exposure (deviation from this is only in the case of products with large inner closed spaces where the length of exposure also increases). In order to eliminate quality differences, the conciliation of the wall thickness of the welded units is important. If there is a significant difference among the material thickness of the elements, then the following disadvantages should be taken into account. In the case of structures made with *point welded nets* similar phenomena may occur, i.e. the thin wire mesh gets deformed, so it is reasonable to mount it afterwards.

o On the surface of elements, parts with lower wall thickness the forming coatings may be significantly thicker than it is desired.

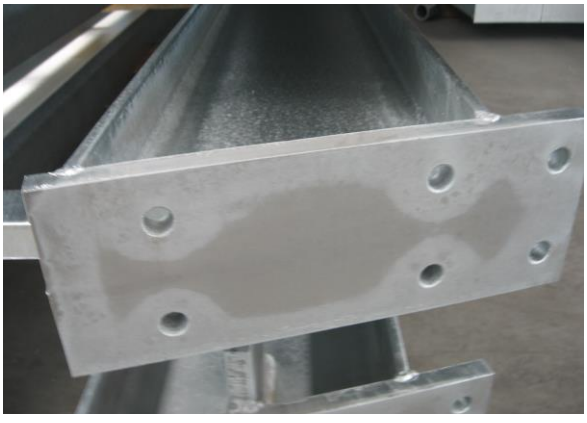
o Because of the different heat expansions deformations, cracks and rips may appear. In order to reduce the above risks the application of extreme thickness differences should be avoided when designing, and solvable connections have to be applied, which must be made after galvanizing.

o It is practical to keep the rule that between the elements welded to each other there can only be a 3 or 4 times difference in wall thickness.

o Especially with the elements of lower wall thickness, the sharp indentures (e.g. in-whetting) should be carefully avoided on the surfaces and at the corners.

o During manufacturing the large internal tensions, hardenings forming in the material structure must be eliminated.

When building elements, parts of different thickness into the same structure, it may occur that there are parts with significantly different heat storage capacity within the structure. Because of this, on the very slowly cooling surfaces darker, grey stains appear. This phenomena that can occasionally be experienced, is called the "heat stain" appearance. These heat stains do not have impact on the anti-corrosion function of the galvanizing.



Heat stains because of thick material

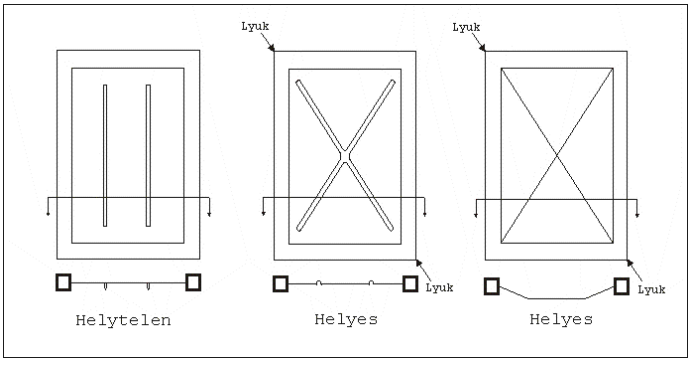
Heat stains because of closed space and thick material

3.4. Construction of steel structures made of plates

With these structures - in the lack of appropriate surface bracings - one surely must take the harmful deformations coming from hot galvanizing into account. A possible way of eliminating deformations is that the plate surfaces must be appropriately braced, which takes place exclusively by grouting of the ribs of appropriate size and shape into the surface.

Fundamental possibilities to avoid harmful deformations:

- Bracing of the plate surfaces in question by the grouting of appropriately placed ribs and hurls.
- An already hot galvanized plate must be built in (here care must be taken that the thickness of the zinc coating on the plates coated on the non-stop galvanizing line is significantly lower than specified in standard EN ISO 1461 for steel structures. Later it may cause corrosion problems.).

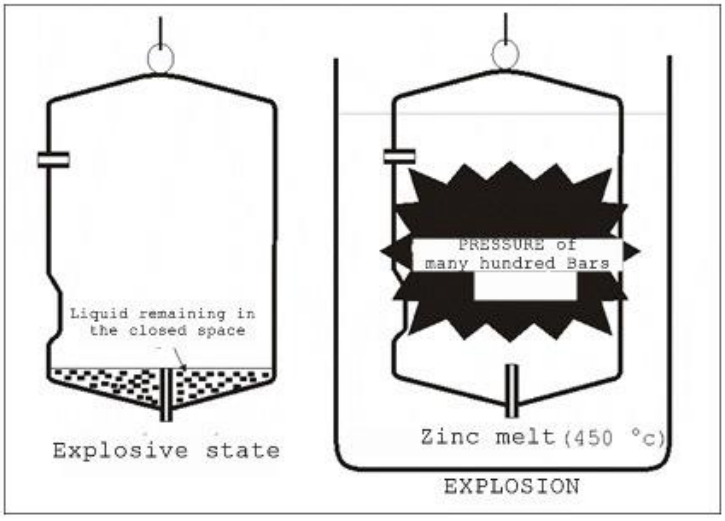


Correct and incorrect bracing of plate surfaces
("helyes" means *correct* and "helytelen" means *incorrect*)

The bracings of necessary extent can be provided through test-galvanization in most of the cases.

3.5. Explosive constructions, avoiding risks

The concerned structures are the tanks and the overlapped surfaces. If there is moisture (water) in the closed space in the moment of arrival into the zinc melt, then at the ºC 450 temperature of the metal bath it suddenly turns into high pressure steam (many hundred Bars), and it can explode the closed space. It does not only cause damage to the product, but may also cause injuries to the people working there and damage to the equipment used. In a lucky case the equalization of the pressure takes place by out-blow from the closed space, and it can cause severe damage in a serious case. Therefore the specified technological slots must be created with great care.



Explosive construction

4. Welding before hot galvanizing

In the steel structure's designing phase we have to take the simple but important technological requirements of hot galvanizing into consideration. During the welding of the elements one fundamentally has to strive to minimize the tensions brought in during production, as well as their distribution should be symmetric with the cross-section's center of gravity or at least to the two center of gravity axis perpendicular to each other.

Keeping the following main rules is justified:

1. The number of welding seams designed for the steel structure must be minimized with reasonable provisions, in order to decrease drawing tensions originating from shrinking as much as possible.
2. The spots for seams is determined in a way that they should preferably be located in the center of gravity axis of the cross-section. If it is not possible, then they should be symmetric with the cross-section's center of gravity axis.
3. Those seams which determine the rigidity of the structure the most, should be scheduled at the very end of the welding order.
4. The welding parameters should be determined in such a way so that the amount of heat intake is as small as possible, and even that should be concentrated on the least possible material cross-section.
5. The seam strengths cannot be greater than it is statically justified.
6. In order to keep the inner tensions originating from shrinking as low as possible, the structure must be welded going "from the inside out".
7. Taking the above-mentioned aspects into consideration, before the execution of welding *a welding plan* should be created. In the case of an appropriate construction and keeping the welding plan, the inner tensions originating from welding will be minimal, and will distribute evenly in the product's cross-section. In the case of steel structures with a complicated shape and large cross section please turn to an expert for the appropriate design and formation of the welded steel structure.

Parameters of the welding connections following galvanization: According to the almost concordant statements of the research in this field, keeping at the temperature of hot galvanization (immersion time) usually has a beneficial effect on the tension conditions of the welded structures - their mechanical properties improve. If the appearance and continuity of the welding is faulty, that remains after coating, too, moreover, sometimes the defect gets even more contrasted. The general rules for welding are true and sufficient in the case of hot galvanized steel structures as well.

The most important conditions of implementation:

- In the case of welding with a coated electrode the forming slag must be completely removed.
- In the case of welding with a protecting gas, and application of wrong, incorrect welding parameters, thin, glass-like slag residues form on the edges of the seams, which should also be removed.
- In the case of the application of sprays for the prevention of adhesions, only the use of silicon-free and oil-free products is recommended.
- The welding defects, craters, edge burns remain even after galvanizing, these should be avoided.
- The application of discontinuous seams should preferably be eliminated (exception: overlapping joints).
- The width of the seam-interstices should be such, that only the minimally necessary seam strength and width is formatted.
- One must strive to apply plane seams (blunt seams), because the corner seams increase the risk of defects.

- The root welding must be implemented with great care. gyökhegesztés
- In the case of forming long seams welding must be carried out starting from the middle of the piece going towards the edges.

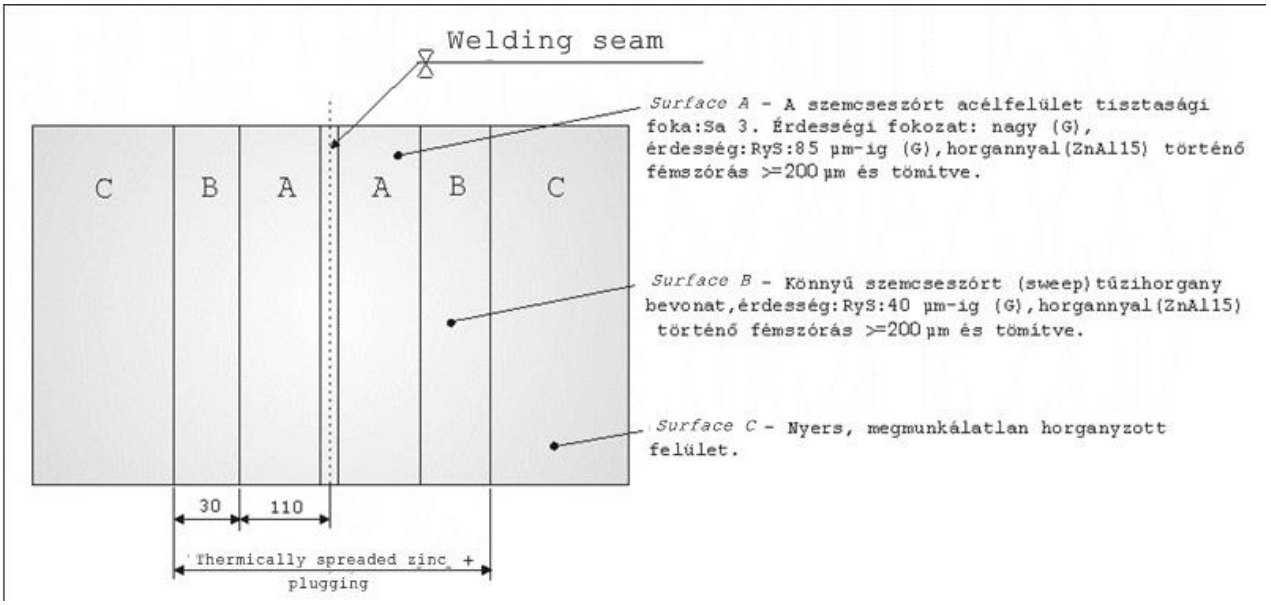
The electrodes and wires used for welding in many cases have a too high silicon content from the aspect of hot galvanizing. On these seams grayer and thicker coatings may form. It is especially conspicuous, if the seam is whetted into a smooth plane. In the case of extreme aesthetic requirements it's logical to choose the composition of the welding material in such a way (Si- and P-content) that it results in a coloring similar to the other parts of the structure (point 1). If there are special requirements against the welded structure in terms of alaktűrés shape tolerance, then it is practical to make sure by test-galvanizing whether the construction and technology are correct, if this is not possible, the help of an expert must be asked for.

The vast majority of quality issues faced during the galvanizing of steel structures can be related to the quality of welding, and to the processing aids used during or before welding. The heat forming at welding burns these materials and after the burning the residues remaining on the surface occur as contaminations. Occasionally in the surroundings of the welding they "burn into" the material of the steel structure.

While the material residues appearing on the surface can be cleaned with a better chance, the materials burnt into the surface can only be removed completely by a procedure including mechanical cleaning (sand blasting). The posterior cleaning of integral structures have some other quality risks - because of the residues of sand blasting. That is why the galvanizing plants ask from their clients to do the sand blasting on the units and parts of the structures in a semi-manufactured or raw material state. During welding, with special consideration to the types of processing aids applied and their residues after welding, they should proceed carefully, but at least after welding as soon as possible they are to remove those from the hot surfaces concerned. After the sand blasting carried out as a mechanical cleaning following the operation of welding, care must be taken about the removal of sand grains remaining in the internal parts and cavities.

5. Welding after hot galvanizing

It is a general suggestion that hot galvanized steel structures should NOT be welded afterwards, because at the welding spot and its surrounding area the coating burns down. However, there are some rare cases, when the posterior welding of the hot galvanized steel structures cannot be avoided (e.g. on-site splicing, repairs). The necessary information about the largest galvanizable product size must be acquired in the designing phase. In certain cases, besides the execution of special provisions, the posterior welding of structures already having a hot galvanized coating can still be done. In the case of a normal thickness of zinc coating (v<100µm) the formed welding seam's properties do not differ from those of the seams formed on non-galvanized steel. If the zinc coating on the surface is thicker than this, then it should be gently removed at the spot of welding and in the nearby area, and then the resulting clean steel surface can be welded according to regulations. After welding the missing or damaged coating must be repaired according to the rules and regulations about the repair of galvanized surfaces (EN ISO 1461:2009). In this case the damaged surface should be coated with an at least 100 µm thick zinc-rich paint, if the customer does not state otherwise.
In the case of steel structures exposed to higher requirements, the repair of the zinc layers damaged at welding with thermic metal blasting may be justified. Concerning this method, the customer should proceed according to the figure presented here. It is important that the surfaces sprayed/blasted with metal grains should be stanched with an appropriate paint. This is how the proper protection period can be guaranteed.



Notes: **Surface A:** cleanness grade of the grain blasted steel surface: Sa 3. Roughness grade: high (G), roughness: RyS: up to 85 µm (G), metal spreading with spelter (ZnAl15) >= 200 µm and plugged; **Surface B:** Light grain blasted sweep zinc coating, roughness: RyS: up to 40 µm (G), metal spreading with spelter (ZnAl15) >= 200 µm and plugged; **Surface C:** Raw, unelaborated surface.

Repair with thermic metal blasting and then with the stanching of the pores
(Source: Institut Feuerverzinken GmbH, Feuerverzinkte Stahl-und Verbundbrücken, 2015)

If there is still a need for welding zinc coated surfaces, then the following should be taken into account.

Aspects that should be considered during the welding procedure:

o Basically all fusion welding procedures are suitable for the welding of the already galvanized surface.
o Autogenic welding can only be recommended at a plate thickness below 3 mm, above this arch welding is recommended.
o With welding under protecting gas a stronger squirting, splashing is to be accounted for.
o For the sake of better outlet of gases usually a lower welding speed has to be applied, than at the welding of non-galvanized steels.
o In the case of blunt seams a bit larger welding gap should be left in order to let the exhaust gases leave more freely from the seam effusion.
o The amperage of welding should be chosen at a little bit higher value, because the burning zinc slightly obstructs the forming of seams.
o In the case of fillet welds the electrode should be lead in such a way that the zinc burns down at the seam edges.
o The selection of a suitable welding electrode is crucially important from the seam quality point of view. Those electrodes are better on which the slag forms more slowly because these enable the gases leave from the effusion in time. With structure steels, where the welding seams are not exposed to an extremely high strain, for example the medium-thick rutiled or rutile-cellulose electrodes can be recommended.
o The welding area must be carefully cleaned, then the surface must be restored as soon as possible according to the surface protection standards (MSZ EN ISO 1461).

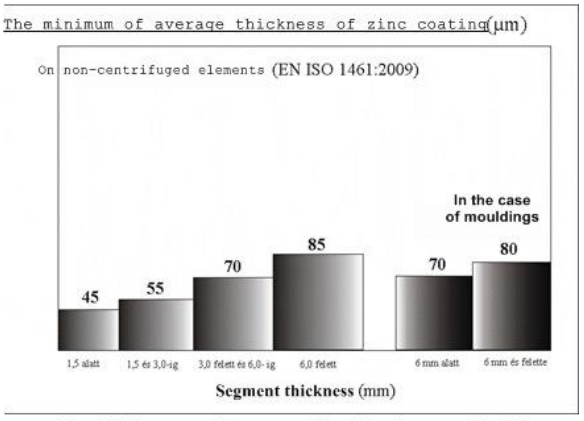
Security technology standards:

o The zinc-oxide welding smoke must be drained away from the workplace, it is prohibited to breathe it in.
o The workplace must be thoroughly ventilated.
o If some people inhaled a larger amount of such smoke, they immediately need medical attention. The smoke inhaled may perhaps cause flu-like symptoms (metal-fume fever), however, it heals without a trace following medical treatment. The inhalation, however, can be entirely eliminated in the case of the use of the proper security equipment (local extraction devices).

Due to the surface cleaning necessary in the case of welding after galvanizing, the zinc coating is removed from the given area. In order to carry out the regular repair of the areas in question one should look for the restoring paint that can be acquired at the galvanizing plants, because following the spreading of the layers of locally available paints the given area will have the appropriate protection against corrosion. About the use of this paint you should get in touch with the experts of the galvanizing plant.

6. Thickness of zinc coatings

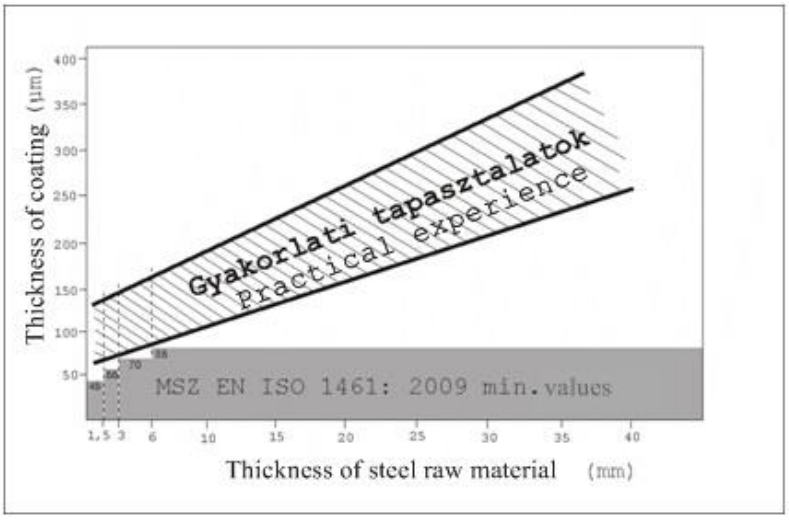
The quality standards of the protective coatings formed by hot galvanizing on the steel structures are contained by the respective EN ISO 1461 standard. In this - besides other important parameters and requirements - the thickness regulations relevant for steel structures are set. Depending on the wall thickness of the steel structure, the minimum values specified for coating change. There are technological reasons for this.



The thickness values specified by the standard for steel structures (EN ISO 1461: 2009)

("felett" means *above* and "alatt" means *below*)

For the tiny products hot galvanized by the centrifugal procedure (e.g. fittings, washers etc.) there are separate regulations in the standard. In practice the thickness values of the coatings made on steel structures usually significantly exceed the values recorded in the standard.



The conformation of thickness values in practice

In the quality assurance system of the hot galvanizing plant the checking of layer thicknesses by sampling is always carried out using the method specified by the standard. Therefore in each case, when the customers have a demand for a layer thickness different from the standard, that demand should be indicated to the galvanizing plant in advance.

In the case of the threaded and tiny borehole formations it may occur that they get clogged up with zinc. We would like to draw the attention of designers, manufacturers and customers to the fact that moving spare parts, built-in sleeves, assembled components suffer shape and size change as a consequence of galvanizing, due to the thickness of coating, and this is unavoidable because of the capacities of galvanizing technology.

As a consequence of the technology of hot galvanizing, in some cases the zinc intake of the elaborated accessories, structures locally differs from the extent of zinc intake characteristic to the material. The most usual reason for this is if during the manufacturing of the products surfaces were formed using flame, laser and plasma cuts. On the surfaces concerned thinner coatings form than specified in the standard and/or it may cause the zinc coating to come off at the edges.

7. The economic efficiency of hot galvanizing

When planning the protection of steel structures against corrosion, we recommend to take into consideration the regulations of the respectively valid Hungarian Standard (MSZ) EN ISO 14713 (Protection of iron and steel structures against corrosion. Zinc and aluminum coatings).

7.1. About the planning of costs in general

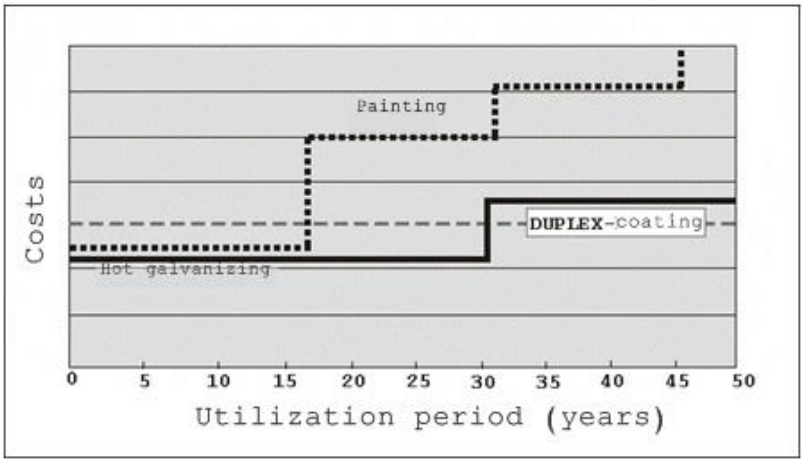
When - in the planning phase of a facility - economic analysis must be carried out, it is important that we take all the costs of the complete operational cycle (the total lifecycle of a facility) into consideration. This means that in the case of a steel structure not only the costs of the first investment, but also the recurring maintenance, renovation costs, moreover the cost implications of the deposition of the waste after demolition. If these costs are not considered, then the expected profit results can be easily overestimated. For the establishment and during the "operation" of a steel structure the following major costs (future payments) arise:

- Costs of design.
- Costs of the manufacturing and mounting/installation of the steel structure.
- Costs of the first protection measure against corrosion.
- Maintenance costs of the abilities of the anti-corrosion protection (renovation, maintenance).
- Costs or profits after the structure became useless (cost of waste or salvage value).

Since at the comparison of a painted and a hot galvanized steel structure from among the above-mentioned costs the costs of design and manufacturing as well as the costs of destruction are basically the same, thus the costs of the first anti-corrosion protection and maintenance should be compared.

7.2. Cost-effective procedure

The industry continuously compares the costs of hot galvanizing and painting. The costs of a good quality painting, where the paint is applied in two layers are usually equal to the costs of hot galvanizing. It is easy to realize that the cost(s) of the first anti-corrosion protection (at investment) in most of the cases amount to only a small part of the mass of costs payable for the entire lifecycle of the product. Because during the operation of the steel structure further restoration costs may occur. These maintenance jobs repeated only in every 10 to 15 years are not applied in the case of hot galvanizing, or may become relevant after a very long time (40-50 years).



Comparison of the costs of hot galvanizing and painting
(costs of protection with hot galvanization and superb quality painting with 3 layers applied)

7.3. Ensures maintenance-free anti-corrosion protection for decades

This procedure provides such a highly effective protection against corrosion that the capacity of anti-corrosion protection usually exceeds the required period of operation/utilization. Therefore steel structures after hot galvanizing in most of the cases serve their function free of maintenance. On the contrary, maintenance needs to be done from time to time in the case of painted steel structures in order to maintain their stability, and to meet other requirements, such as aesthetic demands. This in fact increases their maintenance costs significantly.

Difficulties occurring during the restoration of painted steel structures:
The damaged paint layer must be completely removed.
Metal-clean surfaces must be achieved in such a way that the structure usually cannot be disassembled.

- In the closed or not easily reachable places, spots it is impossible to achieve proper surface cleanness.
- The local surface-cleaning is environmentally harmful and very expensive.
- Local (on-site) painting is obstructed by the given, in many cases during-operation working conditions and the effects of the weather.

On-site paintings take place with a heavy labor input, so they are expensive. Hot galvanized coatings are not only corrosion-proof but they also resist beating and wear outstandingly. During their period of utilization the zinc patina formed on the surface of the protective coating protects the zinc underneath, from corrosion. This protective layer usually very slowly decreases - depending on strain - and reproduces from the zinc underneath.

Category of corrosivity	**Corrosive strain**	**Average corrosive speed (µm/year)**
Internal space: dry	Very low	≤ 0,1
Internal space: occasional humidity precipitation External space: isolated rural clear	Low	0,1-0,7
Internal space: high moisture content, moderate air pollution External space: city downtown or slight coast	Moderate	0,7-2
Internal space: swimming pools, chemical factories, etc. External space: industrial downtown, or urbanized coast	High	2-4
External space: industrial area with high moisture content or coast with high salt content	Very high	4-8
Sea water in a temperate zone area	Very high	10-20

Service life of hot galvanized coatings under different climates (extract from EN ISO 14713:2209 directives)

In practice the hot galvanizers typically apply zinc coatings that significantly exceed the standard values (50–150 µm), the renovation date usually comes only after several decades, until that time they can be used without maintenance.

In most of the European countries the corrosive strains (macro corrosive impacts) are moderate or weaker. This means C3 or C2 category of corrosivity (ISO 9223:2012 and ISO 9224:2012). According to this, very long service life can be expected.

Category of corrosivity (ISO 9223:2012)	**C2**	**C3**	**C4**
Moderate corrosivity rate „r" (µm/year)	0,1< r ≤ 0,7	0,7 < r ≤ 2	2 < r ≤ 4
Moderate coating service life (years), in the case of 85 µm thick zinc coating	very long	63	28

The expectable service life of a 85 µm thick coating

7.4 Important standards, recommended regulations

The knowledge of these following standards is important for the designers and manufacturers of steel structures.

- (MSZ) EN ISO 1461: Coatings made by hot galvanizing on finished iron- and steel products. Requirements and inspection methods (ISO 1461)
- (MSZ) EN ISO 14713: Anti-corrosion protection of iron- and steel structures. Zinc and aluminum coatings. Directives (ISO 14713)
- DASt-Richtlinie 022:2014 (Germany)

8. Rules and regulations valid/effective in a hot galvanizing plant

Hot galvanizing is a service provided by the galvanizing company for its customers. From first contact till the payment of the final invoice the entire process requires the close co-operation of the two parties. This co-operation can be carried out by spoken, written and electronic information exchange, the bases of which are the correct technical collaboration between the Parties, and the legitimate procedures. As a result of these, a business procedure closing with complete satisfaction for both parties can be expected.

8.1. Cooperation tasks of the customer and the hot galvanizer

There has to be or recommended to be a built up co-operation between the customer and the service provider (hot galvanizer) in the following areas:

- Selection of optimal steel raw material quality and chemical composition.
- Keeping of the constructional directives concerning the steel structures.
- Elaboration of a correct steel structure manufacturing technology.
- Troubleshooting, error management and prevention in mutual cooperation.
- Keeping of contracting processes.
- Keeping of the delivery-, shipping- and recommended storage requirements of products.

Finally, as the most important item, process of cooperation, it is a must to mention contract galvanizing. All information mentioned above, and perhaps further information or requirement concerning the structure and the contract galvanizing that may contain important or critical piece of information, must be shared with the galvanizing plant. In the lack of this, the elaboration of an optimal hot galvanization procedure, that takes the real state of the structure into consideration, is impossible. We must draw attention to the fact that the

operation of galvanizing is a simple anti-corrosion procedure *only* in a base case. There is a wide range of such problems which cannot or only very expensively can be improved. However, with timely information exchange, and then as a result of this, with the appropriate planning and parametering of the galvanization process, these could easily be avoided.

8.2. Loading of the products to be delivered for hot galvanizing

For the sake of efficient operation, the employees of the plant carry out machine unloading. The fundamental condition for this is that the steel structures delivered are loadable with a forklift. Before the start of loading in the structure manufacturing factory, it is practical to consider - when choosing the transport vehicle - whether the loading machines of the galvanizing plant are able to effectively unload the loaded structure. Mistakes in loading may mean an occupational safety risk both at loading and unloading. If the galvanizing plant was not notified in time, the customer should *not* expect from the workers of the plant to unload the products delivered to the plant - in a form not suitable for machine unloading - fast and efficiently. Too lengthy loadings increase the waiting time of other clients as well.

It also has to be taken into consideration at the loading of the selected vehicle, that it should have the appropriate stability and maneuverability from the traffic safety point of view, even when carrying the load. The chosen path, route should also fit to the expectable safe speed of the vehicle.

According to the above, our customers must load the transport vehicle in a way that their products could be lifted safely in lots using *forklift trucks*. For the safe positioning of the forklifts a minimum of 80 mm distance must be provided between the grip point of the device and the level of the floor.

In the case of delivering structures or lots above 10 tons, the preliminary notification of the galvanizing plant is necessary, with regard to the fact that, due to the characteristics of the structure, a special lifting technique or lifting equipment will be needed for effective and safe loading.

If the delivered steel structure elements arrive in wrapping or with rolls, then the client has the decide whether these will be either passed over to the galvanizer as scrap or as wrapping material for the finished product. It might happen that the employees of the galvanizer indicate that the wrapping material is not suitable for the transport of the given structure in galvanized state. In this case the customer and the galvanizing plant have to separately agree in the conditions of wrapping and loading of the products following galvanizing.

8.3. Acceptance of the delivered products in the hot galvanizer

When driving in to the galvanizing plant please prepare your documents received, printed at contracting. The workers of the plant will identify the demands and requirements concerning the given customer based on the information recorded in the contract, as well as other terms of the contract – among others the response time. If the customers do not - for any reason - have any of the mentioned documentation, then the requirements and parameters must be listed for the galvanizer. If the partners have the opportunity, the should fix these parameters before contacting the workers taking the job, thus making the entire procedure much faster.

It is a frequent error that the person appearing on location representing the customer does not have information about the delivered structure, and at the same time he is not in possession of the documents

made during making the deal/order, neither he has their copies. In order to serve the needs and demands concerning the delivered structures, the galvanizing plant needs more time to identify the structures and the related clients, so the process takes longer.

Following delivery and unloading the workers of the plant check the delivered materials and structures. They primarily conduct a galvanizability examination, but they also check whether the structure/piece delivered meets the preliminary notification received from the client. If questions, issues or deviations arise either about the galvanizability of the structure or concerning the preliminary information, the workers checking the pieces summarize their experiences in an *Error Report*. Then this error report is sent to the client concerned via e-mail and sms messages. Contact info is taken from the data previously given by the customer to the galvanizer. Depending on the work load of our colleagues (the number of incoming clients) can they carry out a detailed or just a technical safety check at the acceptance of the goods. If the detailed checking takes place after the delivery (e.g. in the next shift), then - implicitly - the concerned clients will receive the possible error reports only later.

It is crucially important to know that the tracking system used in the galvanizer's plant enables the individual tracking of the structures within one lot only if the delivered materials are sorted by the customers before delivery or upon delivery by the latest, or supervise the unloading carried out by our employees. The structures/accessories unloaded within the same service or shipping unit and provided with a job number can be kept in one piece during the entire galvanizing process. If the products delivered in one lot require different services, or they are going to be delivered to separate destinations by the customer, then we kindly ask the customer to sort the products by service type and destination. In this case each sorted and separated product group will get a separate job number for identification, and these groups will be processed and let out based on their number. The above mentioned things do not have an impact on the bargained galvanization fee.

Because of the above-mentioned, it is prohibited to add materials, pieces afterwards to the structures previously delivered and accepted/arranged in a stack and identified by the galvanizing plant using a job number, because the lot already gone through checking according to the identification will not be checked again, and as a result of this, some materials may enter the technology which were absolutely not inspected.

It is a very important piece of information for the clients, that the workers of the plant can not in each case give the finished structures back in the same packaging and loading form as it had arrived to the factory. The reason for this is that we strive to protect the surface of the galvanized goods against the harmful impacts of shipping and loading. It is a typical problem when the number of sleepers used during the original delivery is not enough. In this case, the galvanizing plant provides the wrapping/packaging material for the client, charging a packaging fee. We also draw your attention that if the wrapping/packaging material applied at delivery is contaminated, our colleagues - in order to ensure superior quality - are going to use brand-new packaging materials, the offset of which will be presented on the invoice issued for galvanizing.

During loading it is important that the customers think of the shipping following galvanization. Because the loading and packaging of the galvanized goods not in each case concur/can concur with the method of loading and packaging used for the delivered untreated products, primarily because of the protection of the zinc coating (e.g. application of sleepers and smaller loading units). In the case of the delivery of small-sized goods, batching of the accessories is necessary. The galvanizing factory has only a limited capacity to do this job - unless the customer made a preliminary agreement on this activity with the factory. If the delivery of small-sized goods is carried out based on a separate agreement, the galvanizing plant provides the labor force needed charging an additional fee.

In the case of some commitment deadlines in order to be able to accomplish the task in a timely manner, the galvanizing plant needs early delivery or one conciliated in advance. Unfortunately, if the delivery gets delayed, for any reason, the galvanization of the structures cannot be guaranteed to be completed within a

day. The reason for this is that fulfilling of the orders of customers delivering timely and delivering structures properly prepared for hot galvanizing enjoys an advantage versus late deliveries. It is not possible to take warranty for the recovery of each error, at the same time, the galvanizing plant cannot exclusively take the responsibility for the resulting galvanizing and/or quality flaws.
It occurs that the unsuitability of the delivered material for galvanizing is not noticeable even with the carefulness of a professional, under factory conditions, so the mutual contribution of the builder of the structure and the galvanizing plant is necessary to examine the raw material quality and galvanizability of the steel structure as well as the conditions determined above.

8.4. On-site repairs of the faulty products

The "black" (not yet galvanized) products delivered to the hot galvanizing plant of NAGÉV GROUP the recipients of the company examine from the galvanizability point of view. If the elaboration, material quality or surface of some of the products does not completely meet the requirements set against the delivered products, then the expert fills out an *Error report*, the contents of which (error, flaw detected, improvement/repair option) are conciliated primarily in writing with the deliverer of the product. Subsequent correction of detected errors is possible at the customer's own site.

We offer an opportunity for the clients to preliminarily approve the possible repairs carried out by the galvanizing plant - concerning a given type and amount of repair work. In this case our employees will send an error report the same way, but this time it is just for information, since the repairs are started - based on the preliminary approval of the clients - without further feedbacks from these clients. Logical, that by this both for the clients and the galvanizing plant the administration and processing of the products becomes smooth.
If the customers did not approve the repairs without notifications, then our employees will send the information related to the repairs to the mobile phone and e-mail contacts provided by the customers. So it is crucially important that the customers provide real and up-to-date contact info.

If NAGÉV GROUP undertakes the repairs of the defects, that can be carried out only after the written approval (to the method, cost and deadline of the repair) of the customer.
In the case of the products repaired afterwards it may happen that the quality of the galvanized product more or less differs from the best quality, perhaps from the requirements specified by the standard (MSZ EN ISO 1461).

With regard to that, that the checking of the arriving goods and the repair of their defects are especially critical events, we draw the attention of all customers that they should be completely aware of the relevant parts of the commitment/undertaking conditions of the given galvanizing plant.

If on the surface of the delivered product such a degree or type of defect can be detected that the usual factory conditions (including other possibilities of the galvanizing factory) do not enable the processing of the product, then these pieces are not galvanized, the customer, following his/its notification, is to transport them away.

8.5. Grading and documentation of hot galvanized products

According to the preliminary indication of the customers, the galvanizing plant can issue manufacturer self-certificates and measuring minutes. There is no possibility to issue "good accomplishment" declarations or warranties on the anti-corrosion protection. The simple reason for this is that the plant

does not have any information about the installation and use of the structures, however, these parameters form ultimately the duration of the protection against corrosion, and describe the local (on-site) corrosive impacts at the installation location of the product. On the other hand the hot galvanizing plant does not have the special knowledge concerning anti-corrosion protection. This does not make a part of its scope of activities, so it cannot issue a legally effective document, the best it can do is to draw its partners attention to the standards and directives to be taken into consideration.

The employees of the galvanizing plant by issuing the manufacturer's self-certification will actually certify the galvanizing process carried out according to EN ISO 1461/DAST Richtlinie 022. The measurement record provides information about the sampled layer thickness measurements carried out according to EN ISO 1461.

8.6. The packaging of hot galvanized finished goods

The galvanizing plant - according to its obligations undertaken in the agreement - carries out the the packaging of the finished products into appropriate stacks by job numbers. During packaging the plant takes into consideration the contract made on the product, and the relevant profesional rules and regulations. The products – if there is no other agreement between the parties about this - are in each case fixed to piles by rust-resistant tying tools (plastic straps). It provides the opportunity of movement with a forklift between the stack rows. The size and weight of the stacks adapts to the possibilities, options of the plant. The rolls or wrappings previously brought in by the customer are used by the plant to package the finished products, or it sends them back to the owner.

The packaging of the finished products sometimes cannot be carried out in such a way as the customers prepared the structures for delivery. The reason for this is that in order to protect the surface quality of the galvanized products, the instable stacks and those exposed to rubbing effect, as well as the contact of galvanized surfaces with contaminated wrapping materials are to be avoided - also, ventilation should be provided for the galvanized materials.

It is practical experience that if the customers arrive with a vehicle for the finished products different (model) from the one used for delivery, it might occur that the galvanized structures cannot be shipped with the new vehicle because of the different stacking/packaging (e.g. due to a larger amount of sleepers the height of the stacks increases and the do not fit in the cargo hold.

8.7. Storage of freshly hot galvanized products

Because of the limited storage area of the galvanizing plants - the freshly hot galvanized, after-treated and packaged products are stored in the outdoor warehouse area of the plant, or if specifically requested (recorded in an agreement), in an external, covered storage facility. During the outdoor moving and storage a slight superficial corrosion may form (zinc-oxide formation) on the surface of the freshly coated products, which is a natural part of the formation of the protective zinc layer. This later on transforms into, becomes part of the zinc patina. If the client wishes to avoid it, it has to make an agreement in advance with the galvanizing factory.

In most of the cases the storage of the finished structures is possible on the area of the galvanizing plant, but the customers must gather information about the conditions of storage from the employees of the plant.

8.8. Acceptance and shipping of products

The place of quantitative and qualitative acceptance of the galvanized products is the premises of the galvanizing factory. During acceptance the contracted partner or his assignee without limitations entitled to represent him may proceed. The attendance and acceptance of the person with the above authorization is extremely important because for the majority of errors, mistakes related to loading and shipping their place and time of occurrence is very difficult to determine afterwards. Moreover, in almost all of the cases, after the shipping carried out by the customer more loading and shipping may follow. In the case of the damages, quality defects occurring during the further activities, their place and time of occurrence is again very difficult to determine.

If the customer did not request the issue of a layer-thickness measurement minutes *before* the delivery of the goods, then the factory cannot be obliged to examine the thickness of zinc coating and evaluate the outer appearance of the product *afterwards*. By signing the exit document or gate-ticket necessary to exit from the area of the factory the customer or his representative certifies the quantitative and qualitative acceptance of the galvanized products (certificate of accomplishment).

The loading of the galvanized products can exclusively be carried out by the employees of the galvanizing plant. Checking during loading is the task of the customer or his representative proceeding upon his authorization, the freighter. For the fixing of the goods loaded on the vehicle the freighter is responsible.

8.9. Complaints

The customers have the opportunity to make complaints about the quality of galvanizing even after leaving towards the galvanizing plant – with special regard to those problems which he did not have the chance to spot during the acceptance of the goods, or perhaps those defects which are found when installing the structures. All quality complaints must be submitted in writing. In order to enable the galvanizing plant to examine the complaint/defect in question, and recommend a professionally, technically appropriate repair procedure for the customer – it is prominently important that the clients immediately inform the workers of the galvanizing plant about the defects found. Te customers in each case are informed about the procedure of complaint processing, and the progress made.

9. Rules and regulations effective in a hot galvanizing plant

The entrepreneur draws the Customer's attention that in its premises occupational safety, fire control, environmental protection regulations are in effect and also rules for smoking and the use of the driver waiting room, and confidentiality, which have been hanged for information of the guests in the Guest Waiting Room and the customer service office. From the entrance to the premises of the Entrepreneur until leaving the premises, the Customer or his/its representative is obliged to keep the above-mentioned rules and regulations.