Surface Treatments

Anodizing– /Hard Anodizing

ELOXAL is a contrived word and the abbreviation for ELectrolytic Oxidized ALuminum. During anodic or electrolytic oxidation of aluminum and its alloys, anodically charged aluminum (Al = pos. pole) is converted by passing electric current through a cooled acidic solution onto a surface as an Al2O3 (aluminum oxide) layer. This oxide shift is many times stronger (x 100) than a natural oxide layer. Its strength is defined and limited by the specific process used. While a layer can be deposited from the bath onto the surface of the workpiece in conventional electroplating (purely layer by layer build up), aluminum oxide can only be built up from the inside out from the boundary surface between the oxide layer and metallic aluminum. Metallic aluminum is also acquired from the conversion process and is continuously removed and converted. [Al2O3 directly forms aluminum (2/3 inwards, 1/3 outwards).]

Properties:

Type:	oxide layer, hard and dense
Color:	colorless/natural colors, colored or black
Hardness:	approx. 250 ~ 300 HVH
Layer thickness:	~ 5-25 0m.
Corrosion protection:	Protection against weather and corrosive attack.
Miscellaneous:	Special wear protection properties occur in hard anodizing due to the increased layer thickness.

Black Oxiding

In black oxiding a dense, black and adhesive iron oxide layer is created on a steel surface. After subsequent immersion in oil, the shine is highlighted and an optically appropriate corrosion protection is achieved, which is, however, limited in its protective effectiveness. Black oxided surfaces do not change the dimensional accuracy of the workpiece. Black oxiding is a chemical process. The workpiece is immersed in a 135-145°C alkali and oxidizing solution (sodiumhydroxide solution and oxidizing agent) a thin oxide layer of black iron oxide (Fe3O4) is created on the surface of the part.

Properties:

Type:	Oxide layer
Color:	black surface
Layer thickness:	~ 0.5 to 2 0m.

Chromating/Passavating

Chromating and passivating are secondary treatment methods (often after zink plating) in which the workpiece is treated without an external electrical supply. This process creates transparent, shiny, yellow, olive-green, blue, black and other color top coats. They are used as corrosion and tarnish protection layers or for improving adhesion of subsequent painting. Passivated conversion layers occur from a chemical reaction with chrome containing acids, where a reaction occurs between the workpiece surface and the solution. Chromates are salts from chromic acid H2CrO4 and are derived from CrO3 (chromium (VI) oxide). They are highly poisonous. Chromating and passivating are differentiated visually according to color (e.g. blue, yellow chromating and olive-green passivating). In technical terms typically only III-value bonds are used for passivating and only VI-value bonds for chromating. Looked at closely, however, even chromates can also be from group III bonds. Yellow chromates are the most common and in them the chromium is usually in the group VI bonding form. However, recently also yellow chromates are on the market based on group III bonds. Blue chromates are usually based on group III chromium bonds, however some are also group IV bonds. Thick film passivates (olive-green chromates) are foodstuff compatible "chromates" . Here the layer is formed from chrome-III ions (Cr2O3 [chromium (III) oxide]). Therefore, on the basis of the color or designation alone, no definite conclusion is possible.

Properties:

Type:	Non-metallic coating, conversion layer
Layer thickness:	~ 15 0m.

Black chromium-plating properties:

Color:	deep black matte layer
Light return:	good absorption properties
Friction/abrasion:	Abrasion resistance lower than with bright finish or hard chromium
Hardness:	HRC 68-74. All coated steel parts <HRC 36 should be tempered after coating with 190°C +/- 25°C.

Hard chromium-plating properties:

Color:	metal colored
Corrosion:	very good corrosion resistance
Friction/abrasion:	high abrasion and wear resistance
Hardness:	800 - 1100 HV
Miscellaneous:	high temperature resistance

Chrome Plating (Chromium-Plating)

Bright chromium-plating:
There is a differentia here between mirror finish chromium-plating (ground and polished before electroplating, where a mirror finish surface is the goal after processing) and technical chromium-plating (the pretreatment is eliminated and machining marks can be seen, for example).

Industrial chromium-plating:
Chromium-plating without pretreatment and copper-plate is referred to here. A matte surface (light gray) can also be the result of chromium-plating. A relatively inexpensive process, since the cost-intensive work is eliminated. Hard chromium-plating is the direct deposit of thicker chromium layers without an intermediate layer.

Black chromium-plating:
Using a very high current density, black chromium can be deposited at room temperature. The deposited layers have a high oxygen content. It is assumed that they contain approx. 60% chromium and approx. 40% chromium(III)-oxide.

Dicoat

Refer to:	TD coating (Toyota diffusion)

Elektroless Nickel-plating

The nickel is dissolved in the electrolyte and is not available as a metal plate. The advantage is in the contour definition. Chemical nickel-plating is a process in which the workpiece can be coated with high contour conformity and dissolved nickel penetrates everywhere. In contrast to electroplated deposited nickel, the layer in this process is applied absolutely uniformly, even in less accessible areas. This layer distribution therefore guarantees an exceptionally high corrosion resistance. Chemical nickel-plating is carried out without external power supply, normally with sodium-hypophosphite as a reducing agent. The bath temperature is approx. 95°C. The chemical nickel-layer contains 6-10% phosphorous, which results in high hardness and outstanding corrosion protection. The disadvantage is in the significantly higher price. Today layers to 50 0m thick can be deposited with 5 µm accuracy.

Properties:

Type:	metallic pore-free
Color:	light shiny
Hardness:	600 HV (In deposited condition significantly harder than electroplated nickel and other layers), through thermal treatment up to 1200 HV Phosphorous contents: 10-12 %
Resistance:	60-70 0q (insulating layer function)

KANIGEN® (chem. Nickel)

KaNiGen: Catalytic nickel generation. KANIGEN coating was originally a process developed by the General American Transportation Company (GATC in USA). (It is currently patented in many countries). In comparison to other mech. coating processes hydrogen embrittlement is avoided with this chem. nickel deposition. The process is comparatively expensive, offset by a high degree of corrosion resistance and the better soft satin finish appearance.

Microstructure:	shapeless, amorphous, (amorphous layer which crystallizes when heated over 300°C).
Density:	7.75 kg/dm³
Melting point:	890°C
Coercivity/magnetism:	Magnetism does not exist at room temperature, but can occur by heating the part over 300°C.
Hardness:	500HV; (HRC 49) after coating at 20°C, 900HV (HRC 67) after heat treatment at 400°C and 1hr, 1100 HV (HRC 70) maximum.
Coefficient of friction:	KANIGEN against steel; 0.13 lubricated, 0.4 unlubricated. (It prevents scoring and burning-in based on friction between metals such as titanium and austenitic stainless steel).
Attachment/adhesion:	It does not chip off like electroplated nickel. Even if a part is bent after coating the layer stays adhered. The same applies to heating. Max. adhesion is 240 N/mm² for soft steel (up to 400 N/mm² max.).
Layer thickness:	Particular emphasis should be placed on the uniformity of the layer, similar to chemical nickel plating.
Corrosion resistance:	The corrosion resistance is outstanding. The reason is that it is available as an alloy. It is not attacked by most organic liquids and demonstrates high resistance especially to organic acids, salts, alkaline etching fluids and dilute inorganic acids. It protects iron and steel from oxidation at high temperatures. In particular, spot corrosion is avoided.
Other properties:	It effectively prevents material removal due to cavitation.
Wear resistance/abrasion:	Much better than nickel plating. Better wear resistance results after heat treatment at 650°C, similar to hard chrome. In general heat treatment above 400°C is recommended.

LTBC Plating

Low Temperature Black Chrome Plating
Coating technology by which an alloyed surface is formed by an electrochem. reaction below 0°C. A part of this surface forms an alloy like time diffusion layer in the periphery of the metal. This way the base material and layer are completely integrated into each other and are joined "permanently". Through this total integration into the base material, the layer can neither flake or peel off. The resulting surface consists of a uniform film and forms an rust protection film based on chromium ceramic.

Advantages:
No hydrogen embrittlement, no tempering process necessary (material's original properties are retained completely)/ improved relationship between hardness and elasticity/ most suitable film for carbon steels (C45)/ most resistant and effective rust protection layer of all conventional processes/ in friction or wear resistant applications no peeled particles occur/ ideal option to increase service life of parts in rust protection and abrasion applications.

LTBC as some general treatment is avaible in 2 layer versions.
Layer thickness: 1~2 µm (without fluoropolymer layor on top)
Layer thickness: 5µm (with fluoropolymer layer on top)

Friction/abrasion:	very resistant, since no particles can be flaked or peeled of
Miscellaneous:	No change in microstructure during the process

Nickel plating

Nickel electroplating is used for corrosion protection reasons and also for decorative purposed. Basically: The thicker the nickel layer the more reliable the corrosion protection. Nickel is a prized coating material because of its specific chemical and physical properties and is today perhaps the most significant metal deposited by electroplating.

Properties:
Higher degree of gloss
Increased corrosion resistance
Very good ductility (without separating particles)
Low tarnish
Good resistance to acids and alkali
Can passivate in the air (significantly higher resistance against corrosive influences)
Weldable, magnetic and can be polished
Hardness is located between 450 - 600HV, depending on the layer thickness (with good formability)

Phosphating

In phosphatizing a phosphoric acid solution is used to form a thin, finecrystalline, water insoluble phosphate on part surfaces. Depending on the solution used, iron, manganese, zinc or zinc/calcium-phosphate layers are formed on the surface. These light to dark grey phosphate layers have pores and capillaries because of their fine-crystalline structure, which in the next step fill with oil or wax. High corrosion resistance results. Besides high corrosion resistance, phosphatizing is also used to reach an optimum paint adhesion. Furthermore, frictional forces which occur with pulling and forming processes are reduced.

Properties (Manganese phosphate process):

Type:	Phosphate based, fine-crystalline
Color:	dark gray to black
Corrosion protection:	significantly improved by oiling or waxing
Friction:	improved sliding properties
Miscellaneous:	Corrosion protection by oil absorption

TD coating (Toyota diffusion)

Development by Toyota Central Research Institute Co. Ltd. Coating with properties similar to TiCN, however coating process is carried out by heat treatment diffusion at 1020°C and an insoluble surface layer (typically vanadium carbide) forms. Common names: Dicoat, TD-VC COATING, TD thermoreactive diffusion. In this process the part is immersed in a salt bath. Active vanadium combined with C atoms in steel now form the vanadium carbide layer and simultaneously an enormous adhesion of the layer occurs. Layer thickness can be precisely controlled by processing times, bath temperature and substrate composition. This multiple step coating process consists of a pre-heat to a given temperature, coating, ultrasonic cleaning and heat treating. TD coatings are found in similar areas of application as CVD coatings due to their similar properties. However, there are areas where their advantages are put to full use, e.g. for Al and Zn die casting, hot forging tools and forming die for stainless steel.

Properties:
Coated parts can be coated again multiple times (up to 9 times is known of).

Hardness:	Surface harden between 3200 HV and 3800 HV
Layer thickness:	from 5µm ~ 10µm are common
Miscellaneous:	Particularly resistant to abrasion and wear. TD coatings increases ductility (in hardened steel even the toughness)