Galvanic process

Fasteners with electroplated coatings according to ISO 4042:2018

Galvanizing – Passivation. Galvanizing followed by passivation of fasteners is a procedure which has proven itself in terms of both corrosion resistance and appearance. We can offer you an extensive assortment from our range of goods in stock.

Chromating and / or passivation after-treatment. Is a process for generating a chromate and / or passivation coating by treatment with a solution containing a hexavalent chromium compound (chromating) or trivalent chromium compound (passivating). This after-treatment is carried out immediately after galvanizing by brief immersion into chromic acid solutions. The chromating and / or passivation process increases corrosion resistance and prevents tarnishing and discolorations of the zinc coating. The protective effect of the different chromate or passivation can differ depending on the types of process used (see the table!). It is possible to further increase the corrosion protection through the use of sealant or top coats.

Developments in processes involving chromium (VI)-free coatings offering the same or similar protective effect were spurred onwards by environmental regulations due to EU Directives 2000/53/EC (ELV) und 2002/95/EC (RoHS) respectively 2011/65/EU (RoHS 2). In the past normal practice has been to use galvanic zinc coatings (ISO 4042) with chromate treatment based on chromium (VI) for the corrosion protection of fasteners. Today the use of chromium (VI) coating is restricted. For this reason, for new applications it is recommended to use only Cr(VI)-free conversion coatings (passivation).

The surface treatments based on chromium (VI) – free systems usually require a more complex process control since the so called «selfhealing effect» is less pronounced. Bulk handling, automatic processes such as feeding and / or sorting, storage and transport can cause a reduction of the corrosion protection (especially protection against corrosion of the coating) depending on the coating system and the type and geometry of the fasteners.

Guiding values of the corrosion resistance for commonly used zinc and zinc alloy coating systems according to ISO 4042:2018

The neutral salt spray test (NSS) in accordance with ISO 9227 is used to evaluate the corrosion resistance of the coating.
According ISO 4042:2018 the «as-coated» condition is defined as the condition after completion of all steps of coating (including application of any passivation, sealant or top coat) without the negative impact from other factors like sorting, packaging, assembling, transportation or storage.

Zinc based coating system	Cr(VI)-free	Typical aspect	Designation of the electroplated coating systems according ISO 4042:2018	Nominal thickness of the coating µm	Minimum neutral salt spray test duration for barrel coating[3) 4)]	
					White rust (h)	Red rust (h)
Zn, transparent / blue passivated	yes	transparent, clear to bluish (standard)	ISO 4042/Zn5/An/T0	5	8	48
			ISO 4042/Zn8/An/T0	8	8	72
Zn, thick layer passivation	yes	clear to iridescent (bluish, greenish, yellowish, silver)	ISO 4042/Zn5/Cn/T0	5	72	120
			ISO 4042/Zn8/Cn/T0	8	72	192
Zn, thick layer passivation, sealed	yes	clear to iridescent	ISO 4042/Zn5/Cn/T2	5	120	168
			ISO 4042/Zn8/Cn/T2	8	120	240
Zn, black chromated[1)]	no	darkbrown to black (decorative)	ISO 4042/Zn5/F/T0	5	12[2)]	–
			ISO 4042/Zn8/F/T0	8	24[2)]	72
ZnNi, iridescent passivated	yes	iridescent (bluish – silvergrey)	ISO 4042/ZnNi5/Cn/T0	5	120	480
			ISO 4042/ZnNi8/Cn/T0	8	120	720

1) On edges, the edges of the Phillips recess etc. use of the barrel process means that you can practically always expect the black chromate coating to be rubbed off here and the underlying bright grey-colored zinc coating to become locally visible.
2) Low coating thickness impairs the resistance of the chromate conversion coating.
3) With a rack plating process, the effect of possible damage to coating is reduced and therefore increased corrosion resistance can be achieved.
4) For small thread size the mentioned values may be reduced (insufficient clearance at the thread pitch diameter to accommodate the needed coating thickness). See also coating thicknesses for ISO metric threads.

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Reduction of the risk of hydrogen embrittlement (ISO 4042)

There is a risk of failure due to hydrogen embrittlement in galvani cally finished fasteners which are under tensile stress and which are made from steels with high tensile strengths corresponding to ≥ 360 HV.

Heat treatment (baking) of the parts, e.g. after the acid pickling or metal coating process, will reduce the risk of embrittlement. However, it cannot be guaranteed that the risk of hydrogen embrittlement will be removed completely. If the risk of hydrogen embrittlement must be reduced, then other coating procedures should be considered.

Alternative methods of corrosion protection or coating should therefore be selected for parts which are important to safety, alternatives such as anorganic zinc coating, mechanical plating or a switch to rust and acid-resistant steels.

Where the method of fabrication allows, fasteners with hardness ≥ HV360 are provided with an anorganic zinc coating or are mechanically plated.
The user of the fasteners knows the purposes and requirements for which the fasteners are to be used and he must specify the appropriate type of surface treatment!

Maximum coating thickness for ISO metric threads

according to ISO 4042:2018

Thread pitch P	Nominal thread diameter [1] d1	Internal thread		External thread					
		Tolerance position G		Tolerance position g		Tolerance position f		Tolerance position e	
		Fundamental deviation	Coating thickness max.[2]	Fundamental deviation	Coating thickness max.[2]	Fundamental deviation	Coating thickness max.[2]	Fundamental deviation	Coating thickness max.[2]
[mm]	[mm]	[µm]	[µm]	[µm]	[µm]	[µm]	[µm]	[µm]	[µm]
0,35	1,6	+19	4	−19	4	−34	8	–	–
0,4	2	+19	4	−19	4	−34	8	–	–
0,45	2,5	+20	5	−20	5	−35	8	–	–
0,5	3	+20	5	−20	5	−36	9	−50	12
0,6	3,5	+21	5	−21	5	−36	9	−53	13
0,7	4	+22	5	−22	5	−38	9	−56	14
0,8	5	+24	6	−24	5	−38	9	−60	15
1	6	+26	6	−26	5	−40	10	−60	15
1,25	8	+28	7	−28	5	−42	10	−63	15
1,5	10	+32	8	−32	8	−45	11	−67	16
1,75	12	+34	8	−34	8	−48	12	−71	17
2	16 (14)	+38	9	−38	8	−52	13	−71	17
2,5	20 (18; 22)	+42	10	−42	10	−58	14	−80	20
3	24 (27)	+48	12	−48	12	−63	15	−85	21
3,5	30 (33)	+53	13	−53	12	−70	17	−90	22
4	36 (39)	+60	15	−60	15	−75	18	−95	23
4,5	42 (45)	+63	15	−63	15	−80	20	−100	25
5	48 (52)	+71	15	−71	15	−85	21	−106	26
5,5	56 (60)	+75	16	−75	15	−90	22	−112	28
6	64	+80	20	−80	20	−95	23	−118	29

[1] Information on nominal diameter for coarse pitch thread is given for convenience only: the determining dimension is the thread pitch P.
[2] Theoretical minimum clearance and corresponding maximum coating thickness. See reference areas for coating thickness determination.

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If no particular plating thickness is specified, the minimum plating thickness is applied (between 3 µm and 5 µm depending on the thread size). This is also considered as the standard plating thickness.

In the case of parts with very long thread or small dimensions (≤ M4), a non-uniform coating thickness resulting from electroplating process may occur. This can cause assembly problems (thickness increase at external edges and thickness increase at the extremities of long parts).
Typically bolts with l > 5d could have a local thickness at mid-length down to one third to half when compared to local thickness at the reference areas.
The specification of thicker layers (in order to get a sufficient coating thickness at mid-length of a long bolt – typically 10d to 15d – for the purpose of corrosion protection) could result in excess of coating at the end of the thread, thus impairing assembly and/or gaugeability.
On the other hand, the specification of thinner layers will allow easy thread engagement, but could result in lack of coating thickness at mid-length.
Possible solution: use of a chemical nickel plating or stainless steel screws A2 or A4.

External threads are normally fabricated in tolerance zone 6g.
e and f tolerance are not common and require special methods of screw manufacturing. Minimum quantities, longer delivery periods and higher prices may make these economically unviable. An alternative is to use parts made from stainless steel A2. Internal threads have a thinner coating due to technical reasons. How ever, this has no significance in practical use because when assembled these are protected by the coating of the external thread of the screw.

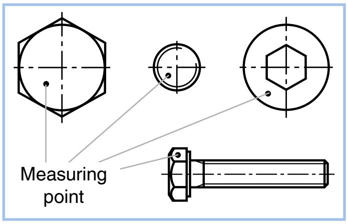
Coating thickness example M10 screw

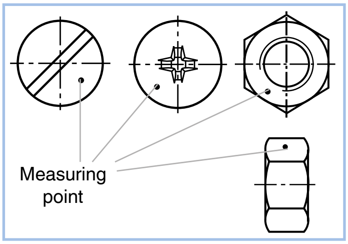
Zinc	5 µm
Passivation (standard)	0,05 – 0,1 µm
Thicklayer passivation	0,2 – 0,5 µm
Sealant	0,5 – 1,5 µm

Possible tolerance adjustments for surface coatings ISO 10684 (hot galvanization)

Product	Thread	Tolerance	Headmark example
Bolt thread	undercut	6 az	8.8 U
Nut thread	overtapped	6 AZ	8 Z

Reference areas for coating thickness determination





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Further galvanic coating processes

Process	Details
Nickel-plating	Nickel-plating is decorative and provides effective corrosion protection. A hard coating, used in the electrical appliance and telecommunications industries. No coating abrasion occurs, especially with screws. Improves protection against impregnation, see table below.
Chromium-plating	Usually following nickel-plating. Coating thickness about 0,5 – 1,0 µm. Chromium is decorative, enhances resistance to tarnishing and also serves as corrosion protection. Bright chromium-plated: high brightness finish. Matt chromium-plated: matt lustre (silk finish). Barrel process for chromium plating not possible. Creates a hard surface with good wear and sliding properties.
Brass-plating	Brass plating is mainly applied for decorative purposes. In addition, steel components are brass-plated in order to improve the adhesion of rubber to steel.
Copper-plating	As primer prior to nickel-plating, chrome-plating, and silver-plating as needed. Used for decorative purposes.
Silver-plating	Silver-plating is employed for decorative and technical applications.
Tin-plating	Tin-plating is carried out mainly to permit or improve soldering (soft-solder). Simultaneously serves as corrosion protection. Subsequent heat treatment not possible.
Anodizing	When aluminum is anodized (electrolytic oxidation), a coating which provides corrosion protection is produced – also prevents tarnishing. Practically any color can be produced for decorative purposes in a downstream coloring process.
Zinc / iron alloy coating	Is a galvanic coating process which uses an electrolyte that precipitates a zinc-iron alloy on a metallic surface. Following the coating a Cr(VI)-free black passivation and black sealing is applied. It is mainly used when a cosmetic black surface is desired.
Zinc / nickel alloy coating	The zinc-nickel coatings have a deposition of approximately 12 – 16 % share of nickel during the galvanization. Here one has the possibility to use a transparent or black passivation and to optimize by a sealing. This coating is mainly used because of its good corrosion protection in use.

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Further surface treatments

Process	Details
Hot-dip galvanizing	Immersion in molten zinc with a temp. of about 440 °C to 470 °C. Thickness of coating not less than 40 µm. Finish dull and rough. Color change possible after a certain time. Very good corrosion protection. Can be used for thread parts from M8. Threads need to be over or undercut to assure proper thread mating.
Zinc flake coatings Geomet® Delta-Tone® / Delta-Protekt®	Zinc flake coatings provide excellent corrosion resistance and are suited for high strength components with high tensile strength or Hardness ≥ 360 HV. The coating process practically eliminates the possibility of hydrogen embrittlement. Temperature resistant 300 °C. Can be applied for size M4 and larger.
Mechanical plating	Mechanical / chemical process. The degreased parts are placed in a drum with powdered zinc and glass pellets. The pellets serve to transfer the zinc powder to the surface to be treated.
Black oxidizing of Stainless steel	Chemical process in hot hydroxide solution. For decorative purposes.
Black oxidizing	Chemical process, bath temperature about 140 °C. For decorative purposes. Temporary corrosion protection only.
Phosphate (bonderizing, parkerizing, atramentizing)	Only slight corrosion protection. Good undercoat for painting. Grey to grey-black appearance. Better corrosion protection oiled.
Waterproofing / sealing	Particularly with nickel-plated parts, subsequent treatment in dewatering fluid with the addition of wax may seal the micropores with wax. Significantly improves the corrosion resistance. The wax film is dry and invisible.
Baking	Following electrolytic or pickling treatment, high tensile strength steel parts with hardness ≥ 360 HV can become brittle due to hydrogen absorption (hydrogen embrittlement). This embrittlement increases for components with small cross sections. Part of the hydrogen can be eliminated by baking between 180 °C and 230 °C (below tempering temperature). Experience indicates that this is not guaranteed 100 %. Baking for > 6 hrs must immediately be carried out after pickling and after galvanic treatment.
Sealing	Sealing is applied to the component using an immersion process after galvanization and passivation. Sealing increases corrosion resistance.
Tribological dry coating[1)]	These coatings provide a friction reducing and wear resistant film. Reduce galling tendency.
Waxing	Provide a lubrication layer, reduces driving torque of thread-forming screws.
WIROX®	Is a galvanic coating with zinc, average thickness at least 8 µm. The corrosion protection is more than 20 times higher, compared with plain galvanizing. The coating is resistant to abrasion, mechanical loads and is characterized by an exceptionally high corrosion resistance.
YELLOX®	Is a galvanic coating with zinc, average thickness at least 4 µm. The corrosion protection is more than 6 times higher, compared with plain galvanizing. Screw applications with yellowish appearance are guaranteed in the future.
GreenTec®	Is a galvanic coating, thickness about 5 µm, zinc-nickel-based and provides hard, wear-resistant coating with very high corrosion resistance.

[1)] For example **CresaCoat®**
CresaCoat® tribological dry coating is a non-electrolytically applied, thin layered coating with integrated lubricating properties and additional corrosion protection. The coating consists of a composition of fluoropolymers and organic submicroscopic solid lubricant particles, which are dispersed in carefully selected synthetic resin blends and solvents. The AFC coating (Anti-Friction-Coating) creates a smooth film, which balances all unevenness of the surface thereby optimising friction under extreme loads and working conditions. The synthectic resin in turn ensures better corrosion protection.

Which coating systems represent the best possible option based on technical and economical consideration shall be decided depending on the customer specific application and the intended operation purpose.

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