Technical Bulletin

Tungsten Carbide – Cobalt – Chromium

Versatile WC 10Co 4Cr portfolio tailored to specific wear and corrosion needs

Introduction

Tungsten Carbide (WC) based thermal spray powders with a cobalt-chromium matrix are applied in numerous applications to provide optimal surface protection against abrasion, friction wear, erosion, or cavitation. Depending on the ambient conditions, the coatings can be used at moderate temperature levels, up to a maximum of 500 °C.

The carbide content, primary carbide size, matrix composition, and powder morphology define key properties of the coatings, such as wear resistance and mechanical properties. Therefore, proper material selection is crucial for achieving the best possible performance of the coating in the targeted application.

In comparison to WC-Co or WC-Ni, Tungsten Carbide in a matrix of Cobalt and Chromium (WC 10Co 4Cr) is suitable for applications that require better corrosion protection. The Co-based matrix, with its high Cr content, ensures good protection in a wide range of corrosive environments, such as humid atmospheres, seawater, and other aqueous solutions with moderately alkali or slightly acidic properties.

The combination of excellent wear and good corrosion resistance makes materials such as **Amperit 558** versatile solutions for many applications in aviation, steel and paper making, Oil & Gas, mining, or the replacement of galvanic hard chrome overlays/plating.

Powder Properties and Typical Applications

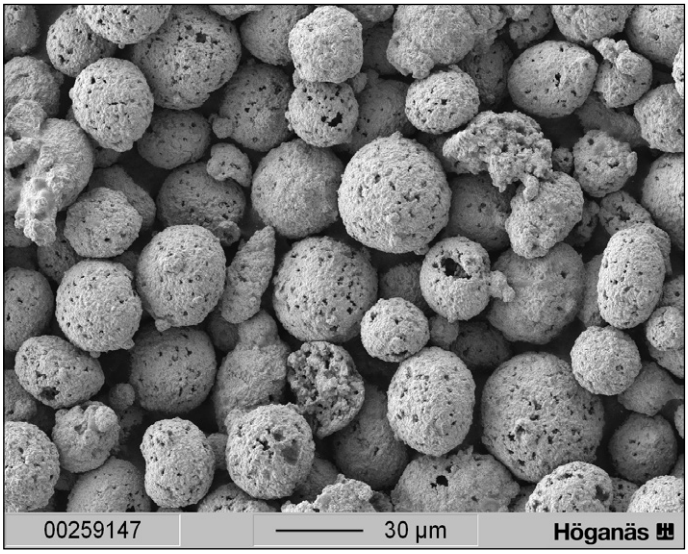
Höganäs' carbide portfolio contains various grades of agglomerated & sintered, as well as sintered & crushed WC 10Co 4Cr powders (Figure 1). In addition to particle size, our customers can choose between different primary carbide sizes to find the best solution for their specific application.

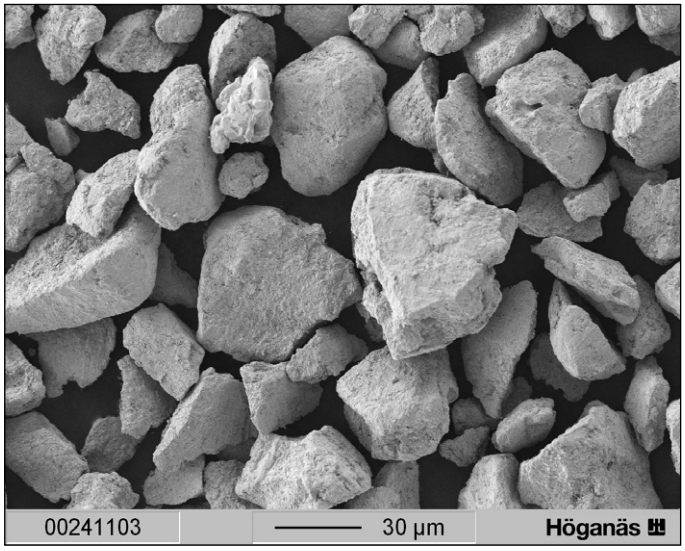
Powders with nano-metric or submicron tungsten carbides (**Amperit 507** and **556**) are the best choice for applications requiring a mirror-polished surface finish and a homogenous microstructure, such as paper production, film, or foil making processes (Figure 2).

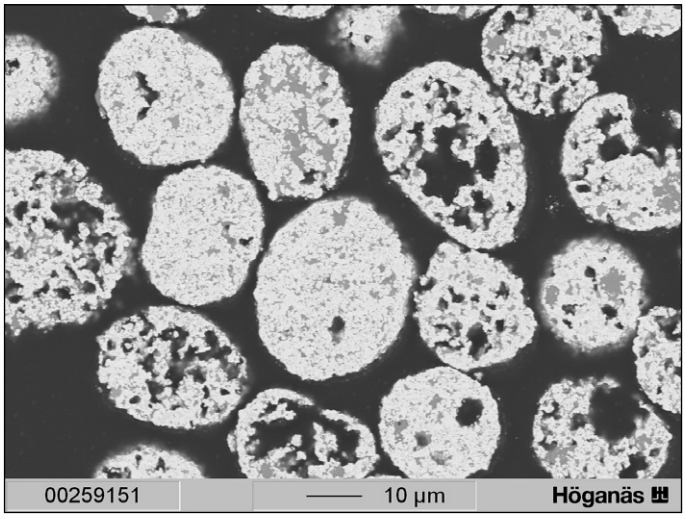
For applications where parts are exposed to higher mechanical load, high-stress abrasion, or cavitation, coatings made from powders with coarser carbides (such as **Amperit 558** or, especially, **Amperit 557**) generally show better performance. Landing gear components for aircrafts, process rolls in steel production, or hydro-turbine parts are just a few examples.

Ultra fine powders, such as Amperit **558.052**, **554.071**, **554.067**, and **658.067** are specially developed for smooth, extra-thin, and dense coatings. With a coating thickness of even below 50 µm, they provide an economic and sustainable alternative solution to galvanic hard chrome. The low surface roughness in the as-sprayed condition significantly reduces the efforts needed for final finishing or is suitable for surfaces that are intended to be in the as-sprayed condition, such as on corrugated rolls in paper processing.

Figure1: Typical Powder Morphology

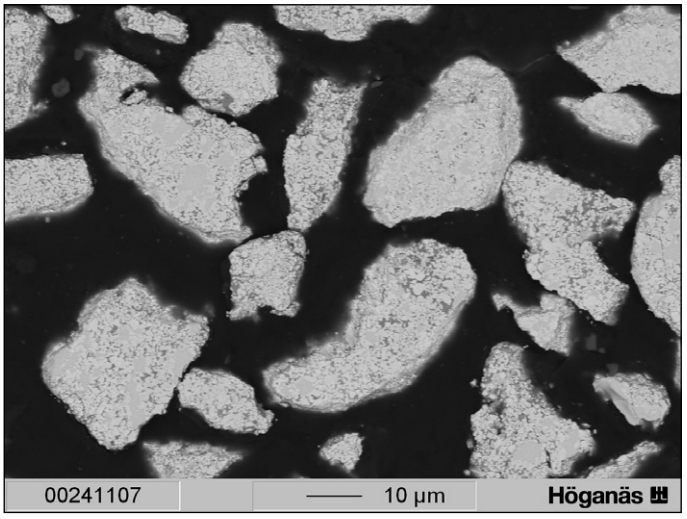






Amperit 558

Agglomerated & Sintered, predominantly spherical particle shape



Amperit 554

Sintered & Crushed, blocky and dense particles

Typical Properties of HVOF- and HVAF-Sprayed Coatings:

HVOF- and HVAF-sprayed coatings of WC 10Co 4Cr typically outperform other thermal spray coatings in terms of hardness, general wear resistance, as well as bond strength and other mechanical properties. The combination of different coating properties must be adjusted to meet the application requirements in the best possible way by selecting the right combination of powder grade on one hand, and process and parameters on the other (see table below).

Typical Properties of HVOF- and HVAF-Sprayed Coatings		
Deposition Efficiency:	40–65%	
Roughness as-sprayed, Ra:	2.5 – 7.0 µm, 2.5 µm or below achievable, using fine powders such as 30/5, 25/5, 20/5 or 15/5 µm	
Bond Strength (on steel):	> 80 MPa	
Hardness HV0.3:	HVOF	1000–1400
	HVAF	1200–1550
Wear (ASTM G65, mod):	< 3 mm^3	

**Typical data. For more details please contact us at: www.hoganas.com/en/contact/*

Table 1: Comparison of Typical Wear Coating Properties Made from Different Amperit WC 10Co 4Cr Powders

Amperit	Carbide Size	Abrasive Wear (ASTM G65)	High Stress Abrasion	Cavitation
507	Nano-metric	+++	+	+
556	Submicron	+++	+	+
558	Fine	+++	++	+++
557	Medium	++	+++	+++
554, s+c	Medium	+++	++	++

**Typical data. For more details please contact us at: www.hoganas.com/en/contact/.*

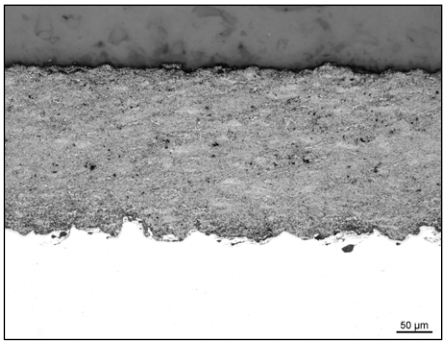
Corrosion

The corrosion behavior of coatings not only depends on the environment but also on coating quality, microstructure, phase composition, and substrate material, all of which significantly influence corrosion performance.

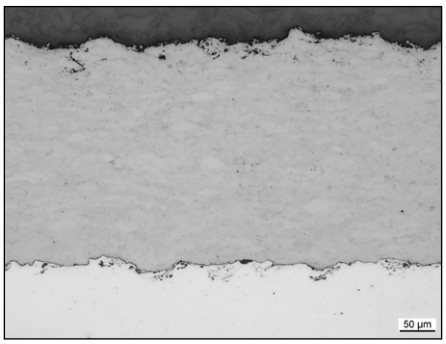
Generally, carbide coatings exhibit excellent corrosion resistance against neutral and moderately alkali aqueous media. In acidic conditions, the metallic matrix may undergo corrosive attack, facilitated by a contact corrosion cell formed between the carbide and the matrix.

At room temperature, dense and crack-free HVOF-/HVAF-sprayed coatings of WC 10Co 4Cr provide excellent corrosion protection in environments containing NaCl. Additionally, in various aqueous acidic environments (such as 0.5 M citric acid, 0.5 M H_2SO_4, or 0.1 M HCl) fair corrosion resistance can be achieved under ideal conditions.

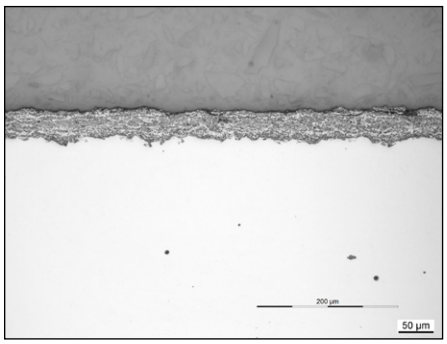
Figure 2: Microstructures (LOM) of Typical Coatings of WC 10Co 4Cr



Amperit 558.074
sprayed with liquid-fueled HVOF



Amperit 507.074
sprayed with liquid-fueled HVOF



Amperit 558.052
sprayed with HVAF for economic replacement of galvanic hard chrome

Table 2: Overview of Höganäs' WC-Co-Cr Portfolio

Amperit	Particle Size (µm)	Carbide Size	APS	HVOF	HVAF	Special Features and Typical Applications
WC 10Co 4Cr, Agglomerated & Sintered:						
507.059	30/5	Nano-metric		X	X	• For homogeneous, nano structured coatings; mirror-polished surface finish • Excellent wear resistance against micron and submicron-sized abrasives • Paper and foil industry: calendar rolls, coater blades, film rolls
507.074	45/15			X		
556.059	30/5	Submicron		X	X	• Excellent surface finish and homogenous microstructure of the coatings • Paper and foil industry: calendar rolls, coater blades, film rolls
556.074	45/15			X		
557.059	30/5	Medium		X	X	• Optimized carbide size and powder morphology for dense coatings with improved stress tolerance and cavitation resistance • Aviation: landing gears, actuators • Hydropower: hydro turbine runners, Pelton buckets • Oil & Gas: high pressure valves in submarine exploration • Hard chrome replacement
557.074	45/15			X		
558.052	20/5	Fine			X	• Hard chrome replacement: hydraulic cylinders, piston rods • Aviation: landing gears, actuators • Paper industry: calendar rolls, corrugated rolls • Oil & Gas, chemical industry: gate and ball valves, compressor shafts, mud pump rotors • Steel production: various process rolls • 558.052 specially developed for thin, dense and smooth coatings as economic hard chrome replacement with superior wear and corrosion performance; applied e.g., by HVAF, ID-HVOF/HVAF
558.059	30/5			X	X	
558.072	38/10			X		
558.074	45/15		X	X		
558.088	53/20		X	X		
WC 10Co 4Cr, Dense Sintered & Crushed:						
554.067	15/5	Medium			X	• Blocky and dense particles • Typical applicaiton in hydropower due to good cavitation resistance • 554.067 & 554.071 suitable for thin, dense and smooth coatings as economic hard chrome replacement with superior wear performance; applied e.g., by HVAF, ID-HVOF/HVAF
554.071	25/5			X	X	
554.074	45/15		X	X		

OEM Approvals

OEM	Specification	Amperit
SAFRAN Landing Systems	PCS-2561	Amperit 558.655
SAE (AMS)	AMS 7882 Method 1	Amperit 558.434
SAE (AMS)	AMS 7882 Method 1	Amperit 558.444 (low AD)
SAE (AMS)	AMS 7882 Method 2	Amperit 558.433
SAE (AMS)	AMS 7882 Method 3	Amperit 558.426
SAE (AMS)	AMS 7882 Method 4	Amperit 558.443

Related Products

- WC 12Co coatings achieve in general higher hardness levels and thereby offer lower wear and abrasion for applications with moderate corrosive attack. Höganäs products are Amperit 512, 515, 518 and 519.
- WC 17Co materials are chosen for higher toughness, improved impact resistance, and lower fretting compared to WC 10Co 4Cr, albeit with lower corrosion resistance. Höganäs product is Amperit 526.
- Cr_3C_2 20(Ni 20Cr) and Cr_3C_2 25(Ni 20Cr) are recommended for applications at service temperatures up to 870°C. Additionally, they offer better corrosion protection in saline, sulphuric, or alkaline environments.
- Amperit 538.074 (WC 30WB 10Co), is designed for special applications such as Zn-bath equipment or other applications involving contact with liquid metal.
- Amperit 618.074 (WC 15FeCrAl) is a Co- and Ni- free alternative for wear protection coatings.
- Amperit 658.067 (WC 10Co 4Cr) in 15/5 µm is specially designed for producing very economic and sustainable Net Shape Coatings or Near Net Shape Coatings. For more details, please refer to the Amperit 658 Technical Bulletin.
- Nickel self-fluxing alloys with the addition of hard phases are widely used for hard facing applications. The coatings are mainly applied by flame spraying with a subsequent fusing treatment.
- Nickel self-fluxing alloys applied by HVOF reach hardness levels of 400–600 HV0.3 and are suitable for moderate wear applications and offer good corrosion protection.
- Iron-based alloys such as 3.50 and 3650-02 can be applied by HVOF and offer moderate wear protection and good corrosion resistance at hardness values in the range of 400–600 HV0.3.

Handling and Safety Recommendations

- Store in dry location.
- Open containers should be stored in a drying oven to prevent moisture pickup.
- Tumble powder prior to use to prevent segregation.
- For information related to health, safety and the environment, please refer to the respective Safety Data Sheets.

More info: scan or click the QR Code