STANDARD
DIN : 267 Part 9
ISO : 4042
ANSI : –

SURFACE COATINGS

Electroplated coatings

1. Scope and field of application
These technical conditions are in particular related to threaded fasteners (mainly bolts and nuts), but are also applicable to the whole range of mechanical fasteners.

2. Electroplated coatings
An electrolytically applied coating shall be defined as a protective metallic layer being deposited onto the surface of metal articles by immersing these parts in an aqueous solution through which an electrical current is passed.
Note: The use of the nomenclature "galvanizing" for this treatment is not correct.
This information on electroplated coatings corresponds with DIN 267 Part 9 and ISO 4042.

3. Code system
The electroplated coatings of mechanical fasteners are designated by a code consisting of a combination of two capitals and a number.
This system is built up as follows: – a capital for the coating metal (table 1)
– a number for the minimum layer thickness (coating structure) (table 2)
– a capital for the degree of gloss and after-treatment (table 3)

Table 1. **Coating metal**

Code letter	Coating metal	Symbol
A	Zinc	Zn
B	Cadmium	Cd
C	Copper	Cu
D	Brass	CuZn
E	Nickel	Ni
F	Nickel-chrome [1])	NiCr
G	Copper-nickel	CuNi
H	Copper-nickel-chrome [1])	CuNiCr
J	Tin	Sn
K	Copper-tin	CuSn
L	Silver	Ag
N	Copper-silver	CuAg

[1]) Thickness of chrome layer ≈ 0,3 µm

Table 2. **Minimum layer thickness (coating structure)**

Codenumber	Layer thickness (coating structure) in µm 1 coating metal	2 coating metals
0[1])	–	–
1	3	–
2	5	2+ 3
3	8	3+ 5
4	12	4+ 8
5	15	5+10
6	20	8+12
7[2])	25	10+15
8[2])	32	12+20
9[2])	40	16+24

[1]) Code number 0 applies to screw threads below M 1.6, where no specific layer thickness can be specified.
[2]) Does not apply to threaded components.

Table 3. **Degree of gloss and after-treatment**

Codeletter	Degree of gloss	Chromatizing in accordance with DIN 50 941 Process group	Self-colour of chromatizing layer
A	mt (dull) (mat)	none [1])	none
B		B	bluish to bluish iridescent [2])
C		C	yellowish glistening to yellowish-brown,iridescent
D		D	olive green to olive brown
E	bk (bright)	none [1])	none
F		B	bluish to bluish iridescent [2])
G		C	yellowish glistening to yellowish-brown,iridescent
H		D	olive green to olive brown
J	gl (glossy)	none [1])	none
K		B	bluish to bluish iridescent [2])
L		C	yellowish glistening to yellowish-brown,iridescent
M		D	olive green to olive brown
N	hgl (high gloss)	none	–
P	bel (optional)	B, C or D [3]) at manufacturer's discretion	as for process group B, C or D
R	mt (dull) (mat)	F	brownish black to black
S	bk (bright)	F	
T	gl (glossy)	F	

[1]) In the case of Zn and Cd however, process group A
[2]) Only applies to Zn coatings
[3]) Process groups B, C or D in accordance with DIN 50 941 only apply to cadmium and zinc coatings. In the case of other electroplated coatings, "P" in the code symbol signifies "degree of gloss optional".

Ordering code of electroplated coatings for commercial fasteners on stock.

Nominal size		Coating	Zinc-chromatized				Nickel	Copper nickel
		Degree of gloss	Glossy					
		Colour	none	bluish	yellowish	black	–	–
metric	inch							
< 5	< 3/16"		A1J	A1K	A1L	A1T	E1J	G2J
≥ 5 < 10	≥ 3/16" < 3/8"		A2J	A2K	A2L	A2T	E2J	G2J
≥ 10	≥ 3/8"		A3J	A3K	A3L	A3T	E3J	G3J

Example of coding: A3L means zinc-plating (A in table 1) with a minimum layer thickness of 8 µm (3 in table 2) and yellow-chromatized with a glossy degree of gloss (L in table 3).
Example of designation: Hexagon bolt DIN 931 - M16 x 60 - 8.8 - A3L.

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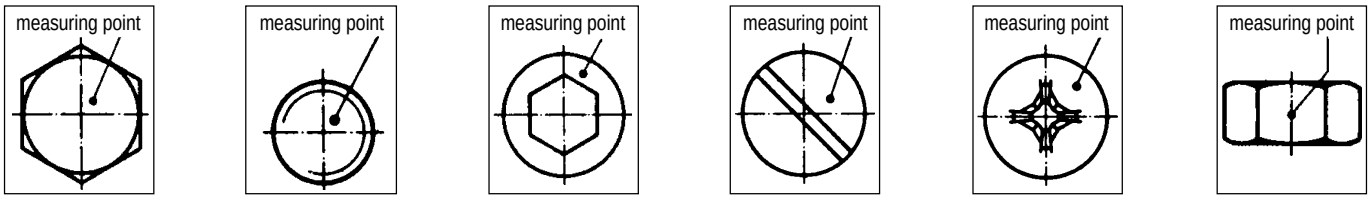
SURFACE COATINGS

Electroplated coatings

info

4. Layer thickness, measuring point and measuring method

The layer thicknesses on the measuring point as indicated in table 2 are minimum values.
Because of the variations in layer thickness on electroplated surfaces on mechanical fasteners, the local layer thickness is measured at a given spot considered significant for the purpose of assessing the protection against corrosion as is indicated in the examples:



The layer thickness can be measured by:
- direct determination in accordance with DIN 50933
- the jet method is accordance with DIN 50951
- the coulometric method in accordance with DIN 50955
- microscopic determination in accordance with DIN 50950

In borderline cases the last method is governing.

5. Screw thread tolerances

The basis for the layer thickness of electroplated coatings is given by the tolerances for ISO-metric screw threads in accordance with DIN 13 resp. ISO-unified screw threads in accordance with ISO 5864 (ANSI B1.1) **prior** to the electroplating, that means tolerance field g resp. 2A for bolts and screws and H resp. 2B for nuts.
The coating must not cause the zero line to be exceeded, so bolts and screws have to meet the go-gauge with tolerance field h resp 3A and a measurable layer thickness can only be applied to nuts on condition that the tolerance field H resp 2B is not being fully utilized down to the zero line.

6. Hydrogen embrittlement

Due to the risk of hydrogen-induced delayed brittle fracture bolts and screws with a tensile strength Rm ≥1000 N/mm or a hardness ≥ 300 HV (F ≥ 98N) have to be baked on 200 ± 10°C as soon as possible but within 4 hours after the coating process.
This is also mandatory for resilient (springy) fasteners with a hardness ≥ 400 HV (F ≥ 98N).

Note: In spite of this special precaution hydrogen embrittlement cannot be excluded for certain with the electrolytical processes in general use today.
Electroplating of bolts and screws of property class 12.9 and higher is strongly advised against.
No responsibility is taken for reduced loadability or the resulting claims from this. This particularly concerns products which are not coated by ourselves.

7. Passivation by chromate treatment

This after-treatment has to be carried out in accordance with DIN 50941 and **after** baking.
The protection against corrosion is considerably increased by chromatizing.
Out of the different colours from bluish (white) to black in table 3, **yellow** passivation is preferred.

In June 1992 a new **national** German standard, DIN ISO 4042-electrolytic surface plating, was published. This standard is identical to the **international** standard ISO 4042 (1st. edition 1989-12-15).

This standard consequently replaces the old **national standard**, DIN 267 Teil 9. This standard has also been replaced in Holland, where the DIN standard is also recognised.

It is generally expected that a **European** EN-standard (identical to ISO 4042) will be introduced, until that time the present standard, DIN 267 Teil 9 will be maintained.

STANDARD	SURFACE COATINGS	
DIN : 267 Part 10 ISO : 1461 ANSI : –	**Hot dip galvanizing**	

1. Scope and field of application

These technical conditions are in particular related to threaded fasteners (mainly bolts and nuts) with M6 up to and including M36 coarse thread and property classes up to and including 10.9 for bolts and 10 for nuts.
The minimum coating thicknesses also apply to other accessories such as washers.

2. Hot dip galvanizing

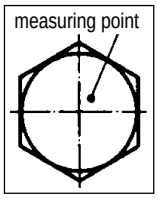
Hot dip galvanizing shall be defined as a protective zinc layer deposited onto the surface of metal articles by immersing these parts in liquid zinc.
Note: This information on hot dip galvinizing corresponds, as regards content, to DIN 267 Part 10.

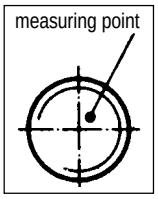
3. Ordering code

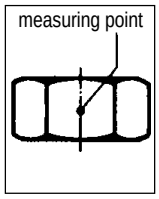
Hot dip galvanized fasteners are designated with t Zn e.g. high strength structural bolt DIN 6914 - M20 x 100 - t Zn

4. Layer thickness, measuring point and measuring method

The **minimum** coating thickness at the measuring point is 40 µm.
The measuring point is a given spot considered significant for the purpose of accessing the protection against corrosion as is indicated in the examples:







The layer thickness can be measured by:
– direct determination in accordance with DIN 50933
– the magnetic measurement in accordance with DIN 50981
When comparing the layer thickness with the mass per unit area 100 µm≙ 700 g/m² may be used.
The thread is tapped in the nuts AFTER hot dip galvanizing.
The bolt thread shall not be recut after galvanizing.

5. Screw thread tolerances

The tolerances of the ISO-metric thread in accordance with DIN 13 and the unified thread according to ISO 5864 (ANSI B1.1) for commercial fasteners are not large enough to permit a coating to the specified minimum thickness.
To ensure that the bolt/nut assembly continues to function properly after hot dip galvanizing without impairing the thread, one of the following methods shall be used:

– standard bolts are hot dip galvanized and become “oversize” thread. These bolts have to be combined with nuts, which have been tapped “oversize” (about 0,3 mm larger) AFTER galvanizing. They do not meet the usual thread fit. These bolts and nuts have to be used as a set. This combination is usually applied and is recommended.
– The bolt thread shall be produced to tolerance position a in accordance with DIN 13 Part 15 BEFORE hot dip galvanizing. The bolts have to be prepared thinner.
  Because the thread profile shall not at any point transgress the zero line it means that the bolts AFTER galvanizing have to meet the go-gauge with tolerance position h.
  These “ISO metric mating” hot dip galvanized bolts have to be combined with nuts, which have been normally tapped AFTER galvanizing and so have to meet the go-gauge with tolerance position H.
  This method satisfies the usual thread fit and can be used with nuts or in tapped holes with standard ISO metric thread

6. Hydrogen embrittlement

Hot dip galvanizing itself does not cause hydrogen embrittlement.
Pre-treatments like pickling have to be processed professionally, because careless treatment may induce hydrogen embrittlement.

7. After-treatment

When in high strength joints a better torque/tension relationship is required, it is neccessary to provide the bolt or nut with an adequate lubricant e.g. molybdenum disulfide Mo S_2.

8. Colour

The colour of the zinc coating may vary from bright to greyish, depending on different circumstances.
The colour however is not an indication of the quality of protection against corrosion and cannot be an argument for rejection, although as bright and glossy an appearance as possible has to be aimed at.

9. Loadability

Generally it can be stated that the mechanical properties of the bolts in accordance with DIN ISO 898/1 and the nuts in accordance with DIN ISO 898/2 resp. DIN 267 Part 4 are not influenced by hot dip galvanizing.
However, taking in account the reduced overlap of the bolt and nut threads, the loadability of the bolt/nut combination is reduced by about 5% for the largest size M36 and gradually increases to 20% for the smallest size M6. For further specific values see DIN 267 Part 10.
Due to the fundamental deviations of the thread tolerances the screw thread of the bolt is allowed to strip off at the minimum ultimate tensile load.

For guidelines concerning the assembly of hot dip galvanized, high tensile bolting in steel structures DIN 6914 see elsewhere in this section.

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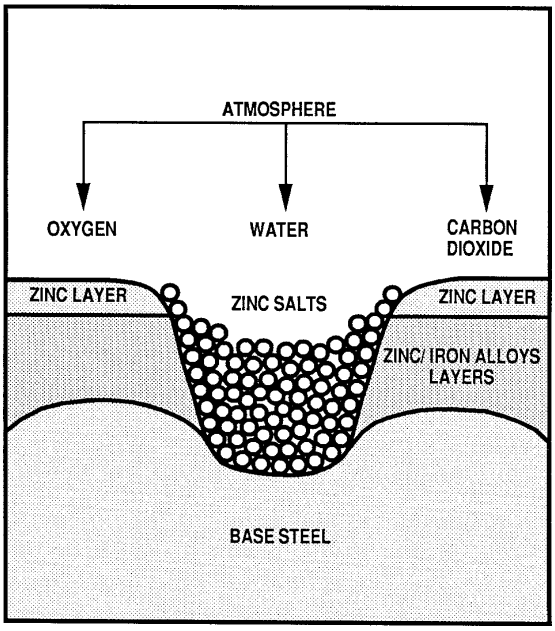
SURFACE COATINGS

Hot dip galvanizing

10. Corrosion protection

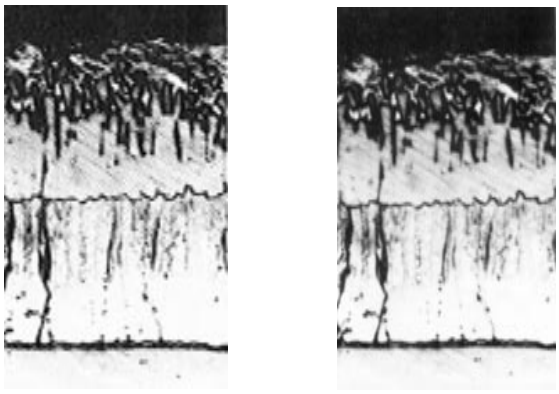
Because zinc is a lesser noble metal than iron (steel), the zinc will corrode first, protecting the steel against rusting until all zinc has dissolved.

Also on spots where the zinc layer has openings with a distance of 1,5 to 2 mm resp. a surface of 10 mm^2, the steel remains protected by an electrochemical process, called “cathodic bridging”. The zinc provides sacrificial protection and the breached coating will be covered by the built-up zinc salts.
A good example of this phenomenon occurs with the screw thread of hot dip galvanized nuts, which are tapped AFTER galvanizing. The zinc layer on the bolt thread completely takes over the protection of the uncoated nut thread.
Another important aspect of cathodic protection is that no under-rusting will occur and the rust-building remains localized to the open spots.



Cathodic protection of hot dip galvanized steel

The hot dipped galvanized zinc layer consists, besides a thick outer layer of pure zinc (the solidification-layer), of 3 alloy layers, of which the iron percentage decreases to the outside. The corrosion resistance of these layers is equal to or better than that of pure zinc, while the resistance against wearing is much higher.

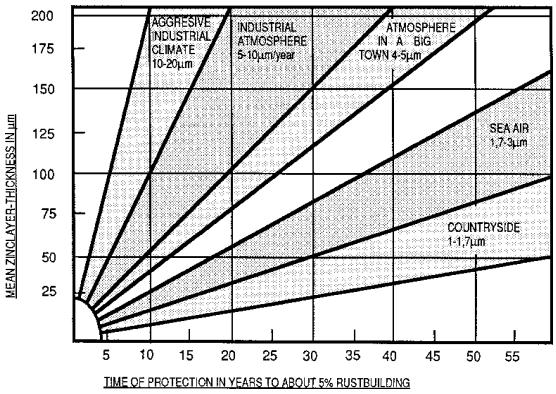


Structure of the zinclayers system of hot dip galvanizing

10.1 Atmospheric corrosion

During atmospheric attack, a layer of corrosion products (zinc-patina) is built up, mainly consisting of zinc carbonate, which is almost insoluble and delays further corrosion. When galvanized steel is kept wet during a longer period and there is insufficient air circulation, a white voluminous zinc corrosion product: “white rust” can be developed which may be less desirable, esthetically, or for painting. White rust building can be suppressed by adequate stocking and packaging or, if necessary, by passivating in chromic acid or oiling.

The time of protection is directly proportional to the thickness of the zinc layer and dependant on the climatical circumstances as is shown in the graph opposite.
Generally the time of protection is from the moment of exposure to the moment the steel surface exhibits rusting not more than 5%.



Influence of the climate on the time of protection of hot dipped galvanized steel

For guidelines concerning the assembly of hot dip galvanized, high tensile bolting in steel structures DIN 6914 see elsewhere in this section.

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SURFACE COATINGS

Hot dip galvanizing

10.2 Contact corrosion

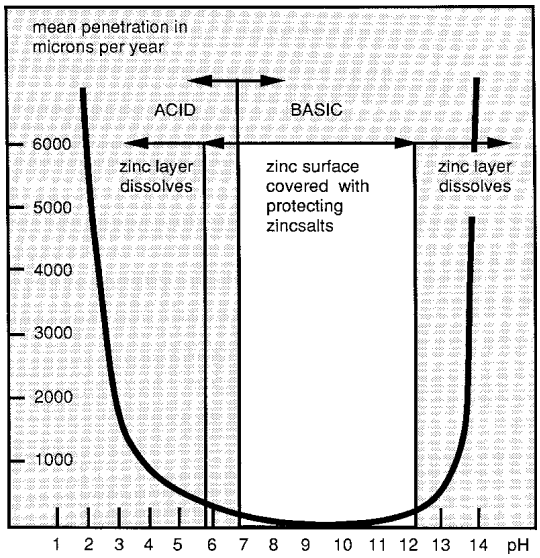
This form of corrosion occurs when two metals are contacted conductively in the presence of a corrosive electrolyte. This is due to the differing electrochemical potentials of the metals concerned, of which the least noble metal will corrode. This process also depends on the relative areas of the contacting metals.
The table opposite gives a practical overview of the reliability of the combination of hot dip galvanized fasteners, of which the area is smaller (second column), and of which the area is larger (third column) than construction area from another material. The assembly of for instance hot dip galvanized bolts in a larger construction of stainless steel will not form a reliable joint.

galvanized steel	reliability of the combination	
contacted with	area zinc smaller than area contacted metal	area zinc larger than area contacted metal
magnesium alloy	good	limited
hot dipped galv. steel	good	good
aluminium alloy	limited	good
cadmium	not	limited
unalloyed steel	limited	limited/not*
malleable steel	limited	limited/not*
alloyed steel	limited	limited/not*
stainless steel	not	good
lead	limited	good
tin	limited	good
copper	not	not
nickel alloy	not	good

* The corrosion speed of uncoated steel contacted with zinc is slow. However a small quantity of rust water will spread over the zinc quickly and cause rust marks, which are unacceptable from an esthetical viewpoint. Therefore this combination will almost always be rejected.

10.3 Chemical corrosion

Zinc is not resistant to strong acids and strong bases (caustics). All in all it can be stated that zinc must not be exposed to solutions with a pH-value of less than 6 and greater than 12,5. The most favourable application range lies between the pH-values 8 and 11.



Resistance of hot dip galvanized steel to chemicals

material	*resistance*	*notes*
concrete (wet)	good	little attack, very good once dry
plastery water	quite good	not permanently resistant
sulphite water	poor	—
phosphor solutions	good	reacts neutrally only
watery extracts of		
oak and beechwood	moderate-poor	permanent influence
ammonia	poor	permanent influence
brine	good	—
calcium chloride solutions	good	—
soap solutions	good	—
detergents in solution	poor-good	depending on composition
weedkillers	good	no free phenols
petrol	good	—
fuel oils	moderate	especially in presence of naphtalene acids, water and/or sulphur compounds
benzene/toluene/xylene	good	only when free of water
solvent- and heavy naphtas	good	only when free of water
methanol and ethanol	poor	during permanent attack
glycerol	good	only when free of water
chloride hydrocarbons	good	only when free of water
organic ester compounds	quite good-good	only when free of water and not reacting as a strong acid
substituted phenols	good	only when free of water
amino compounds	good	only when free of water
liquid glucose	good	—
sulphonates	good	—
synthetic-resin lacquer solutions	good	—
leather, bituminous materials	good	only when free of acid

10.4 Duplex-system

The Duplex-system is a combination of hot dip galvanizing and painting. It may offer a good solution in a very aggressive atmosphere e.g. in the close vicinity of the sea or in an acid environment and/or when maintenance and repairs are practically impossible to carry out, or a special colour is wanted. The time of protection is $1^1/_2$ - $2^1/_2$ times longer than the sum of both separate systems.

For guidelines concerning the assembly of hot dip galvanized, high tensile bolting in steel structure DIN 6914 see elsewhere in this section.