

HART-COAT®

hard anodizing of aluminum alloys



surface
technologies

aalberts

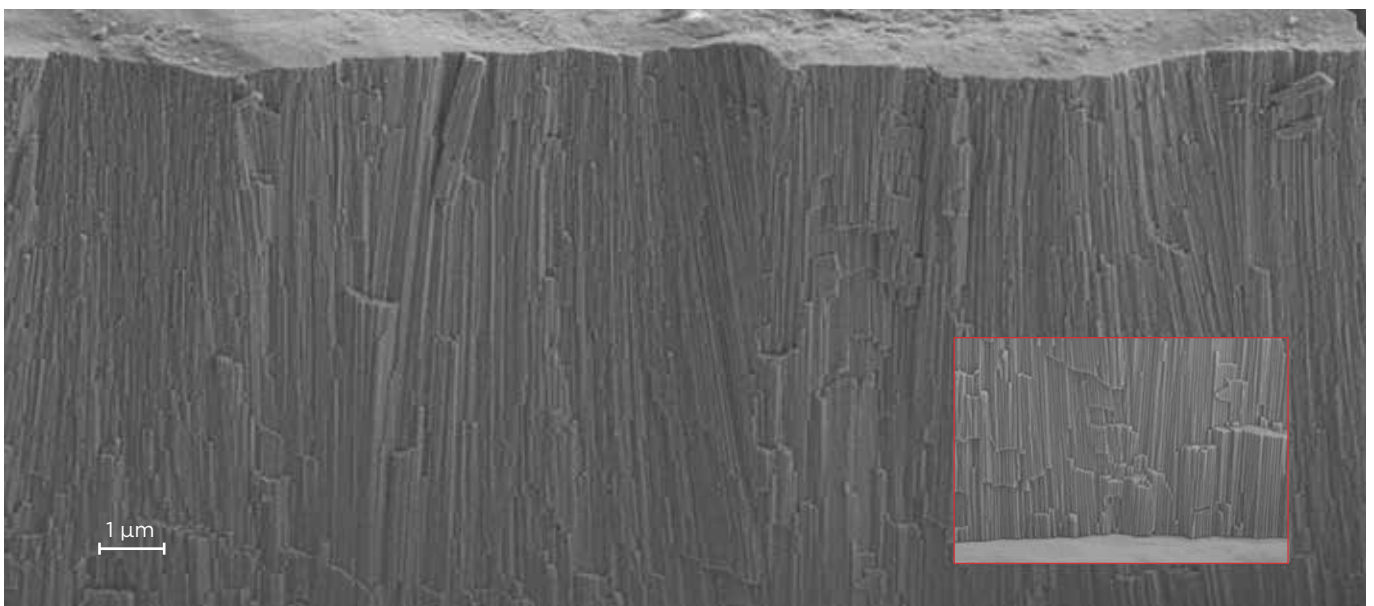
specialist knowledge, experience and first class technology

Alberts surface technologies is the right market partner for you in Hard Anodizing of Aluminum Alloys. We offer you the highest level of economic efficiency as well as quality in the functional coating of your components.

The HART-COAT® process is one of Alberts surface technologies core competencies and is even established as one of Alberts surface technologies brand names. Friebe und Reininghaus oHG developed ALU-HART-COAT in 1960 and since then it has become one of the strongest providers in the functional surface technology sector in Europe, winning world wide importance.

- Reliable series hard-coating (hard anodizing) of more than half a billion components per year
- Process in accordance with ISO 10074
- Extensive experience from thousands of projects in all key industries
- Process diversity for individual component properties
- Highest precision – own electrolytes
- Cutting-edge process technology for aluminum components up to 8 meters in length
- Market leader for anodizing in Germany
- HART-COAT® offered at numerous locations in Europe and at one location in China
- Strongly positioned for international projects

SEM image: The HART-COAT® layers develop in columns (vertically) and form a stable (honeycomb) cell structure. Each cell has a porous cavity.



what is HART-COAT®?

The HART-COAT® process, also known as HC, is an electrolytic treatment of aluminum substrates during which a hard and thick aluminum oxide layer is formed. The essential purpose of this surface treatment is to provide protection against wear and corrosion and to achieve further functional improvements to components from almost all industrial sectors.

how are HART-COAT® layers built-up?

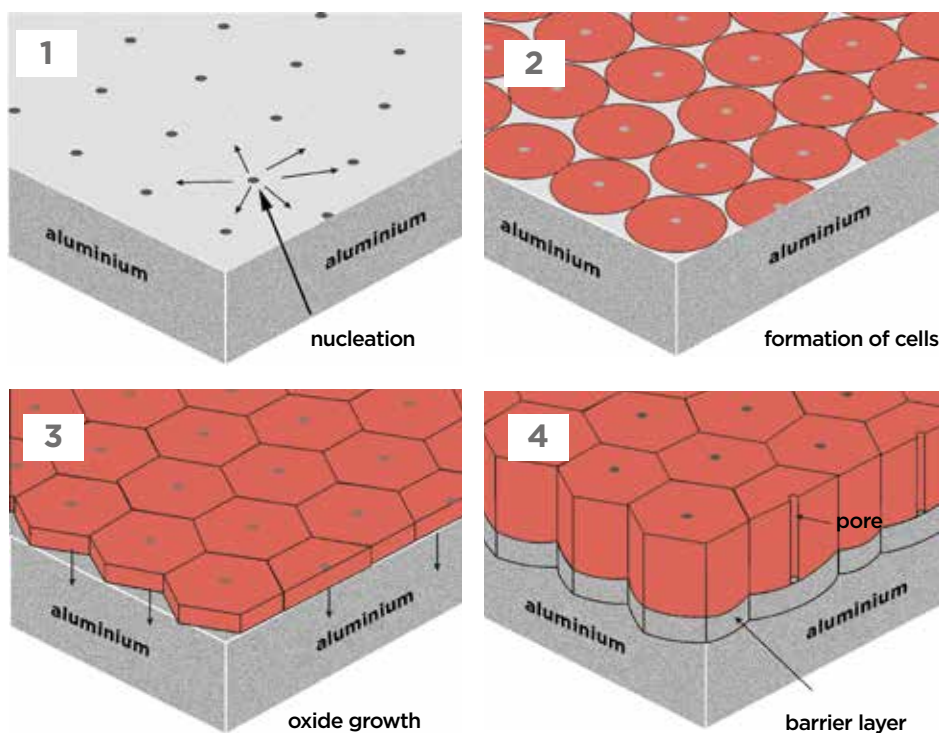
HART-COAT® layers are built up by anodic oxidizing in a specially formulated, cool, acidic electrolyte. By means of electric current, a protective ceramic-like aluminum oxide layer is produced on the surface of the workpiece being treated. Compared to conventional anodized layers, HART-COAT® layers are thick-

er and provide better wear resistance. They have very good adhesion to the base material. HART-COAT® offers more scope for designers to implement new lightweight concepts due to its high load-bearing capacity.

formation of hexagonal cell structures

A metal dissolving/oxidation reaction takes place on the aluminum workpiece connected as an anode. This microscopic reaction does not start uniformly across the entire surface but is distributed over preferred locations, the nucleus points. Starting from these nucleus points the oxidation spreads over the entire surface. The oxidation areas abut one another and finally cover the entire surface; they form a hexagonal cell structure. Each cell structure has a porous cavity.

formation of the HART-COAT® layer



HART-COAT®

what can HART-COAT® do?

HART-COAT® finished aluminum materials

Nearly all wrought, cast and die-cast aluminum alloys destined for industrial use are suitable for treatment with HART-COAT®.

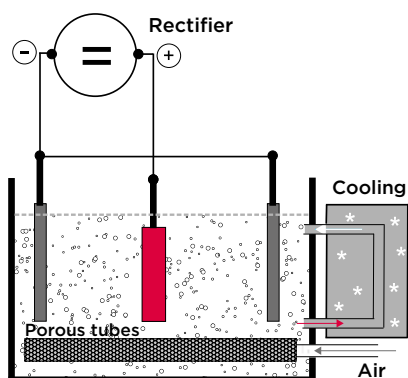
general coating characteristics

These properties depend on the type of alloy to which they are applied and the process variant:

- high wear resistance
- improved corrosion resistance
- improved hardness
- optimum anti-friction properties
- optimum adhesion
- high thermal insulation
- high electrical insulation
- good dimensional accuracy
- resistant to temperature

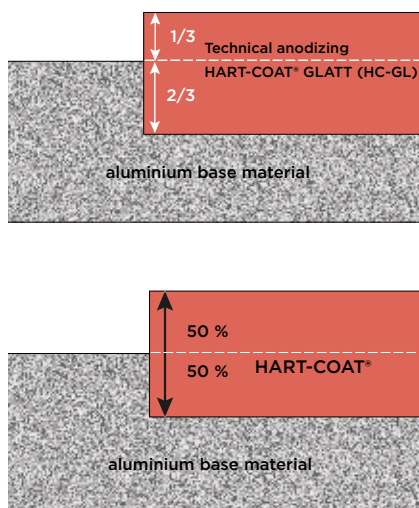
chemical composition and structure

HART-COAT® layers mainly consist of amorphous γ -aluminum oxide and are built up in a regular cellular form, vertically aligned to the surface of the aluminum. The pores of a HART-COAT® layer have a diameter of approx. 50 nm. The cell walls contain complete naturally insoluble alloy components and partially soluble components. The type of base material and the processing parameters selected affect the porosity, hardness and other characteristics of the HC layer. The pores that form in the HART-COAT® layer during the process can be used in many ways in the context of a post-treatment. Depending on the treatment of the HART-COAT® coated component, the friction and/or corrosion resistance can be optimized and the dry lubricating properties improved.



Principle of anodic oxidation:

Aluminum components (shown here in red) are immersed in a precisely specified electrolyte and connected as anodes. At high amperage a hard and ceramic-like aluminum oxide layer results. The electrolyte must be cooled.



Growth of HC-layers:

General image of layer growth. The layer growth is different depending on the process variant. Growth behaviour is important for the correct pre-measurement calculations for dimensioning of components.

Meticulous measurement of the layer thickness of a hardcoated component.



applications

The HART-COAT® surface treatment is used in **almost all industrial sectors** where aluminum alloys are used and **where particularly high specifications are required.**

- defence technology
- domestic appliances
- energy and reactor technology
- measurement and control technology
- mechanical engineering in general
- medical device manufacturing
- mining
- office and data technology
- pharmaceutical device manufacturing
- the automotive sector
- valves and fittings

1/ The Grip Factory Munich GmbH (GFM) in Munich is a renowned manufacturer of professional camera equipment. Cranes, dollies, etc. are used all over the world e.g. when shooting in Hollywood, in World Championship sporting events or spectacular advertising shoots.

The electromechanical GFM Dolly systems feature an incredible functional diversity and variability. As is customary at GFM, the CNC turned and milled lightweight aluminum components of all systems are coated with HART-COAT® from Aalberts surface technologies.

The coating ensures a distinctly better protection and longer lifespan of the surfaces. The resulting “olive green” look has established itself in the film industry as the GFM trademark for extremely robust camera equipment.

2/ Spilker pressure cylinder for receiving printing plates mainly found in flexographic, offset and letterpress machine usage. The hard anodised coating provides increased wear protection. Base material EN AW-6060 (AlMgSi), layer thickness 50 µm.

3/ HART-COAT®-GL coated (25 µm) lever and knife carrier for asparagus peeling machine. The layer protects against corrosion and provides improved cleaning and wear properties.

4/ We cover more than 60% of the European fuel pump market with our coatings. The HART-COAT® layer provides excellent corrosion protection against FlexFuels. In addition, the layer is resistant to wear from particles in fuels.



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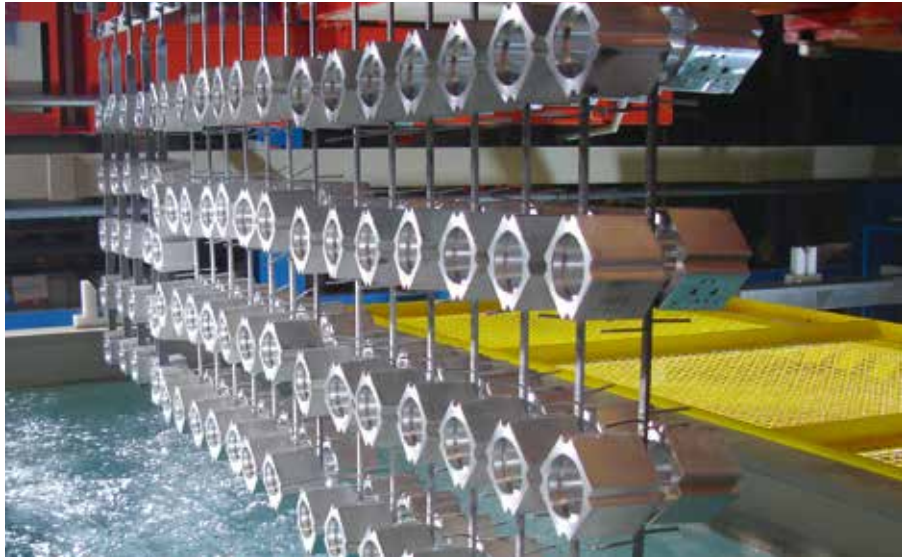
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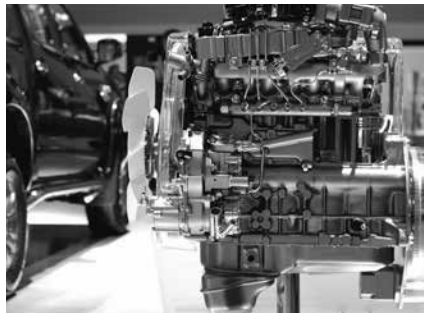
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1/ Rack goods in a HART-COAT®-facility

2/ HART-COAT® finds millions of applications in the automobile industry

3/ Hard-coated printing cylinders are used in offset printing machines

4/ Industrial high-performance asparagus peeling machine from the company HEPRO

5/ The hard-coated GF-8 Xten Crane System has established itself as an industry standard.

HART-COAT®

applications

1/ The installed helicopter seats in the Eurocopter EC 175, shown at the Paris Air Show. Parts of the seats and drive technology are functionally refined by Aalberts surface technologies.

2/ The Bavarian company B/E Aerospace Fischer GmbH, Lands-hut, is a world leader in the sector of crash-safe and ultra-light helicopter seats. They meet the highest international standards and conform to the required stress testing, even withstanding a vertical force of 30 g (!). The company relies on the coating of Aalberts surface technologies for the aluminum substructural parts. The coating significantly increases the longevity of the system.

2/

1/

process variants

HC for wrought aluminum alloys as well as sand and permanent mold cast

Applications	hot-plates, insulators, lifting gear, pneumatic and hydraulic cylinders, rocker arms, screw conveyors, spacers, surgical instrument	
Example alloys	<ul style="list-style-type: none"> • EN AC-51300 (G-/GK-AlMg5) • EN AC-71100 (AlZn10Si8Mg) • EN AW-5083 (AlMg4.5Mn0.7) • ENAW-5754 (AlMg3) • EN AW-6012 (AlMgSiPb) • EN AW-6060 (AlMgSi) 	<ul style="list-style-type: none"> • EN AW-6082 (AlSi1MgMn) • EN AW-7022 (AlZn5Mg3Cu) • EN AW-7075 (AlZn5.5MgCu) • EN AC-43000 (G-/GK-AlSi10Mg) • EN AC-44200 (G-/GK-AlSi12)
Typical layer thicknesses*	25-60 µm	

HC-CU for aluminum alloys with a high copper content (2 % to 6 %)

Applications	components, centrifuges, coils, guide pulleys, levers, nozzles, pistons, pulleys, roller bearings, valves	
Example alloys	<ul style="list-style-type: none"> • EN AW-2117 (AlCu2.5Mg) • EN AC-21100 (G-/GK-AlCu4Ti) • EN AC-45000 (G-/GK-AlSi6Cu4) 	<ul style="list-style-type: none"> • EN AW-2007 (AlCu4PbMgMn) • EN AW-2017A (AlCu4MgSi(A)) • EN AC-46200 (G-/GK-AlSi9Cu3)
Typical layer thicknesses*	25-50 µm	

HC-GD for die-cast aluminum alloys with high copper and/or silicon content

Applications	gears and rack drives, guide cylinders, guide plates, housings, mounting plates, shock absorbers	
Example alloys	<ul style="list-style-type: none"> • EN AC-51200 (GD-AlMg9Si) • EN AC-43400 (GD-AlSi10Mg) 	<ul style="list-style-type: none"> • EN AC-44300 (GD-AlSi12) • EN AC-46000 (GD-AlSi9Cu3)
Typical layer thicknesses*	20-40 µm	

HC-GL for wrought, cast and die-cast aluminum alloys with limited copper, silicon and lead content

Applications	For components requiring an especially smooth and wear-resistant surface.	
Example alloys (consultation with Aalberts surface technologies needed)	<ul style="list-style-type: none"> • EN AC-51200 (GD-AlMg9) • EN AW-5019 (AlMg5) • EN AW-5052 (AlMg2.5) • EN AW-5083 (AlMg4.5Mn0.7) • EN AW-5754 (AlMg3) 	<ul style="list-style-type: none"> • EN AW-6012 (AlMgSiPb) • EN AW-6060 (AlMgSi) • EN AW-6082 (AlSi1MgMn) • EN AW-7020 (AlZn4.5Mg1)
Typical layer thicknesses*	10 to a maximum of 25 µm. Layer thickness and layer thickness tolerance are dependent on the alloy, the bath-load and other parameters.	
Special characteristics	<p>Roughness: In comparison to conventional hard anodizing, the HC-GL process stands out with respect to its very low rate of roughness, which – according to the substrate used – varies between $R_a = 0.1-0.2 \mu\text{m}$. The increase is less if there is considerable surface roughness to begin with.</p> <p>Anti-friction characteristics: The coefficient of friction of HC-GL determined in an anti-friction test carried out with a pin-disc-tribometer had an average value of 0.73 ($F_N = 5\text{N}$; $v = 6 \text{ m/min}$; 9,000 revolutions).</p> <p>Wear resistance: Performance with regard to abrasive wear is especially good. Results of the Taber Abraser wear measurements can be seen in the diagram on page 12.</p> <p>Corrosion resistance: Even without sealing, the corrosion resistance of an HC-GL-treated surface is excellent. It can withstand a test period of well over 2,000 hours in the DIN EN ISO 9227 salt spray chamber test (e.g. 0-2 spots of corrosion per dm^2 to 25 µm HC-GL on EN AW-6082 (AlSi1MgMn)).</p>	
) Maximum possible layer thicknesses depend on the type of alloy to which they are applied. In the case of HART-COAT, the tolerance for wrought alloys normally lies between $\pm 5 \mu\text{m}$ and $\pm 10 \mu\text{m}$. For cast and die-cast materials, the tolerances can total up to $\pm 30 \mu\text{m}$ with high nominal layer thicknesses.		

optimization by post-treatment

Special post-treatments enable HART-COAT® layers to fulfill particularly demanding specifications with respect to, for example, increased anti-adhesion and sliding behavior or improved corrosion resistance.

HC-PLUS surface treatment with PTFE

The anti-friction and corrosion behavior of HART-COAT® layers can be improved with the use of PTFE (polytetrafluorethylene). The PTFE particles are applied to the HART-COAT® layer in a secondary process. PTFE has a very low coefficient of friction and thus optimizes the sliding properties of the coating. Due to its low surface energy, PTFE has excellent non-stick properties. The hydrophobic effect of PTFE improves the corrosion resistance of the coatings.

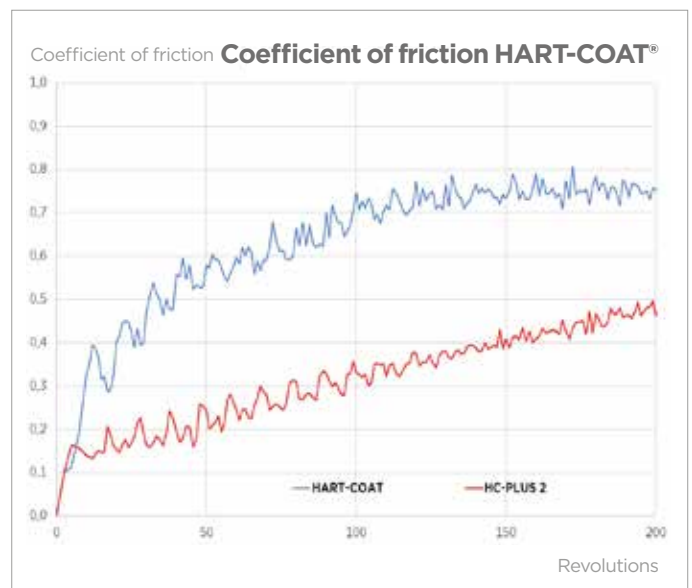
It can be clearly seen that friction is reduced by a good half through surface impregnation.

HC-PLUS 2 surface impregnation with PFA

The aforementioned properties for improving the coating functionalities also apply to HC-PLUS 2. In HC-PLUS 2, PFA particles are used for impregnation. PFA particles are approx. 25% smaller than the PTFE particles and can therefore be better incorporated into the surface structure of the coating. The sliding properties of the coating are thus even better pronounced and are retained for longer.

HC sealing

The HC sealing for closing off the pores is normally carried out in demineralized water (usually without sealant additives) at a temperature of 96-100 °C. This further improves the already excellent corrosion resistance of the HART-COAT® layers. Wear performance does however decrease in comparison to layers as-plated.



Sliding test with pin-disc tribometer:

$F_N = 1\text{N}$; $r = 6\text{mm}$; $v = 6\text{m/min}$; 200 revolutions; pin 100Cr6; disc EN AW-6082 (AlSi1MgMn), 40 μm HC or HC-PLUS 2

1/ Hard coated (layer thickness 65 µm) toothed pulley wheels from the renowned WIAG Antriebstechnik GmbH perform important tasks in printing presses from Heidelberger Druckmaschinen AG, the world market leader in the field of sheetfed offset printing machines.

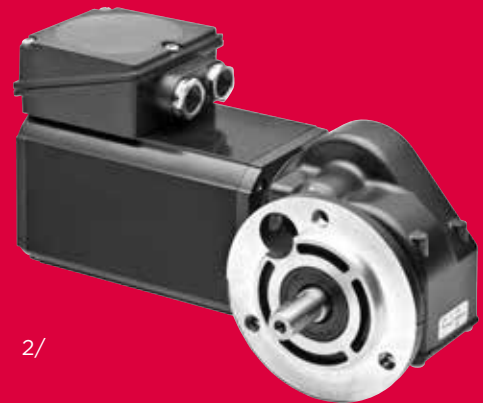
2/ Groschopp AG is a leading company in the field of electric drive technology. Housings for engines and transmissions are HART-COAT® coated and sealed with the dip coating SILA-COAT® 5000. The surfaces are water repellent and scratch and impact resistant. In addition, sealing increases the surface resistance to acids and especially the resistance to alkalis.

3/ Angle rotors from microlitre centrifuges are coated with HART-COAT®. The devices are found in blood banks and clinical laboratories where blood and other body fluids are centrifuged. The centrifuges are used for research in the extraction of DNA, proteins and enzymes. The angle rotors are made from an aluminum alloy in order to save weight. The 40 µm hard anodizing layer protects the components against corrosion.

4/ HART-COAT®-PLUS black (layer thickness 60 µm ± 10 µm) coated gear housing made of EN AW-5083 (AlMg4.5Mn0.7) for hydraulic rigging in sailing boats. The component receives long-term corrosion protection from the coating and takes on an elegant appearance.



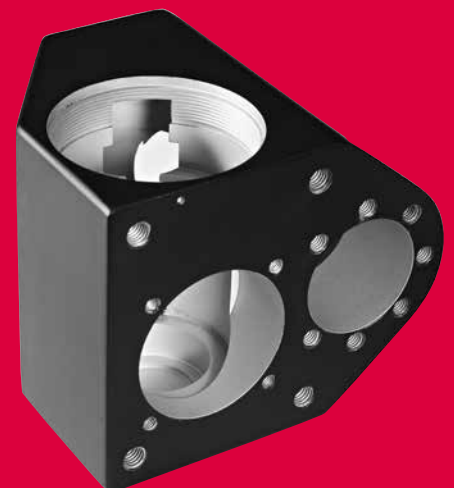
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technical characteristics

wear resistance:

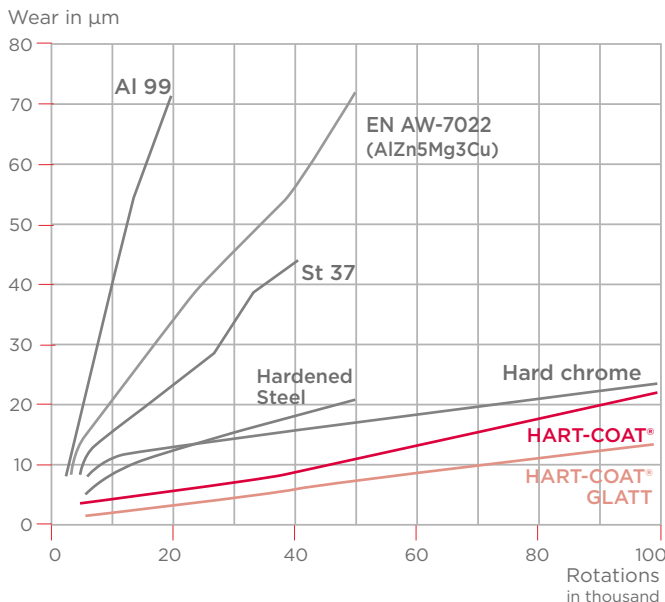
High wear resistance is based on the hardness and the morphology of the aluminum oxide.

hardness:

The achievable hardness of HART-COAT® layers is between 400 and 500 HV_{0,025}, depending on the composition and structure of the base material. The hardness of the HART-COAT®-GLATT layer (HC-GL layer) depends also on the alloy and amounts at least to 400 HV_{0,025}.

Measurement of so-called “apparent hardness” depends on the specific formation of the oxide layer. This depends also to an extent on the volume of the pores and the composition of the alloy.

In case of doubt, a sample job can be carried out to determine the the achievable levels of hardness and wear resistance.



Wear behavior of HART-COAT® layers compared to other materials (Taber Abraser measurements, abrasive wheel CS 17, load 10 N).

physical characteristics

heat conductivity:

about 1/10 to 1/30 of the heat conductivity of the base material.

resistivity

(values measured in dry atmosphere):

at 20 °C: $4 \cdot 10^{15} \Omega\text{cm}$

at 100 °C: $0,8 \cdot 10^{15} \Omega\text{cm}$

at 200 °C: $0,11 \cdot 10^{15} \Omega\text{cm}$

temperature load capacity

short-term up to 2,200 K

electric strength:

depending on the type of alloy; taking into account the layer thickness, the electric strength increases – but not proportionally.

Example*)

30 µm HC on EN AW-6082 (AlSi1MgMn) : 914 V

50 µm HC on EN AW-6082 (AlSi1MgMn) : 1213 V

*) Arithmetic average based on ten individual measurements pursuant to DIN EN ISO 2376

appearance and color:

HC: greyish-brown to black

HC-CU: greenish-grey to dark grey

The color of the HC-GL layer depends on the alloy to which it is applied. In the case of pure aluminum (Al 99.5), the color is golden yellow. The greater the number of alloy components, the more the color tends towards greyish-yellow.

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