

HART-COAT®

Hard Anodising of Aluminium Alloys



HART-COAT®-coated valve spools

- *High wear resistance*
- *Improved corrosion resistance*
- *Improved hardness*
- *Optimum anti-friction properties*
- *Optimum adhesion*
- *High thermal insulation*
- *High electrical insulation*
- *Good dimensional accuracy*

*Innovative and highly functional
surface designs*

The AHC Group is the right market partner for you in Hard Anodising of Aluminium Alloys. AHC offers you the highest level of economy and quality in the functional coating of your components.

Meticulous measurement of the coating thickness of hard-coated components.



Specialist knowledge, experience and first class technology

The HART-COAT® process is one of AHC's core competencies and is even established as one of AHC's 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 anodising) 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 aluminium components up to 8 meters in length
- Market leader for anodising in Germany
- HART-COAT® at numerous locations in Europe and at one location in China
- Strongly positioned for international projects

All technical values published in this brochure are subject to the test conditions specified. We therefore emphasise that the applications and operating conditions, along with the end user's practical experience, will ultimately determine the level of performance achieved by the coating and/or coating system.



This HART-COAT® facility in the AHC plant in Hangzhou, China, functions fully automatically and offers the highest series reliability & efficiency.

What is HART-COAT®?

The HART-COAT® process, also known as HC, is an electrolytic treatment of aluminium substrates during which a hard and thick aluminium oxide layer is formed. The essential purpose of this surface treatment is to provide protection against wear and corrosion as well as 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 oxidising in a specially formulated, cool, acidic electrolyte. By means of electric current, a protective ceramic-like aluminium oxide layer is produced on the surface of the workpiece being treated. Compared to conventional anodised layers, HART-COAT® layers are thicker and provide better wear resistance.

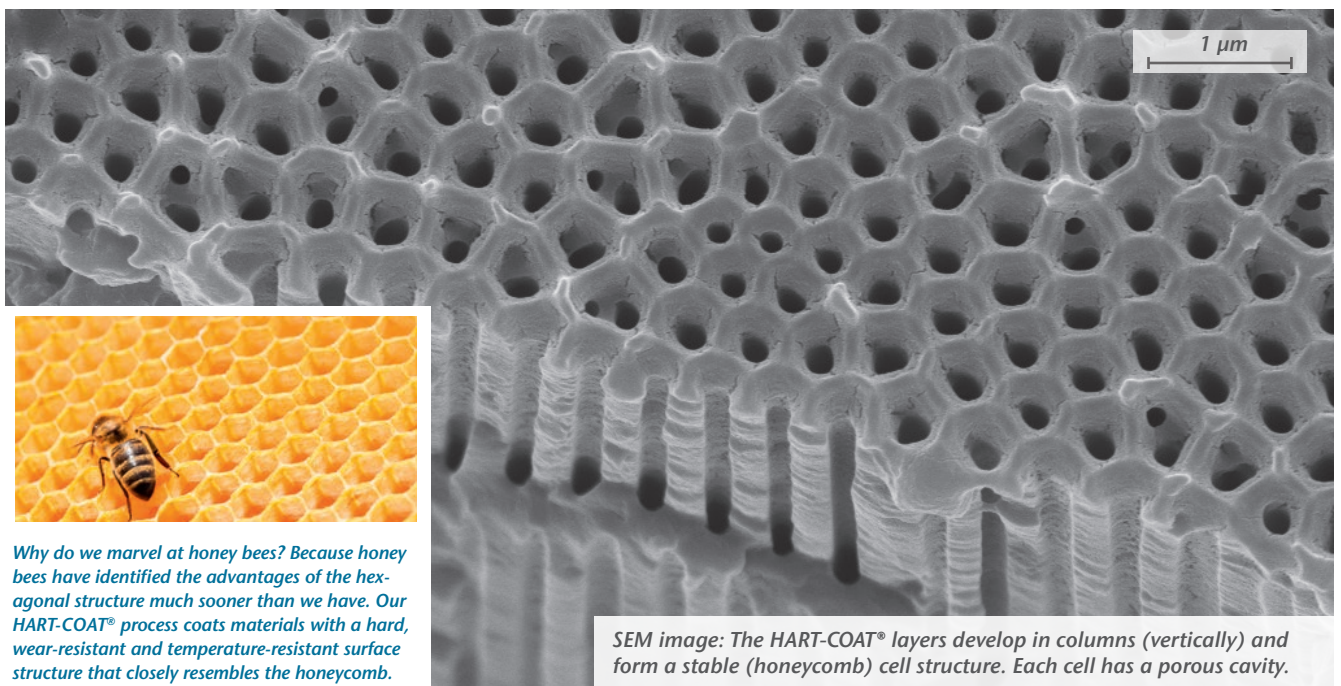
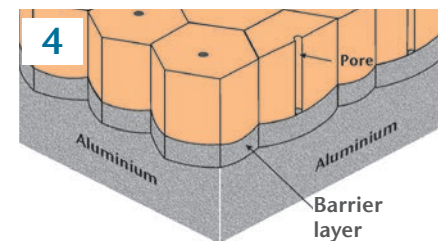
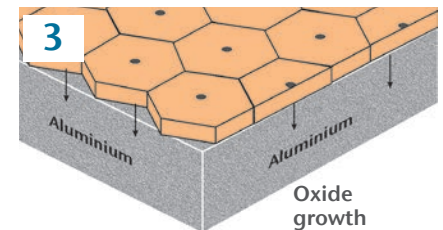
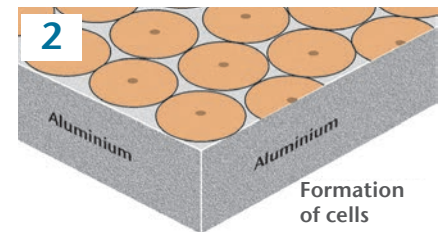
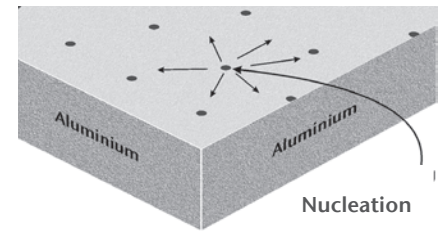
They have very good adhesion to the base material.

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 aluminium 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



Why do we marvel at honey bees? Because honey bees have identified the advantages of the hexagonal structure much sooner than we have. Our HART-COAT® process coats materials with a hard, wear-resistant and temperature-resistant surface structure that closely resembles the honeycomb.

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



Proven technology for consistently high coating quality. Every day at AHC, individual parts and small and large production series are meticulously and reliably coated. Here at AHC Munich the hard anodising of a mechanical engineering part is being discussed.

What can HART-COAT® do?

HART-COAT® finished aluminium materials

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

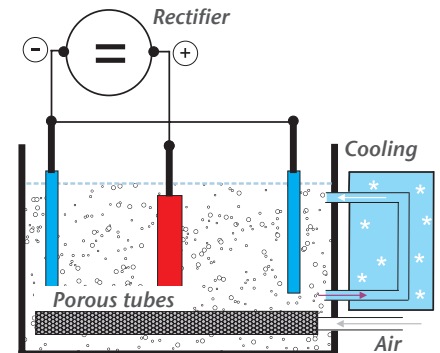
General coating characteristics

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
- food compatible

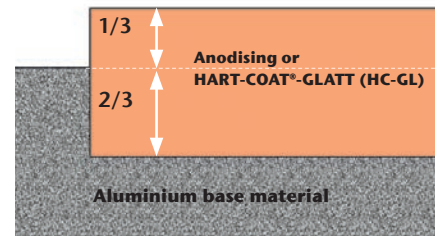
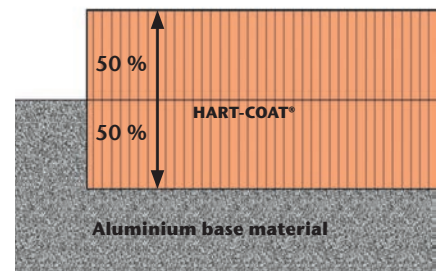
Chemical composition and structure

HART-COAT® layers mainly consist of amorphous γ -aluminium oxide and are built up in a regular cellular form, vertically aligned to the surface of the aluminium. 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 optimised and the dry lubricating properties improved.



Principle of anodic oxidation:

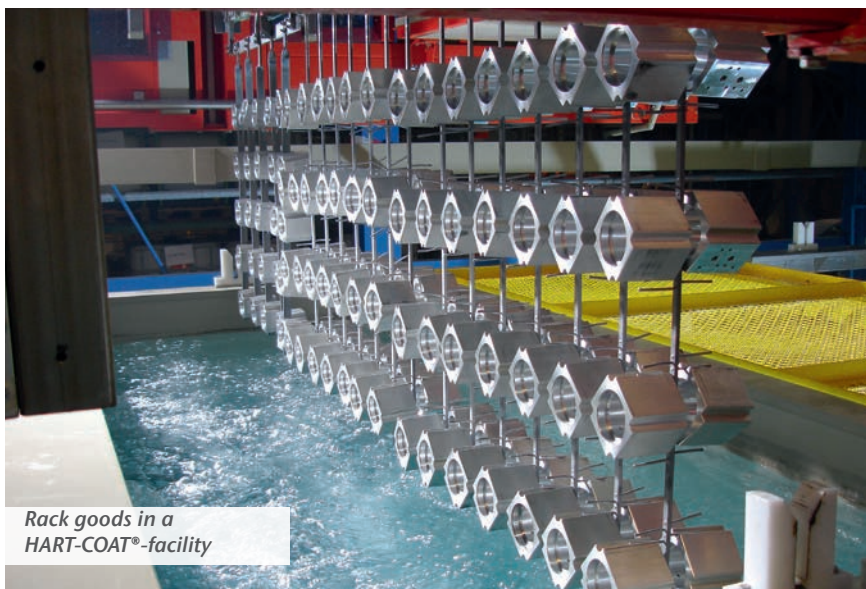
Aluminium components (shown here in red) are immersed in a precisely specified electrolyte and connected as anodes. At high amperage a hard and ceramic-like aluminium oxide layer results. The electrolyte must be cooled.



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.



Rack goods in a HART-COAT®-facility



A large component before coating.

1/ 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.



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



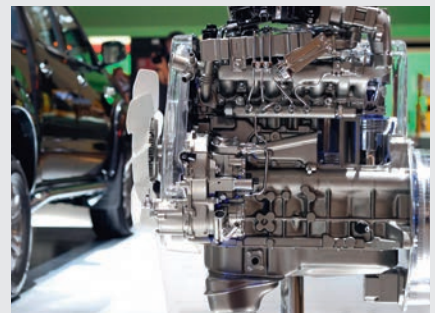
3/ We cover more than 60% of the European fuel pump market with our coatings. The HART-COAT® layer provides excellent corrosion protection against FlexFuels. In addition, the layer is resistant to wear from particles in fuels.



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



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



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

- defence technology
- domestic appliances
- energy and reactor technology
- food processing industry
- 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

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

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 aluminium components of all systems are coated with HART-COAT® from AHC.

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.



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



*The crane system in use on a shoot.
Image: Grip Factory Munich GmbH (GFM)*



AHC is a reliable partner in project work.

The Bavarian company B/E Aerospace Fischer GmbH, Landshut, 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 AHC Oberflächentechnik GmbH for the aluminium substructural parts. The coating significantly increases the longevity of the system.



Production of innovative helicopter seats in Landshut, Bavaria, Germany.



The installed helicopter seats in the Eurocopter EC 175, shown here at the Paris Air Show. Parts of the seats and drive technology are functionally refined by the AHC Group.

HC For wrought aluminium alloys as well as sand and permanent mold cast	
Applications	<ul style="list-style-type: none"> clamping and retaining mechanisms • compressor wheels • cylindrical tubes • hot-plates • insulators • lifting gear pneumatic and hydraulic cylinders • rocker arms • screw conveyors • spacers • surgical instruments
Example alloys	<ul style="list-style-type: none"> EN AC-51300 (G-/GK-ALMg5) EN AC-71100 (AlZn10Si8Mg) EN AW-5083 (AlMg4.5Mn0.7) EN AW-5754 (AlMg3) EN AW-6012 (AlMgSiPb) EN AW-6060 (AlMgSi) EN AW-6082 (AlSi1MgMn) EN AW-7022 (AlZn5Mg3Cu) EN AW-7075 (AlZn5.5MgCu) G-/GK-ALSi10Mg G-/GK-ALSi12
Typical layer thicknesses*	25-60 µm

HC-CU For aluminium alloys with a high copper content (2 % to 6 %)	
Applications	<ul style="list-style-type: none"> bearing shells • cam plates • camera components • centrifuges • coils • guide pulleys • levers • nozzles pistons • pulleys • roller bearings • valves
Example alloys	<ul style="list-style-type: none"> AlMgCu2 EN AC-21100 (G-/GK-ALCu4Ti) EN AC-45000 (G-/GK-ALSi6Cu4) EN AW-2007 (AlCu4PbMgMn) EN AW-2017A (AlCu4MgSi(A)) G-/GK-ALSi9Cu3
Typical layer thicknesses*	25-50 µm

HC-GD For die-cast aluminium alloys with high copper and/or silicon content	
Applications	<ul style="list-style-type: none"> clothes iron plates • clutch components • cylinder heads • 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) GD-ALSi10Mg(Cu) GD-ALSi12 GD-ALSi9Cu3
Typical layer thicknesses*	20-40 µm

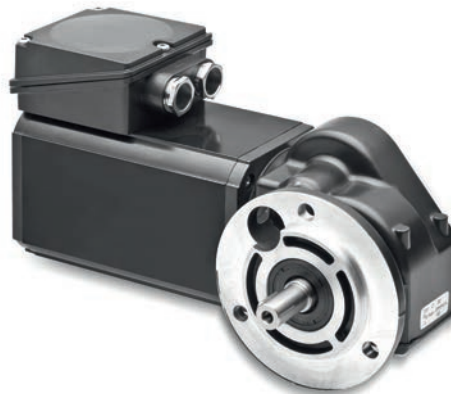
HC-GL For wrought, cast and die-cast aluminium alloys with limited copper, silicon and lead content	
Applications	For components requiring an especially smooth and wear-resistant surface.
Example alloys (consultation with AHC needed)	<ul style="list-style-type: none"> EN AC-51200 (GD-ALMg9) EN AW-5019 (AlMg5) EN AW-5052 (AlMg2,5) EN AW-5083 (AlMg4.5Mn0.7) EN AW-5754 (AlMg3) EN AW-6012 (AlMgSiPb) EN AW-6060 (AlMgSi) EN AW-6082 (AlSi1MgMn) EN AW-7020 (AlZn4.5Mg1) G-/GK-/GF-ALMg3
Typical layer thicknesses*	20-40 µm
Special characteristics	<p>Roughness: In comparison to conventional hard anodising, the HC-GL process stands out with respect to its very low rate of roughness, which – according to the substrate used – varies between $R_a = 0.1\text{--}0.2\text{ }\mu\text{m}$. 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 $\pm 5\text{ }\mu\text{m}$ and $\pm 10\text{ }\mu\text{m}$. For cast and die-cast materials, the tolerances can total up to $\pm 30\text{ }\mu\text{m}$ with high nominal layer thicknesses. In the case of the HART-COAT®-GLATT (HC-GL) variant, a tolerance of $\pm 3\text{ }\mu\text{m}$ can be expected (depending on the type of alloy).

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.



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.



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 aluminium alloy in order to save weight. The 40 µm hard anodising layer protects the components against corrosion.



Special post-treatments enable HART-COAT® layers to fulfil particularly demanding specifications with respect to, for example, increased wear and corrosion resistance or improved anti-friction properties.

HC-PLUS surface treatment with PTFE

The anti-friction and corrosion behaviour 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. This supplies optimum dry-lubricated performance, and the anti-adhesive properties of the surface make it easier to clean.

HC-PLUS 2 surface impregnation with PFA/PTFE

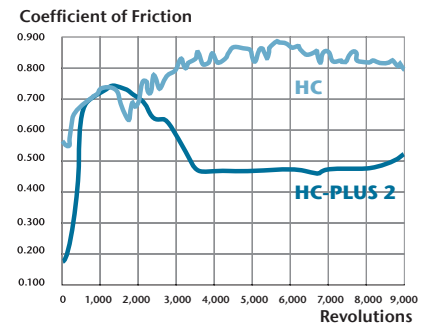
The characteristics described above apply equally to HC-PLUS 2. What makes it distinct from HC-PLUS is that the dry-lubricant is incorporated into the actual surface finish. This means that HC-PLUS 2 does not build-up additional layers. These anti-friction properties remain intact even when the surface is subject to abrasive wear.

HC sealing

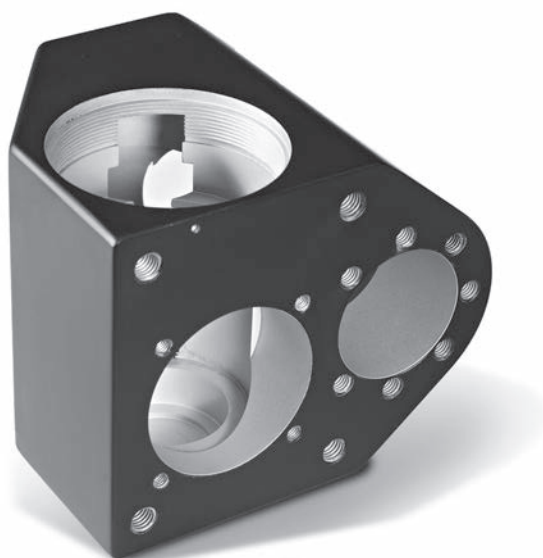
The HC sealing for closing off the pores is normally carried out in demineralised water (usually without sealant additives) at a temperature of 96–100 °C. This further improves the already excellent corrosion resistance of the HART-COAT® layers. Wear performance does however decrease in comparison to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

Sliding test with pin-disc tribometer:

$F_N = 5\text{N}$; $r = 6\text{mm}$;
 $v = 6\text{m/min}$; 9,000 revolutions; pin 100Cr6;
disc EN AW-6082 (AlSi1MgMn),
50 µm HC or HC-PLUS 2



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



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.

Technical characteristics

Wear resistance:

High wear resistance is based on the hardness and the morphology of the aluminium 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, for common types of alloy, lies between 450 and 550 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 for the purposes of determining the achievable levels of hardness and wear resistance.

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: $0.11 \cdot 10^{15} \Omega\text{cm}$

Temperatur load capacity

short-term up to 2,200 K

Electric strength:

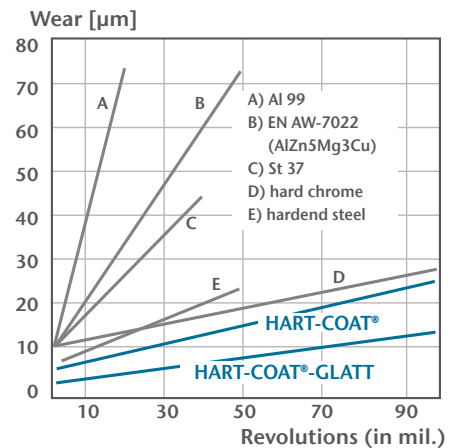
depending on the type of alloy; taking into account the layer thickness, the electric strength increases – but not proportionally

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

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



Under certain conditions, the HART-COAT® layer is as wear resistant as hard chromium or hardened steel.

Appearance and colour:

HC: greyish-brown to black

HC-CU: greenish-grey to dark grey

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



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