

Fastener Surface Treatments and Corrosion Protection — Zinc Plating (ISO 4042), Zinc Flake (ISO 10683), Hot-Dip Galvanising (ISO 10684), Zn-Ni, Phosphate, Black Oxide and Stainless



Selection guide · ISO 4042 / ISO 10683 / ISO 10684 / ISO 9227 / ISO 12944 · cBallast Technical Sourcing · issued 2026-09-15 · Catalogue data: Bufab (Värnamo, Sweden) · cballast.com/documents/fastener-surface-treatments-corrosion-protection-zinc-plating-zinc-flake-hot-dip

A fastener finish does three jobs: it delays corrosion of the steel underneath, it sets the friction (and therefore the torque-to-preload relationship) of the joint, and it must not damage the fastener in the process — the hydrogen absorbed during acid pickling and electroplating can embrittle steel above about 320 HV (property class 10.9 and up). The right choice depends on the service environment (ISO 12944 corrosivity category), the property class, the mating parts and the tolerance budget of the thread. The table gives typical values; the standards referenced fix the requirements.

Finish (common codes)	Typical thickness	NSS to white / red rust (ISO 9227, typical)	Property class limit	Thread effect	Notes
Plain (untreated, may be lightly oiled)	—	hours	any	none	Indoor dry service or where the joint is painted after assembly
Zinc electroplated, Cr(III) clear/blue passivated (ZPL, Fe/Zn 5–8 µm, ISO 4042)	5 – 8 µm	24–72 h / 96–150 h	"d 10.9 with baking; avoid 12.9	6g bolt before plating; nut 6H	Standard industrial finish; decorative; C2–C3 indoors
Zinc electroplated, Cr(III) thick-film / yellow passivated (YZPL)	8 – 12 µm	96–150 h / 200–300 h	"d 10.9 with baking	as above	Higher salt-spray life than blue; colour is not a guarantee of Cr(VI)-free unless stated
Zinc electroplated + sealer / top coat	8 – 12 µm + seal	150–250 h / 300–500 h	"d 10.9 with baking	as above	Sealer also fixes friction (µ 0.12–0.14 typical)
Zinc-nickel (Zn-Ni 12–15 % Ni, 8 µm, ISO 19598)	8 – 12 µm	150–300 h / 720–1000 h	"d 10.9 (low embrittlement risk with control)	as above	Automotive and off-highway standard; good at 150–200 °C; silver or black
Zinc flake, non-electrolytic (ISO 10683; Geomet 500, Delta-Protekt KL 100, Dacromet-type)	8 – 12 µm	240–480 h / 600–1000 h	all classes incl. 10.9 and 12.9 (no hydrogen)	thin — fits 6g/6H	Default for 10.9/12.9 outdoor; friction controlled by top coat (e.g. Geomet 500 A = µ 0.12–0.18 range with lubricant)
Hot-dip galvanised (HDG, ISO 10684; tZn)	"e 40 – 50 µm ("e 45 µm local typ.)	not NSS-rated; 1–2 µm/yr loss in C3, 4–8 in C5	"d 8.8 routinely; 10.9 only with qualified process	bolt normal; nut tapped oversize 6AZ/6AX	Structural steel, outdoor, marine deck; rough surface; ISO 1461 for the structure
Zinc phosphate + oil (PHM)	2 – 8 µm	24–72 h (oil-dependent)	all	none	Corrosion protection in transit and storage; paint base; good lubricity
Manganese phosphate	5 – 15 µm	48–96 h with oil	all	none	Wear-resistant, anti-galling for sliding parts and set screws
Black oxide (BLACK OXIDE) + oil	< 1 µm	< 24 h	all (no hydrogen)	none	Cosmetic / indoor; socket screws 12.9 are usually black oxide
Nickel plated	5 – 10 µm	48–150 h	"d 10.9 with baking	as plating	Decorative, brass and copper parts
Stainless A2 (EN 1.4301/1.4307)	n/a	no red rust; tea staining possible in C4+	A2-70 "d M20	none	Atmospheric, food, water; not for chloride-rich or splash zones
Stainless A4 (EN 1.4401/1.4404)	n/a	resists chlorides; pitting possible in stagnant seawater	A4-70 / A4-80 "d M20	none	Marine, chemical, coastal; isolate from carbon steel and aluminium

Matching the finish to the corrosivity category (ISO 12944-2)

- C1 / C2 (heated interiors, rural dry) — plain, black oxide, zinc phosphate, or zinc plated 5 µm.
- C3 (urban, light industrial, unheated halls) — zinc plated 8 µm with thick-film passivation, Zn-Ni, or zinc flake.
- C4 (industrial, coastal with moderate salinity) — zinc flake "e 480 h, Zn-Ni "e 720 h, hot-dip galvanised, or A4 stainless.
- C5 / CX (marine splash zone, offshore, chemical) — hot-dip galvanised plus duplex paint system, A4 or duplex stainless, or high-alloy (1.4529 / super duplex) for immersion and seawater.
- Where the fastener is inside a painted structure, the paint system carries the corrosion protection and a zinc or zinc-flake fastener is enough; where the fastener head stays exposed, it must match the structure's category on its own.

Hydrogen embrittlement and baking

Electroplating and acid pickling charge steel with hydrogen. In fasteners harder than about 320 HV (class 10.9 and above, spring steel, case-hardened screws) this can cause delayed brittle fracture under static load, days after assembly. ISO 4042 requires the plater to assess the risk and, where needed, bake the parts (typically 190–230 °C for 4–24 h, started within 4 h of plating) and to run process verification per ISO 15330 (sustained-load test). Zinc flake and mechanical plating avoid the problem because no hydrogen is generated — that is why 10.9 and 12.9 outdoor fasteners are normally zinc

flake. Hot-dip galvanising at ~450 °C can temper 10.9 steel; ISO 10684 allows it only with process controls and excludes 12.9.

Thread tolerances and coating thickness

A coating adds to the pitch diameter four times its thickness (it sits on both flanks). Electroplated bolts are therefore made to 6g and plated to a thickness that keeps them inside 6h; nuts stay 6H. Hot-dip zinc is too thick for that: ISO 10684 keeps the bolt thread normal (6g before dip) and requires the nut to be tapped oversize after galvanising — tolerance class 6AZ (nut over-tapped by 0.3–0.5 mm on the pitch diameter, standard) or 6AX (larger oversize for plating the nut too). An HDG bolt with an ordinary 6H nut will seize; an oversize nut on an ordinary bolt loses about 15 % load capacity and must be class-checked.

Friction and torque

The finish sets the friction coefficient the torque table assumes. Plain and black-oxide steel with light oil: μ "H 0.14–0.20; zinc plated (dry): 0.12–0.18; zinc flake with integrated lubricant (Geomet 500 A/B, Delta-Protekt KL 100 with VH 301 top coat): 0.09–0.15 and tightly controlled; hot-dip galvanised: 0.16–0.25 and scattered — HDG joints are normally tightened by turn-of-nut rather than torque. Zn-Ni without sealer runs high (0.20+). Always take the torque value from a table for the actual finish and lubrication state; the same bolt with a different finish can need 40 % more or less torque for the same preload.

Galvanic pairs to avoid

- Stainless fastener in aluminium structure without insulation — aluminium corrodes at the contact; use isolating washers/sleeves or a zinc-flake-coated steel fastener.
- Zinc-coated fastener in a stainless structure in a wet environment — the zinc is sacrificed rapidly; use A4.
- Brass or copper fastener against galvanised steel — accelerated zinc loss.
- Mixing electroplated and hot-dip parts in one joint is acceptable (both zinc), but the thinner coating fails first.

Specifying the finish on the order

Use the standard's designation so the plater and the buyer mean the same thing. Examples: "ISO 4042 – Fe//Zn8//An//T0" = 8 μ m zinc, trivalent clear passivation, no top coat; "Fe//Zn8//Cn//T2" = 8 μ m zinc, thick-film/iridescent passivation, sealed; "ISO 10683 – fZn nc 480 h" = zinc flake, no Cr(VI), 480 h neutral salt spray to red rust; "ISO 10684 tZn" = hot-dip galvanised with oversize-tapped nuts. Add the required salt-spray hours, whether the value is to white or red rust, and the friction window (e.g. μ_{tot} 0.09–0.14) if the joint is torque-controlled.

Values are nominal reference data compiled from the cited standards and supplier catalogue data (Bufab). Confirm against the controlling standard revision, the manufacturer's data sheet and the joint calculation before procurement or assembly. © cBallast 2026 · cballast.com