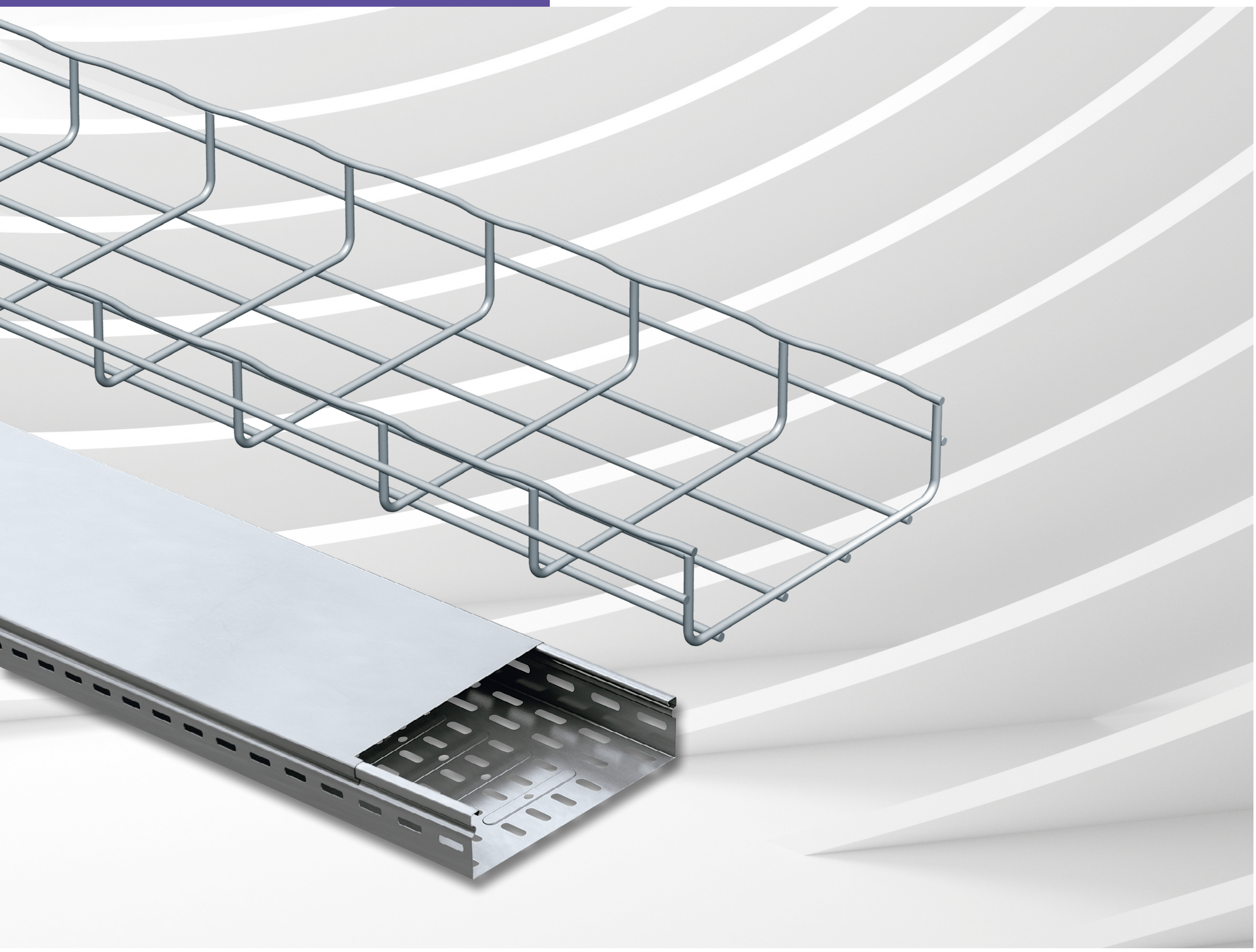
WHITE
PAPER

CABLE TRAYS

ADAPTED COATING FOR CORROSIVE ENVIRONMENTS



#Legrand**ImprovingLives**

LEGRAND SUPPORTS YOU ON ALL YOUR PROJECTS

Legrand's offer of global solutions for wiremesh cable trays (and accessories) is one of the most complete on the market.

It offers true freedom by allowing multiple configurations in a wide choice of finishes for optimal integration into any environment.

Legrand wiremesh cable trays are resistant to corrosion thanks to the various available surface treatments. There is a solution for each type of environment.

This white paper compares the High Resistance (HR) and Hot-Dip Galvanising (HDG) solutions and highlights the new High Resistance range, ZnAl wiremesh, ZnMg metal cable trays and accessories and ZnNi screws and bolts.

LEGAL INFORMATION

Presentation pictures do not always include Personal Protective Equipment (PPE), but this is a legal and regulatory obligation that must be scrupulously respected.

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summary

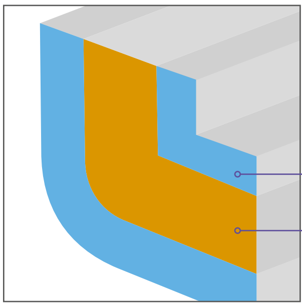
CORROSION RESISTANCE

The primary function of a cable tray is to be a durable, efficient and resistant support.

A recurring theme in all metal applications, uncontrolled corrosion can result in poorer performance and affect the installation's life expectancy, through chemical or electrochemical reaction. The cable tray is exposed to an environment which can be more or less aggressive and thus be a source of corrosion.

Environmental corrosion: when a steel (Iron + Carbon) is in contact with a catalyst and Oxygen, Iron Oxide forms on the surface (red rust). There are two types of protection:

- structures such as stainless steel that are self-protecting (Chromium Oxide - passivation)
- chemical barriers - sacrificial effect, e.g. by Zinc. As long as there is enough Zinc protection left on a steel part, the Zinc will oxidize before the steel starts to rust.



"Corrosion is an unavoidable and natural phenomenon, and we have to take it into account when designing our cable tray systems", according to Cablofil's Marketing Manager.

Hot-dip galvanising by immersion in a bath of molten Zinc at 450°C (850˚F), has been around for more than 150 years, and no longer has to prove itself. Long used in the automotive industry as an anticorrosive protection, the new High Resistance (HR) alloys including Aluminum and Magnesium have however gradually replaced the Hot-dip galvanising process. As such, on a global scale, vine trellis wires, gabions as well as guardrails are now mostly made of Aluminum Zinc or Magnesium Zinc for more than a decade.

Hot-dip galvanising is not suitable for small parts or fasteners, without significant rework, because of its significantly variable thickness. In addition, the thermal shock of the bath heat would deform the thin elements.

Zinc rich coating is a common process used for this type of part, and requires only a temperature of 280°C (536°F) or less, either by centrifuging or spraying. The thickness of the coating (coated Zinc and Aluminum flakes) is thinner than Hot-dip galvanising.

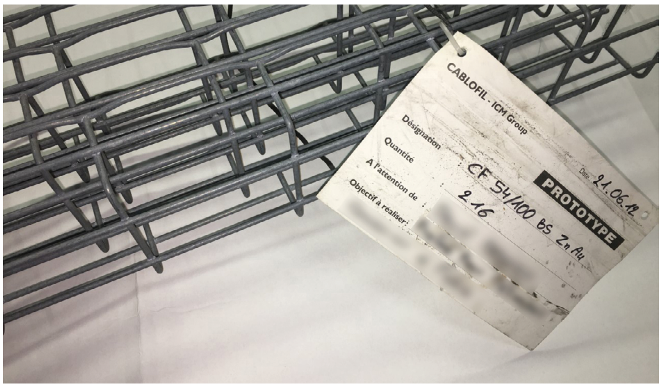
There are different methods to check the durability of steel parts. Some are standardized, others are empirical.

According to IEC 61537, a cable tray system is considered compliant when the red rust surface (Fe_2O_3) is less than 5% of the product surface.

Outdoor testing

With its multiple production centers and international presence, Legrand has undertaken a 10-year program of full-scale tests on various continents.

ZnAl cable tray in 2012:



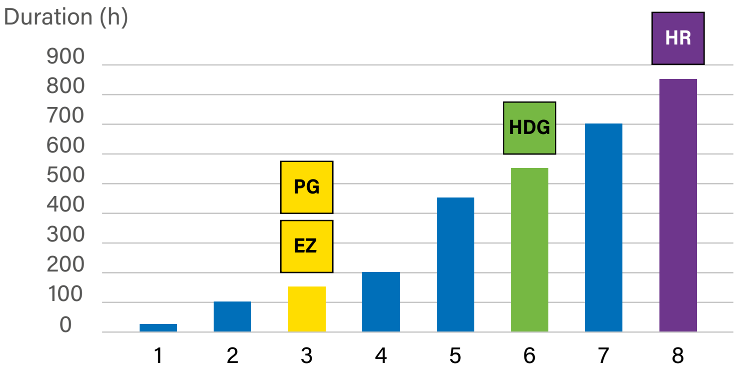
In parallel, two types of test, which are certainly open to criticism for their realism in relation to a given environment, have the advantage of being easily reproducible and are standardized: the salt spray test and the sulfur test. With each time determined characteristics such as temperature, hygrometry and pollution that can be reproduced in the laboratory.

Since the manufacturing processes for wiremesh, metal cable tray or small accessories are slightly different, it is interesting to make a comparison in order to observe which products or processes lower the performance of the system.

HR and HDG products can be mixed without difficulty, with negligible risk of galvanic corrosion. But the performance of the system will be limited to the characteristics of the HDG (Class 6).

Salt spray test

The salt spray test (neutral salt spray) according to ISO 9227 is the most common and recognized test for cable trays, reference IEC 61537:



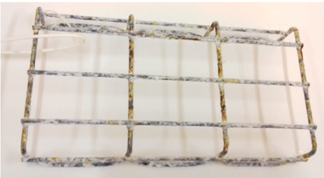
Hot-dip galvanised (HDG) products are class 6 according to IEC 61537. Cablofil and Legrand High Resistance products have a minimum resistance of 850 hours in the salt spray test and are class 8.

The cyclic neutral salt spray test using a Sodium Chloride solution (NaCl 5%) at neutral pH and a temperature of 35°C according to ISO 9227 is a standardized evaluation of the corrosion resistance of metallic materials, allowing a relatively quick comparison between several products.

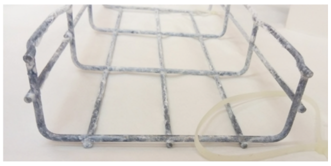
CORROSION RESISTANCE (CONTINUED)

Salt spray test (continued)

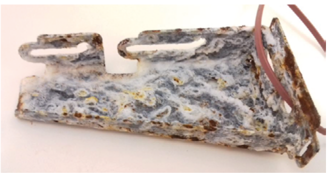
CF 54/200 HDG 850 h salt spray test:
- Rust greater than 5%
- Products are no longer compliant



CF 54/200 ZnAl 2000 h salt spray test:
- White rust spread, no red rust

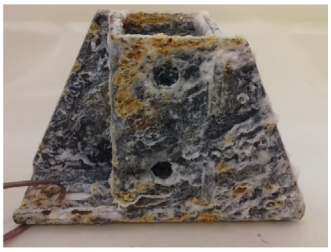


HDG Compact Bracket 1250 h salt spray test:

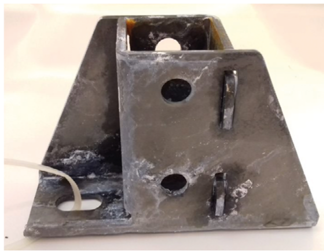


ZnMg Compact Bracket 1250 h salt spray test:

PFN41S HDG 850 h salt spray test:



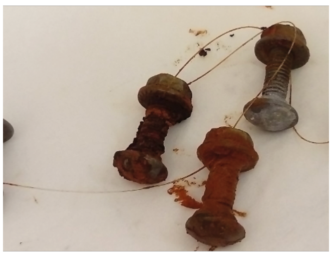
PFN41S ZnNi 1250 h salt spray test:



HDG rail thickness 2 mm 1200 h salt spray test:

ZnMg rail thickness 2 mm 1200 h salt spray test:

BTRCC Zinc rich coating 2000 h salt spray test:
- The loss of mass is important

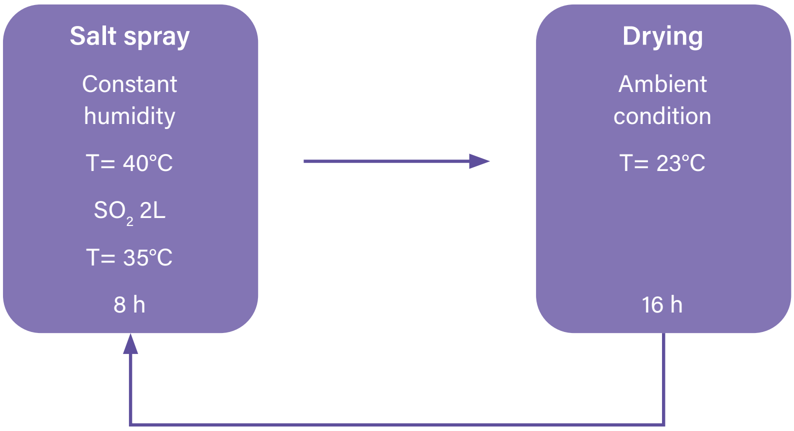


BTRCC ZnNi 2000 h salt spray test:
- Products are still compliant

When hot-dip galvanised at 850 hours, the products are no longer compliant. At 2000 hours, they are almost completely covered with red rust.
According to EN ISO 14713-1, it is accepted for Hot-dip galvanising that the Zinc loss in marine environments (C5*) is at least 4 to 8 µm per year. We observe that this is not the case for alloys such as ZnAl and ZnMg, which have a much smaller loss.

Sulfur Dioxide test

The salt spray test cannot be the only test to be used to assess corrosion in critical environments. That is why we recommend additional tests to ensure that the surface treatment chosen is optimal for the environment in which the product will be used. The Sulfur Dioxide test (SO_2 test, or also known as “Kesternich” test) is an excellent complementary test to be performed in the laboratory.



Test results:

24 h, EDRN in Zinc rich coating (to be associated with HDG):

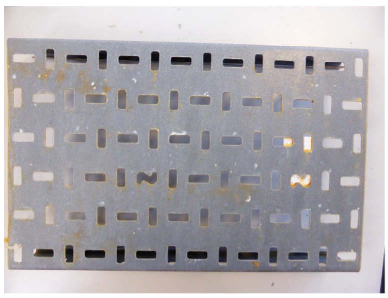
- Red rust > 5%

24 h, ZnNi EDRN (to be associated with ZnAl):

- None present

Cable tray HDG 55 µm.
Appearance of red rust at 384 h

Cable tray ZnMg.
Appearance of red rust at 456 h



Zinc Nickel and Zinc Magnesium alloys withstand this type of test better than Zinc flake and hot-dip galvanised.

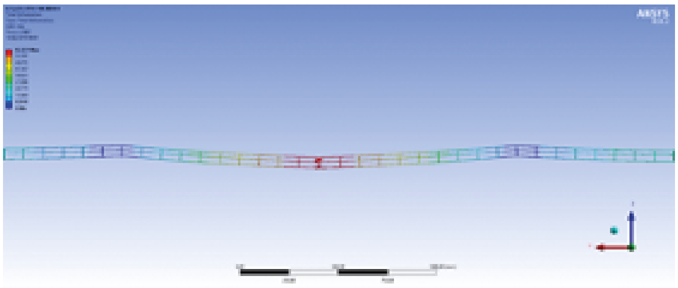
MECHANICAL RESISTANCE

The mechanical strength of cable trays is determined by the steel's ductility, yield strength and elongation at break, but also by its weldability. The protection or coating does not influence the mechanical strength. It can be considered that a steel, protected by electro-galvanising, a Zinc Aluminum alloy, a Zinc Magnesium alloy or a hot-dip galvanised steel keeps the same mechanical strength.

There is no difference in the loading according to the finishes.

However, the porosity and friction coefficient of ZnMg and ZnAl surfaces are significantly lower than for HDG surfaces.

As a result, the cables slide better on the HR surfaces, there is less dust creation, and cable pulling is easier.



For all that, the Zinc layer on hot-dip galvanised products is relatively thick (55 µm). In cases where the HDG coating would be thicker than 85 µm, the effect would be counterproductive for two reasons:

- **Corrosion,** the thicker the coating, the more brittle it is and has a tendency to crack, create cracks that are sometimes visible to the eye or even to come off. According to EN ISO 1461, adhesion tests may be necessary when parts are subjected to mechanical stress. According to EN ISO 1461 table 1 annex D, the maximum possible thickness on a steel substrate of minimum 6 mm accepts a HDG layer of maximum 85 µm.
- **Weight,** on the average, the HDG 55 µm finish makes cable trays 7% to 10% heavier than the Zinc Aluminum or Zinc Magnesium finish, especially on thin-walled or reactive steels. Increasing the galvanising thickness would be tantamount to reducing the load capacity.

China has a capacity of more than 110 million tons of Zinc and Zinc alloy treated steel sheets (ZHANG Qifu, JIANG Sheming, Development of Zinc and Zinc-alloy Coated Steel Sheets in China, p.1 of National Engineering Laboratory of Advanced Coating Technology for Metals, China Iron & Steel Research Institute Group). According to the China Automotive Industry Association (CAAC), China's vehicle sales reached 25 million in 2020. Weight is one of the major reasons for the shift from HDG to ZnMg alloys in the automotive industry in recent years. This phenomenon has accelerated with the advent of electric cars.

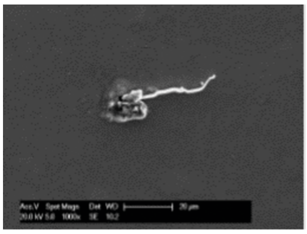
CABLE TRAYS

ZINC WHISKERS

Whiskers have been a recurring topic of conversation since the 1940s. It started with tin whiskers and has continued in recent decades in the data center environment with Zinc whiskers.

Without going back to the consequences that these whiskers can have in a computer room, which are not always proven, it is well known that pure Zinc filaments can be created under certain conditions on the surface of galvanised steel, where the Zinc atoms are subject to compression. These filaments, with an approximate diameter of 2 µm, can then detach themselves and stick to electronic boards or electrical components, without any harmful effects being demonstrated.

Zinc whisker, x 1000



Zinc whiskers can be found on other finishes. To date, no such filament creation phenomenon has been observed on pre-coated finishes (ZnAl/ZnMg), as well as on Zinc-Nickel alloys or Hot-dip galvanising.

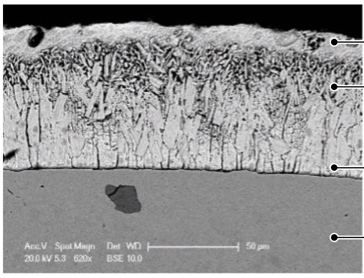
In the data center environment, where temperature and hygrometry are controlled and pollution is non-existent, Cablofil recommends an electro-galvanised finish, as do manufacturers of servers, switches or electronics who use this process for their chassis and covers. The threat of Zinc whiskers is considered negligible, in contrast to electrostatic risks.

APPEARANCE

Scanning Electron Microscopy observation

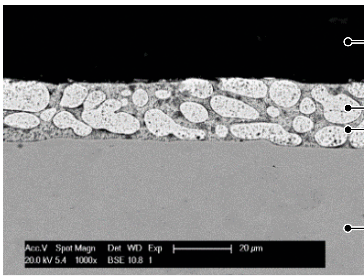
The most efficient way to observe products is probably the use of a Scanning Electron Microscope (SEM).

Cross-section HDG 55 µm x 620



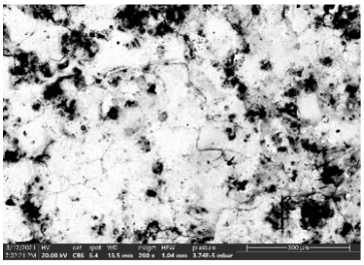
On the steel support, the galvanisation coating is composed of a layer of Iron Zinc alloys, followed by a top layer of pure Zinc.

Cross-section HDG 55 µm x 1000

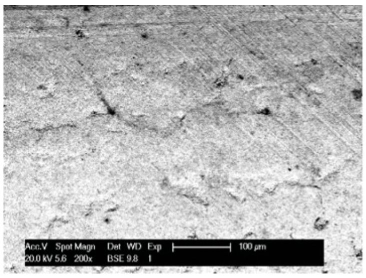


On the steel substrate, a thin Aluminum layer is formed, covered with a relatively homogeneous Zinc Aluminum alloy.

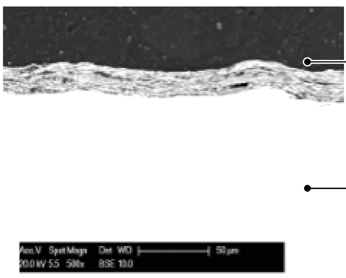
Surface HDG x 200



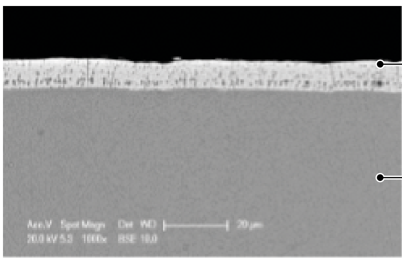
Surface ZnAl x 200



Cross-section ZnL x 500



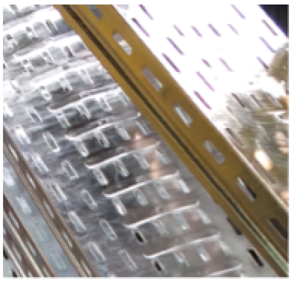
Cross-section ZnNi x 1000



General appearance

▪ Steels Post-treated with hot-dip galvanisation

Hot-dip galvanised products (wire and sheet) have an appearance that varies depending on the environmental exposure where they are installed or stored.



EXAMPLE: P31 hot-dip galvanised at the end of production

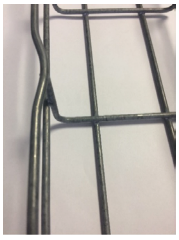
The appearance of the coating on a hot-dip galvanised product varies depending on the steel. Those with less than 0.03% or 0.04% Silicon (Si) promote a nice uniform appearance, while those containing Phosphorus (P) are more reactive, with a more matte, mottled or rough appearance.

This process, conform to EN ISO 1461 must be chosen for its performance above all rather than for its aesthetics.

On delivery of the products, a thin white film (Zinc Hydroxide) may be noticed **which does not affect the resistance to corrosion.**

▪ Pregalvanised/Precoated Steels

Zinc Magnesium products are aesthetically very similar to PG products, smooth, with very few irregularities.



Zinc Aluminum products have a matte, low gloss appearance. On close inspection, slight dullness, veils or white halos can sometimes be observed:

Tarnishing on the wire

White veil

Blackening on the end of the wire

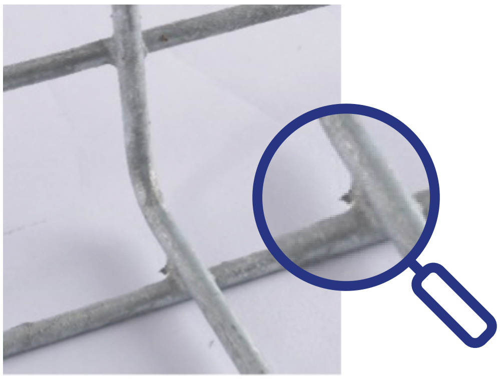
White halos on the weld

APPEARANCE (CONTINUED)

Zinc flakes

When Hot-dip galvanising, the immersion of steel in a 450°C (850˚F) molten Zinc bath, can create residual Zinc droplets, pimples, beards, veils or drips ("Zinc flakes").
The standard EN ISO 14713 chapter 5 and 6 determines the quality of the Zinc layer for Hot-dip galvanising.

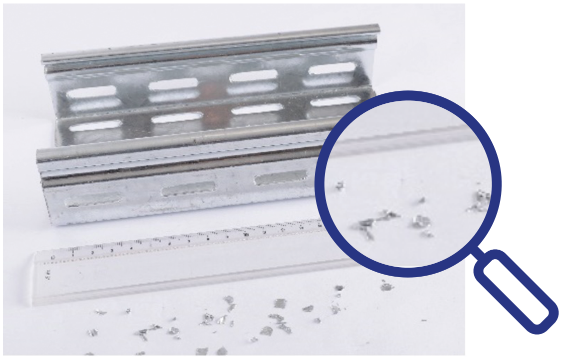
Zinc flakes and drops on wire and sheet metal cable trays



An excess thickness is tolerated as long as it is not sharp, annoying or dangerous for the product's purpose. A perpendicular observation at a distance of one meter, without visual assistance, without revealing any disturbing effects, is considered acceptable (according to EN 13438).

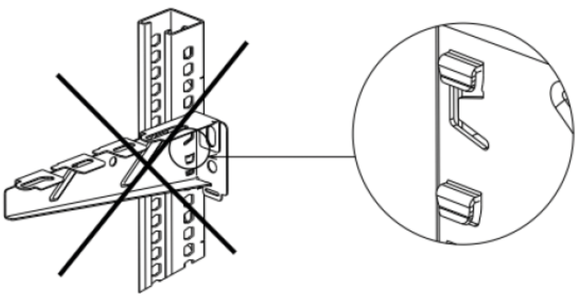
There are ways to limit the creation of Zinc drops (e.g. vibration), but human intervention is almost always required to eliminate sharp or annoying flakes at certain points. It is difficult to obtain cable trays without any flakes. The labor involved in this operation is important because the irregularities removed must not remove the Zinc layer to the steel substrate. It is also important because the rear fastening points must be treated with a Zinc-enriched paint.

HDG deburred parts:

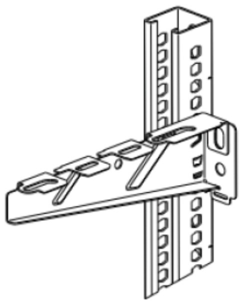


Coating thickness:
In some cases, the thickness of the Hot-dip galvanising can be problematic. In some cases, some products cannot be mounted. For example, the configuration of a CB support in HDG on a HDG rail with screwless hook. In this case, the CB ZnMg on ZnMg rail is recommended.

HDG



ZnMg



APPEARANCE (CONTINUED)

Natural development

For hot-dip galvanised products, the gloss decreases with time:

If water stagnates on a hot-dipped galvanised surface, it prevents the formation of a layer called patina, and whitish stains, mainly consisting of basic Zinc Oxide and Hydroxide, quickly appear. The white rust is only visually objectionable, and can be removed with a pressure washer followed by a quick drying.

White rust on a cover

For Zinc Aluminum, after a few weeks of manufacturing:

1) The color becomes more homogeneous.
2) Potential twisted, white or black marks disappear. But to a lesser extent, the product is sensitive to white rust.
3) It may have some slight traces of red rust at the end of unprotected wire due to cuts during the manufacturing process. The product will mat over time during outdoor storage. Self-repair occurs and the ends become covered with a grayish white protective coating with some red rust. Some of the red rust may remain, but this is only cosmetic, there is no loss of mass.

Superficial red rust on the cut

4) The product matifies

CABLE TRAYS

BEHAVIOR UNDER CUTTINGS

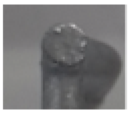
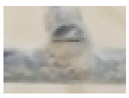
After production

The Zinc Aluminum coating has the advantage of a “healing” effect of the cuts made according to Legrand’s instructions.

The principle of this self-healing effect is quite simple. At the initial corrosion stage, the coating is inhibited by a thin layer of Aluminium Oxides that appears naturally at the surface of the coating. At advanced corrosion stages, the corrosion products of Aluminium covers the surface with a compact whitish layer that hinders the corrosion progression.

This layer swells and covers adjacent areas not covered by the Zinc Aluminium coating (for example, the scratches through the coating). Edges are firstly protected by the sacrificial protection given by the Zinc (galvanic effect), and later by the corrosion products of Aluminium that covers progressively the edges. The protective layer covers completely or partially the section.

Large wire diameters can thus show a very little visible residual spot of red rust in the center of the wire, but without any risk of propagation in depth, in the heart of the wire. The effect is more or less rapid (in the months following installation) depending on the conditions of exposure of the products.

Life expectancy Salt spray test	HDG		ZnAl	
After production		Cut and hot-dip galvanised		Cold cut
After 48 h salt spray test		Protection by Zinc its quantity decreases		Creation of a thin layer of Aluminum Oxides the edge is protected
After 850 h salt spray test		Rusty product		No or little red rust
After 2000 h salt spray test	Products too degraded			White rust in majority no presence of red rust at this stage

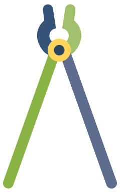
Thanks to its T-weld*, the number of visible cuts on Cablofil cable trays are only at the ends and represent a very small part of the cable tray.

As an example, the ratio $\frac{\text{ratio endpoints}}{\text{total surface}}$ of a CF54/300 is 0.61%.

Since the sacrificial effect on the bevels is limited, additional Zinc protection would be required.

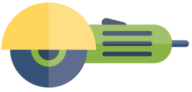
Means of cutting on site

- **Cuty fil, or bolt cutter**



On the wire, this is the cutting tool to use. The buttering effect is important. The use of a spray paint containing more than 90% of Zinc dust is recommended on ZnAl, to avoid having unsightly slices. This protection is mandatory when cutting hot-dip galvanised products to avoid corrosion. The support must be clean in order to have a good hold.

- **Grinder**

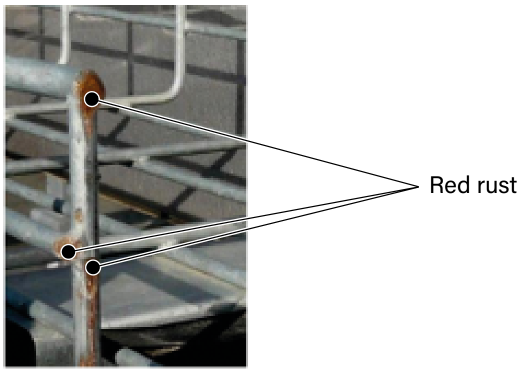


Note that this tool may require a fire permit. Cutting with a grinder should be avoided for two reasons:

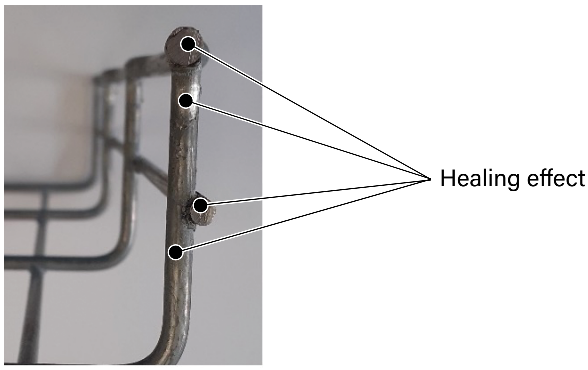
- The first is that for HDG, as for ZnAl or ZnMg, there is a creation of dust, which must be avoided, even if the risk is visibly below the occupational exposure limit value (e.g. French regulation: section 8 FDS VLEP).
- The second is a risk for the corrosion resistance of the products. It splits the slices at very high temperatures during its passage, leaving black burn marks and strong asperities in the form of steel shavings that often need to be filed off. The ends of wire cut with a grinder are damaged and have a degraded protection, whatever the finish. Trying to make nice bevels with this tool is a risk that can lead to corrosion on all parts touched by the disc without realizing it at the time.

After 14 days in a C3* (ISO 9223) environment, on the parts affected by the grinder, we can observe:

On a HDG product, the appearance of red rust.
There will not be a sufficient healing effect to reprotect this part.



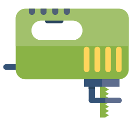
On a ZnAl product, the significant healing effect.
But the affected parts will be weakened against corrosion attacks.



The only recommendation to avoid corrosion when using the hot grinder on ZnAl, ZnMg, HDG, or even electrogalvanised, is to use a dedicated paint.

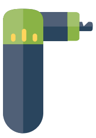
*See table describing the categories in the appendix on page 22.

- **Jigsaw**



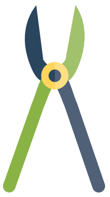
This is the tool of choice for cutting sheet metal. It is fast but causes vibrations of the cable tray, it leaves some steel wires and has a good buttering effect. However, the use of a dedicated paint on the cuttings of HDG products is mandatory.

- **Notching machine**

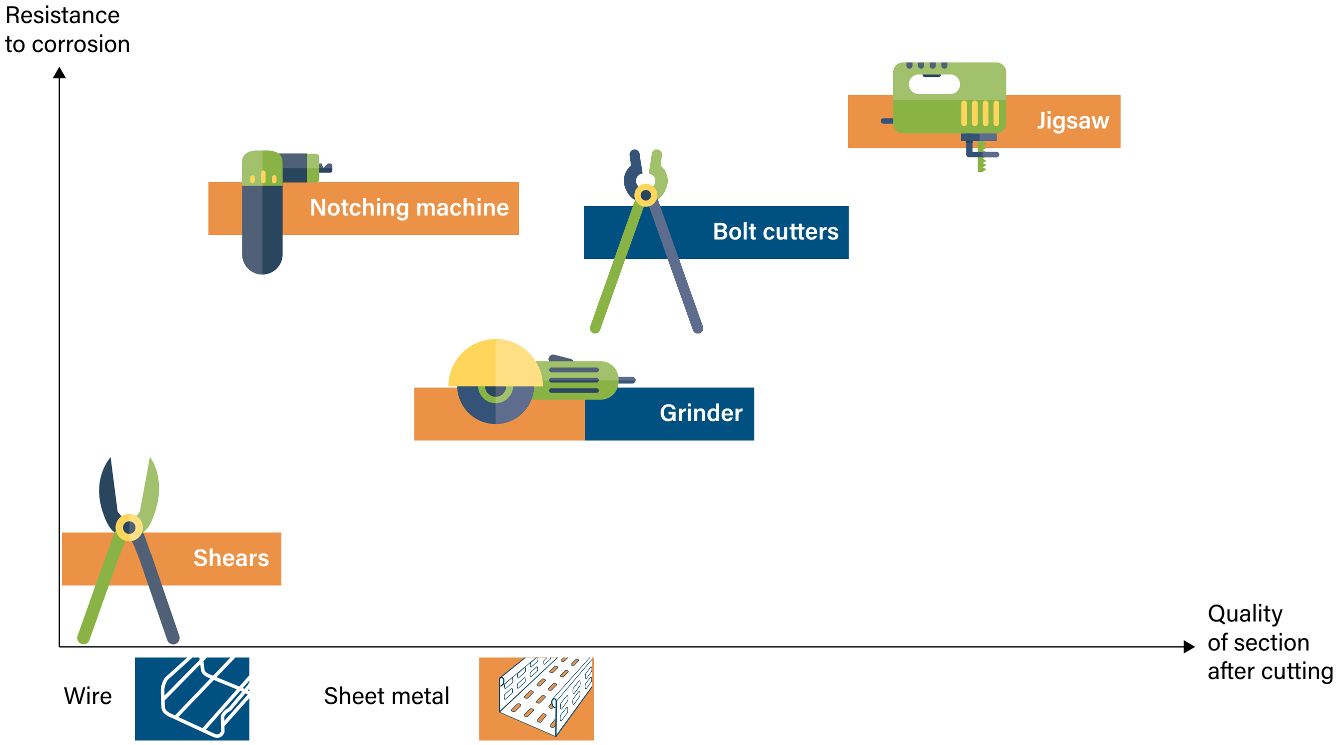


Effective for cutting the bottom of the cable tray. It is more difficult to use in the shelves and can cause local deformation that can lead to stresses when mounting the splice bars. The use of a dedicated paint on the cutouts of HDG products is mandatory.

- **Shears**



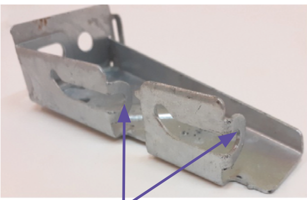
Not suitable for cutting cable trays which have complex geometries. The cutting action is more likely to result in the material being torn away, partially or totally eliminating the Zinc protection, and should therefore be avoided.



Zinc Aluminum or Zinc Magnesium products react very well to cutting. The healing effect is significant. For HDG products, the healing effect also exists, but it is more limited. For example, a cut HDG wire would immediately start to corrode, hence the obligation to reprotect cuts, important scratches or other injured parts on the site.

OVERLAPPING PHENOMENON AND PROTECTION OF FOLDED PARTS ON SITE

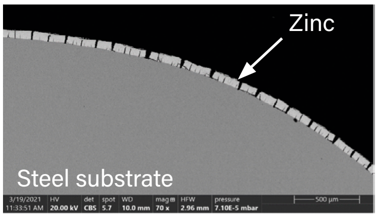
The cable trays can be folded on site to adapt to changes in layout and branching, or even to ensure the rigidity of the system:



Folded parts on site

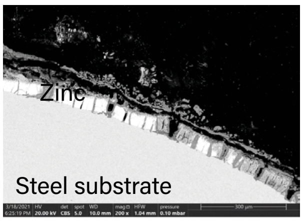
When folding a sheet or wire HDG already coated, we can see that there is a deterioration of the galvanised coating, on the inside and outside of the product, exposing the steel in the bottom of cracks:

Cross-section HDG x 70 before salt spray test

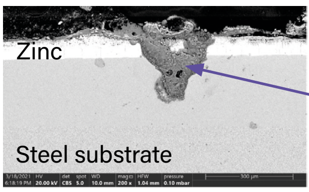


Gradually, the bottom of these large cracks is covered with a layer of Zinc Oxide, thus protecting the steel. The finest cracks are filled with Zinc Oxides.

Cross-section HDG x 200 after fold then after 550 h salt spray test

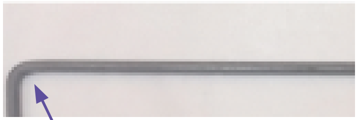


In some places, we can note the presence of Zinc Oxide in the thickness of the coating but also Iron Oxide, the corrosion has crossed the Zinc layer to spread to the substrate:



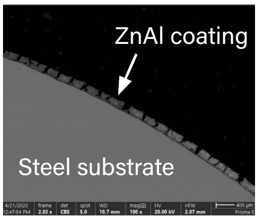
Iron oxides

The cracks were partially filled, sometimes completely in some places, by the Zinc Oxides formed during the test. There is a fairly good healing effect.



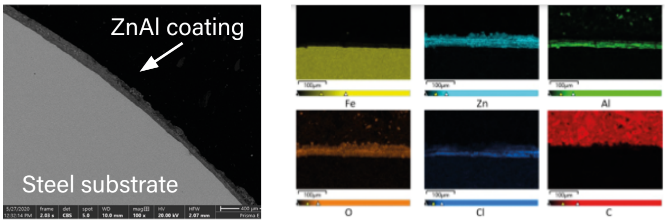
Folded ZnAl wire

Cross-section ZnAl x 100 before salt spray test



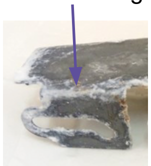
Cracks are observed in the coating mainly on the outside of the fold. After 850 h of salt spray test, the cracks are no longer visible.

Test after 850 h salt spray test - SEM x 100

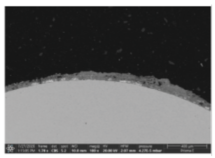


For ZnMg the cracking phenomenon is similar to ZnAl, as well as the phenomenon of overlapping and protection:

Folded ZnMg sheet



ZnMg x 100 after deformation and 2000 h salt spray test:



→ Folded HDG products are potentially susceptible to accelerated corrosion and can be protected with additional protective paint to ensure durability. ZnAl and ZnMg react very well to deformation and the healing effect is very important.

CABLE TRAYS

RESPECT FOR THE ENVIRONMENT

ZINC CONSUMPTION

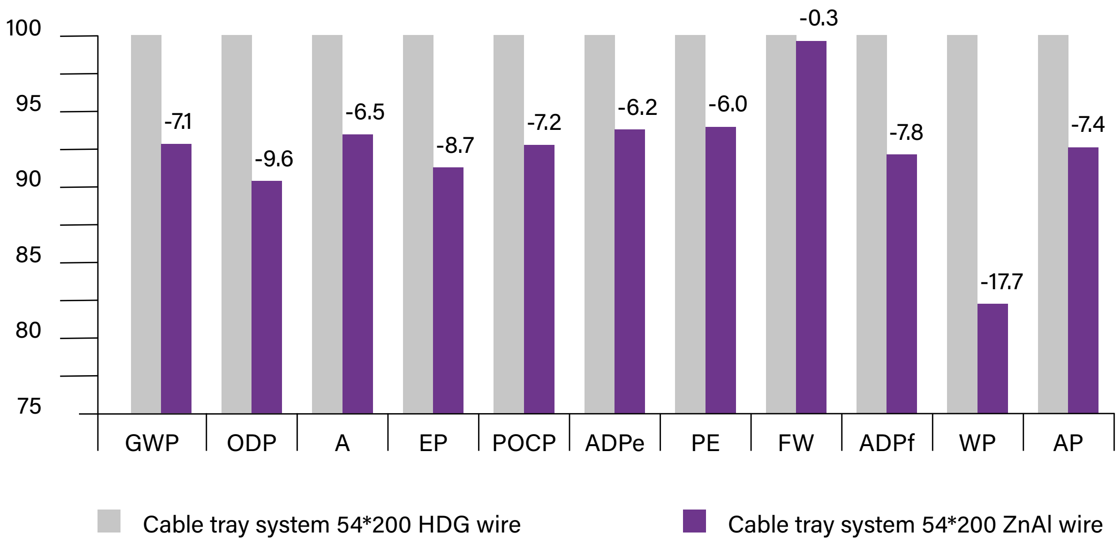
According to the study published by Statista Research Department in 2020, there are about 180 million tons of Zinc on Earth. Mostly in Australia, China, Mexico and Peru. At the current rate of consumption, there is less than 20 years of consumption left.

Only 30% of the Zinc used in the world comes from recycled Zinc. Zinc Aluminum Magnesium alloys release 6 times less Zinc Oxide (ZnO) than Hot-dip galvanising into the ground due to the stability of its anti-corrosion coating.

PEP EXAMPLE (PRODUCT ENVIRONMENTAL PROFILE)

PEP eco PASS PORT®

The ZnAl and ZnMg finishes stand out thanks to their eco-design. For example, the contribution to global warming for ZnAl (noted GWP and expressed in kg CO^2 eq.) is 7.1% lower than that of the standard HDG finish (Hot-dip galvanising).



Based on a study carried out in France, on all the stages of the life cycle of the Reference Product (54 x 200 system), i.e. manufacturing, distribution, installation, use and end of life, the Cablofil ZnAl cable tray system is systematically less impacting or equal from an environmental point of view than its hot-dip galvanised equivalent.

Comparison according to PEP France data "HDG" wire Cable tray system certified 2020 and "for corrosive atmospheres" Cable tray system certified 2019 (on an identical calculation basis: EIME & database CODDE-2018-11) according to PEP Ecopassport rules PSR-0003-ed1.1-EN-2015 10 16 - 3.2.2.1. Cable tray systems.

RISKS OF POLLUTION DUE TO CORROSION

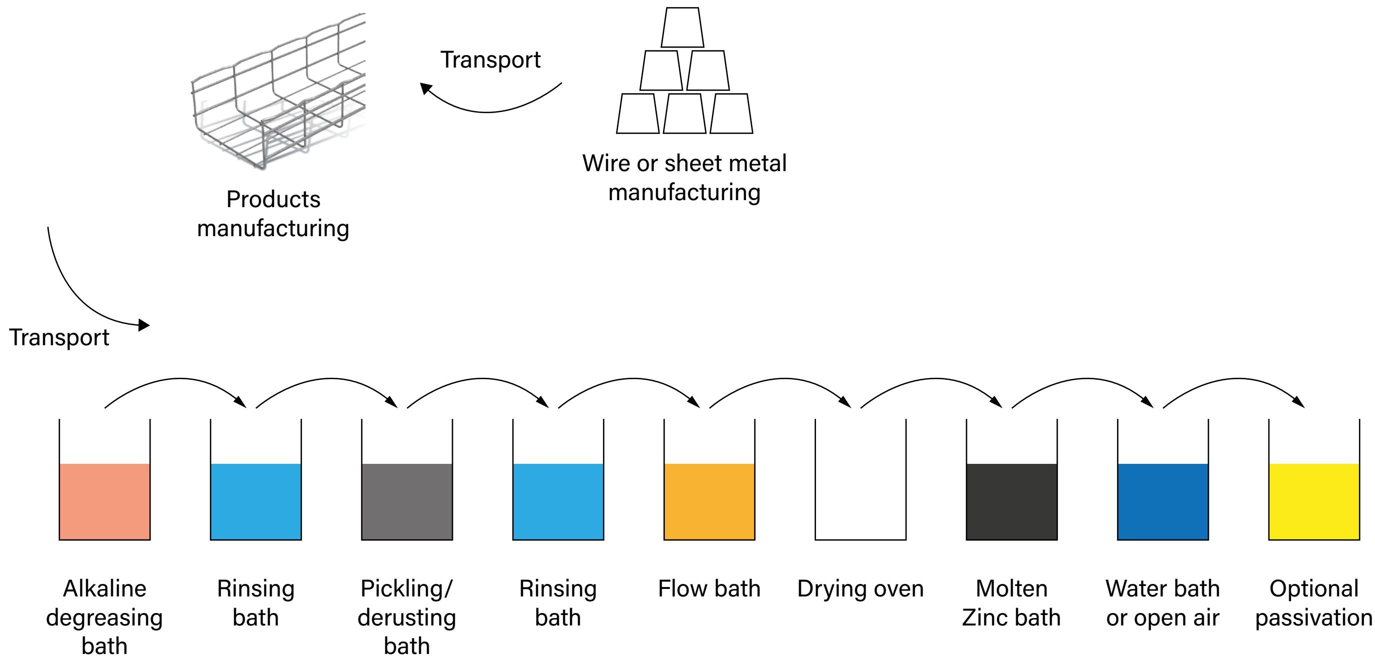
According to the study by Gerhardus Koch, Jeff Varney, Neil Thompson, Oliver Moghissi, Melissa Gould, and Joe Payer, in the 2016 NACE International impact study 'International Measures of Prevention, Application, and Economics of Corrosion Technologies', *"corrosion is a major industrial problem: the overall cost of corrosion, which covers all the means of combating corrosion, the replacement of corroded parts or structures and the direct and indirect consequences of accidents due to corrosion, was estimated at 3.4% of the world gross product in 2013".* Every second, some five tons of steel are transformed into Iron Oxide. One can easily imagine the important pollution induced for unprotected or badly protected products.

RESPECT FOR THE ENVIRONMENT (CONTINUED)

RISKS OF POLLUTION RELATED TO THE PROTECTION PROCESSES

- Hot-dip Galvanising process

Before hot-dip galvanising, the metal must be cleaned (degreased, pickled, rinsed), often treated with solvents or hydrochloric acid (HCl). This process produces water pollution, fumes and solid waste such as Zinc ash and Zinc matte.

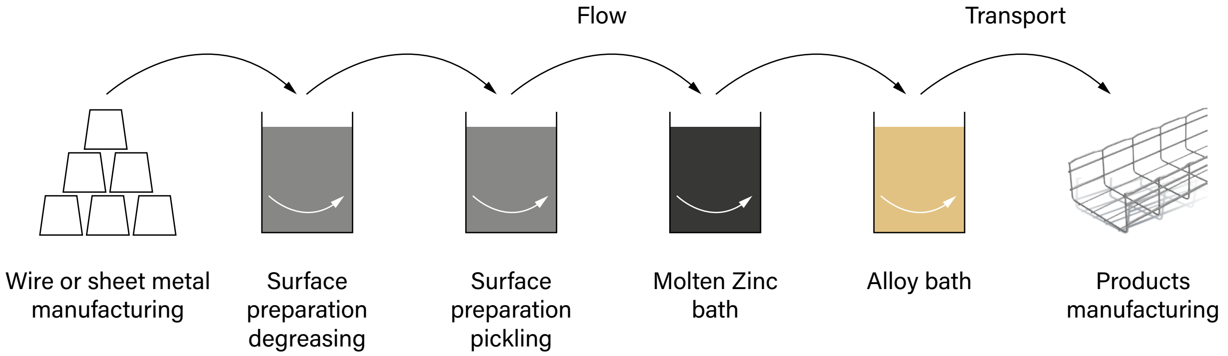


The molten Zinc baths are energy consuming and cannot be shut down on weekends or vacations. The high temperature and the Zinc tend to eat away at the structure of the crucibles (steel tanks), and they also have to be changed regularly to avoid the risk of incidents and the spread of Zinc on the production site, which often requires several weeks of shutdown.
Plants have often been modernized to limit this pollution and recycle some of the waste, but not all plants in the world have the same level of prevention and control, and are not subject to the same standards.

In the past, there have been legal actions against manufacturers who were less careful about this pollution, such as the residents of Graham in the United States, with the help of BREDL, against the galvanizer South Atlantic in 2012.

- ZnAl and ZnMg process

There is also pollution created during the manufacturing of Zinc Magnesium or Aluminium products. But the simplified process and the reduction of the baths make it a less impacting element on the environment:



The HS (High Resistance) alloys used in ZnAl (Zinc Aluminum), ZnMg (Zinc Magnesium) or ZnNi (Zinc Nickel) cable trays have an excellent resistance to corrosion, especially in salt spray tests, and in particular on the screws and bolts, which are often the Achilles' heel of HDG (Hot-dip Galvanising) installations. Healing after cutting and bending is excellent.
The lighter weight of the finish is an important asset. The environmental impact of these finishes is reduced.

APPENDIX

Description of typical atmospheric environments related to the estimation of corrosivity classes (from ISO 9223 standard)

CORROSIVITY CATEGORY[1]	CORROSIVITY	STANDARD ENVIRONMENTS - EXAMPLES[2]	
		INDOOR	OUTDOOR
C1	Very low	Heated spaces with low relative humidity and low pollution (offices, schools, museums)	Dry or cold zone, environment with minimal atmospheric pollution and very short-lived humidity (some deserts, Arctic, central Antarctica)
C2	Low	Unheated spaces with variable temperature and relative humidity. Low incidence of condensation and low pollution (warehouses, sports halls)	Temperate zone, environment with low atmospheric pollution (SO_2 < 5 µg/m³) (rural areas, small towns) Dry or cold zone, atmospheric environment with short-lived humidity (deserts, subarctic region)
C3	Average	Spaces with moderate incidence of condensation and moderate pollution resulting from production processes (food processing factories, laundries, dairies)	Temperate zone, environment with average atmospheric pollution (SO_2 = 5 µg/m³ to 30 µg/m³) or moderately affected by Chlorides (urban areas, coastal areas with few Chloride deposits) Subtropical and tropical zones with low atmospheric pollution
C4	High	Spaces with high incidence of condensation and severe pollution resulting from production processes (industrial processing plants, swimming pools)	Temperate zone, environment with very high atmospheric pollution (SO_2 = 30 µg/m³ to 90 µg/m³) or affected by Chlorides (polluted urban areas, industrial zones, coastal areas with neither splashing seawater nor exposure to the powerful effect of de-icing salts) Subtropical and tropical zones with average atmospheric pollution
C5	Very high	Spaces with very high incidence of condensation and/or very high levels of pollution resulting from production processes (mines, deposits for industrial exploitation, unventilated sheds in subtropical and tropical zones)	Temperate and subtropical zone, environment very with high atmospheric pollution (SO_2 = 90 µg/m³ to 250 µg/m³) and/or strongly affected by Chlorides (industrial areas, coastal areas, protected sites on the shoreline)
CX	Extreme	Spaces with almost permanent condensation or prolonged periods of exposure to extreme effects of humidity and/or high levels of pollution resulting from production processes (unventilated sheds in humid tropical zones allowing penetration of extreme pollution, including Chlorides in the air and particular materials which encourage corrosion)	Subtropical and tropical zones (very long persistence of humidity on surfaces, environment with very high atmospheric pollution (SO_2= content higher than 250 µg/m³) including accompanying factors and production and/or strongly affected by Chlorides (extreme industrial zones, offshore coastal areas, occasional contact with salt spray)

[1] In environments assumed to be of category "CX", it is recommended to determine the corrosivity classification of the environments from the corrosion losses over one year.
[2] The concentration of sulfur Dioxide (SO_2) should be determined for at least one year and expressed as an annual average.

Desired level of performance		Product corrosion class according to IEC 61537	Possible finishes on the system
EZ	Electrogalvanising with Zinc based electrolytic deposit Standard ISO 2081	Class 3	EZ, PG, HDG, ZnI, ZnAl, ZnMg, ZnNi
HDG	Hot-dip galvanised after manufacturing Standard EN ISO 1461	Class 6	HDG, ZnI, ZnAl, ZnMg, ZnNi
HR	Zinc Aluminium prior to continuous manufacturing using the Sendzimir process Standard EN 10244-2	Class 8	ZnAl, ZnMg, ZnNi
304L	Standard EN 10088-2 and 10088-3	Class 9C	304L, 316L
316L	Standard EN 10088-2 and 10088-3	Class 9D	316L

PG	Continuous galvanisation prior to manufacturing using the Sendzimir process
ZnI	Zinc rich coating
ZnMg	Zinc Magnesium prior to continuous manufacturing using the Sendzimir process
ZnNi	Zinc Nickel Zinc and Nickel based electrolytic deposit

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