Technical Bulletin

Chromium Carbide – 20 % Nickel Chromium
Chromium Carbide – 25 % Nickel Chromium
Chromium Carbide – 25 % CoNiCrAlY

High temperature protection against corrosion and oxidation

Introduction

Chromium Carbide (Cr_3C_2) based thermal spray powders are widely used to protect surfaces against erosion and abrasion. Cr_3C_2 coatings containing a matrix of NiCr alloys or CoNiCrAlY also exhibit good resistance to various corrosive media, including humid atmospheres, steam, seawater, and aqueous solutions with alkali or slightly acidic properties. Compared to WC-based materials, coatings made of Cr_3C_2 also show a better hot corrosion and oxidation resistance and can be used at elevated temperatures up to 870 °C depending on application conditions.

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

Hard chrome replacement on hydraulic cylinders and piston rods are typical applications for HVOF- or HVAF-sprayed coatings made of agglomerated and sintered CrC-NiCr powders, such as **Amperit 588** and **578**. Due to their good corrosion and oxidation resistance, these coatings are also applied onto parts exposed to higher temperatures, such as furnace rolls in steel production, boilers in power plants, steam turbine parts, and valve spindles in ship engines.

Powder Properties and Typical Applications

Höganäs' carbide portfolio contains various grades of agglomerated & sintered as well as blended Cr_3C_2 powders with different binder contents and carbide sizes (Figure 1).

Coatings from agglomerated and sintered powders with a NiCr matrix of 25% NiCr (**Amperit 588** and **584**) are the right choice for applications requiring good wear resistance, as well as good hot gas corrosion and oxidation resistance. HVOF and HVAF are recommended processes to achieve the best coating quality (Figure 2).

With its higher carbide content, **Amperit 578** provides better wear resistance under severe abrasive environments. Typical examples include hydraulic cylinders or piston rods in mining or other earth moving applications.

Due to the coarse carbides, **Amperit 585** is also suitable for plasma spraying. Coatings are applied to combustion parts in turbines with wear interfaces, such as mounting pins, fuel injectors, combustion casings, and seal segments in the high-pressure turbine section. Several grades of **Amperit 585** fulfil OEM specifications for aero and industrial gas turbines.

Amperit 594 contains a CoNiCrAlY alloy as the matrix material and has been specially developed for applications such as furnace rolls in steel production, which require superior high-temperature strength, wear resistance, and oxidation resistance.

Corrosion

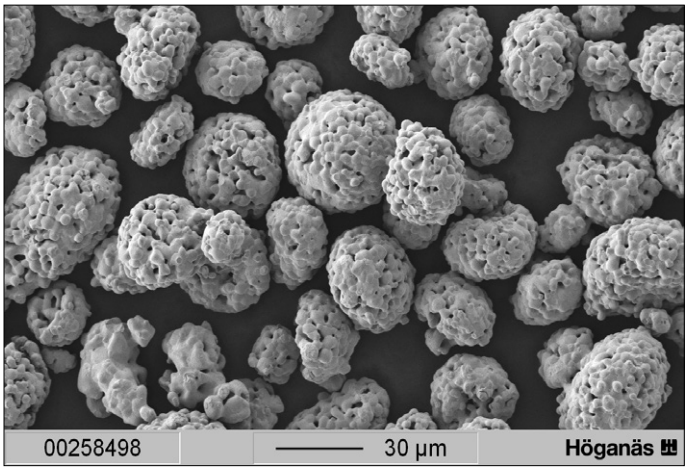
The corrosion behavior of carbide coatings does not depend solely on the environment. Additionally, coating quality, microstructure, phase composition, and substrate material all exert a significant influence on the corrosion performance. Generally, carbide coatings exhibit excellent corrosion resistance 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.

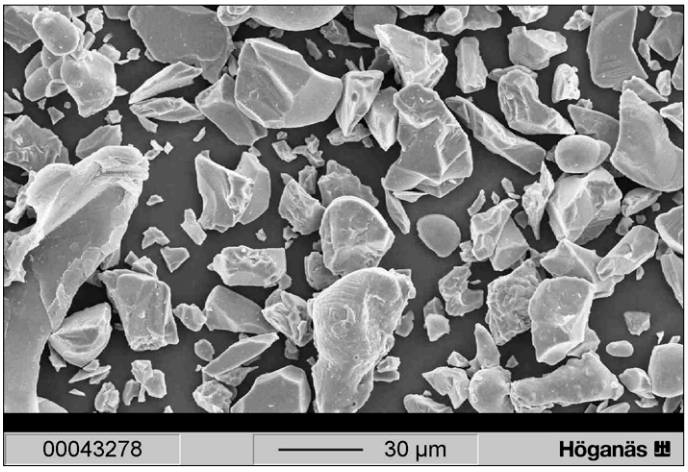
At room temperature, crack-free HVOF/HVAF-sprayed coatings of CrC-NiCr provide excellent corrosion protection in environments containing NaCl. Also, in certain aqueous acidic environments (such as 0.5 M citric acid), good corrosion resistance can be achieved under ideal conditions. In general, an application in HCl cannot be recommended. Compared to WC-based materials, CrC-NiCr/CoNiCrAlY coatings exhibit better oxidation resistance and thermal stability up to 870 °C, depending on the application conditions.

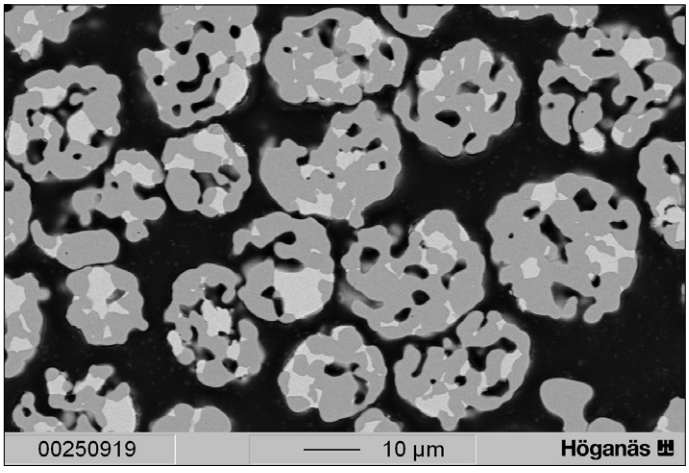
Typical Properties of HVOF- and HVAF-Sprayed Coatings		
Deposition Efficiency:	30–55% (APS 40–70%)	
Roughness as-sprayed, Ra:	2.0–7.0 < 2.0 µm achievable, using fine powders such as 38/10, 30/5 µm	
Bond Strength (on steel):	> 60 MPa	
Hardness HV0.3:	**A585**	650–900 (APS 550–800)
	A584, A588	750–1100
	A578	800–1150
	A594	750–1100
Wear (ASTM G65):	< 9 mm^3	

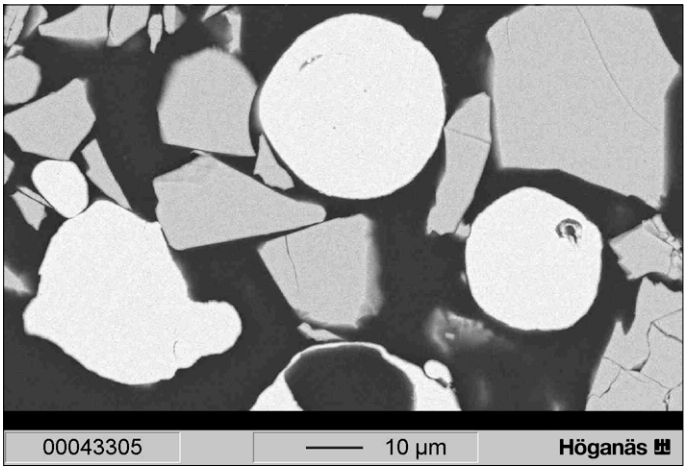
**Typical data. For more details, please contact us at: www.hoganas.com/en/contact/*

Figure1: Typical Powder Morphology





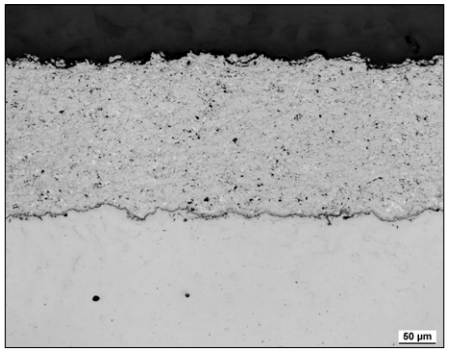




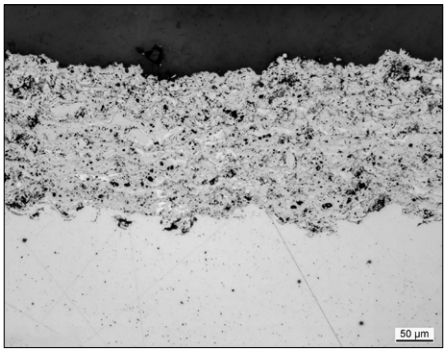
Amperit 588
Agglomerated & Sintered, predominantly spherical particle shape

Amperit 585
Powder blend consisting of blocky dense carbides and spherical atomized Ni 20Cr particles

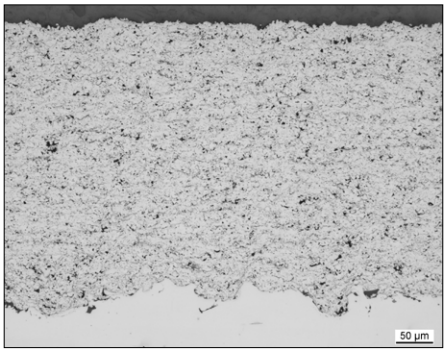
Figure 2: Microstructures (LOM) of Typical Coatings



Amperit 588.074
sprayed with liquid-fueled HVOF



Amperit 585.003
sprayed with APS



Amperit 594.074
sprayed with liquid-fueled HVOF

Table 1: Overview of Höganäs' CrC-NiCr Portfolio

Amperit	Particle Size (µm)	Carbide Size	APS	HVOF	HVAF	Special Features and Typical Applications
Cr3C2 20(Ni 20Cr) Agglomerated & Sintered:						
578.059	30/5	Medium		X	X	• Higher carbide content than CrC 25NiCr for higher wear resistance • For dense oxidation and erosion resistant coatings • Good cavitation resistance • Hot gas corrosion resistant • Used for valve stems, turbine components, fuel rod mandrels, etc.
578.074	45/15			X		
Cr3C2 25(Ni 20Cr), Agglomerated & Sintered:						
584.001	45/22	Coarse	X	X		• For dense oxidation and erosion resistant coatings • Good cavitation resistance • Hot gas corrosion resistant • Used for valve stems, turbine components, fuel rod mandrels, furnace rolls, hydraulic rods, etc.
584.054	45/10		X	X		
584.072	38/10			X		
588.059	30/5	Medium		X	X	• For dense oxidation and erosion resistant coatings • Good cavitation resistance • Hot gas corrosion resistant • Used for valve stems, turbine components, fuel rod mandrels, furnace rolls, hydraulic rods, etc.
588.074	45/15			X		
Cr3C2 25(Ni 20Cr), Blended:						
585.003	45/5	Blocky	X	X		• Coarse dense carbide blended with Ni 20Cr • Good oxidation, abrasion, particle erosion, fretting and cavitation resistance • Hot gas corrosion resistant • Used in pump housing, machine parts, hydraulic valves, tooling, hot forming dies, etc.
Cr3C2 25(9.5Co 7.8Ni 5.6Cr 2Al 0.1Y), Agglomerated & Sintered:						
594.074	45/15	Medium	X	X		• Matrix material with improved oxidation resistance

OEM Approvals

OEM	Specification	Amperit
SAE (AMS)	AMS 7875	Amperit 585.435
GE Power (former Alstom)	HTCT 650560	Amperit 584
	HTCT 650560	Amperit 587
GE Aviation	GE B50TF281	Amperit 593.775
PWA	PWA1307	Amperit 585.405
	PWA1364	Amperit 588.419
Rolls Royce	RRMS 40029	Amperit 585.351
	MSRR 9507/17	Amperit 585.357
Volvo (GKN)	PM 819-11	Amperit 585.868
Boeing	BMS 1067 Type 22	Amperit 584.834

Related Products

- WC-based materials, particularly WC 12Co (Amperit 512, 515, 518, 519), provide higher hardness, resulting in better resistance to particle erosion, sliding wear, and abrasion.
- For enhanced wear resistance and good corrosion resistance at service temperatures up to 500 °C, consider choosing WC 10Co 4Cr materials, such as Amperit 507, 554, 556, 557, and 558.
- WC-CrC-Ni materials such as Amperit 551 and 555 are suitable for service temperatures up to 750 °C and offer better corrosion protection compared to WC-Co coatings.
- In addition, Amperit 543 (WC 42CrC 16Ni) offers higher ductility and wear resistance compared to CrC-NiCr and higher productivity than WC-CoCr.
- Amperit 538 (WC 30WB 10Co) is designed for special applications, such as Zn-bath equipment or other applications involving liquid metal contact.
- Amperit 618 (WC 15FeCrAl) is a Co- and Ni-free alternative for wear protection coatings.
- Nickel self-fluxing alloys with the addition of hard phases are widely used for hard facing applications. The coatings are significantly thicker and mainly applied by flame spraying with a subsequent fusing treatment.
- Nickel self-fluxing alloys applied by HVOF can achieve hardness levels of 400–600 HV0.3, making them suitable for moderate wear applications. They also offer good corrosion protection.
- Iron-based alloys, such as 3.50 and 3650-02, can be applied by HVOF and provide moderate wear protection along with good corrosion resistance, exhibiting 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.

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