

## **Solutions Flash**

Select tailored infiltration materials for PDC drill bits precisely suited for the drilling environment

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### Today's situation

At the heart of every drilling process is the drill bit. In the case of oil and gas drilling, the choice of drill bit is strongly influenced by the type of media where the bit will be used. The right bit choice augments the rate at which drilling can be accomplished and minimizes costly and time-consuming drillstring bit trips.

Polycrystalline Diamond Compact (PDC) drill bits have become very popular for oil and gas drilling applications. A major factor in the selection and effectiveness of a PDC drill bit is the type of formation to be drilled. There are three types of formations—soft, medium and hard:

- Soft formations include unconsolidated sands, clays, soft limestones, red beds and shale
- Medium formations include calcites, dolomites, limestones and hard shale
- Hard formations include hard shale, calcites, mudstones, cherty limestones and other hard and abrasive formations

### The Oerlikon Metco solution

Oerlikon Metco, a leader in engineered surface solutions, has extensive experience as a supplier for materials used in the infiltration process on PDC drill bits.

Our materials engineers and scientists have a deep understanding of the infiltration processing and downhole service conditions for PDC drill bits, and they can collaborate with drill bit manufacturers to design materials that will ensure successful results.

Using a wide variety of in-house manufacturing processes at our disposal, Oerlikon Metco can then produce these customized materials to very exacting requirements.

The result is tailored, high-performance solution, often proprietary, that allows our customers to maintain their leadership position in the market. In turn, the end-user of the drill bits reduce their costs through longer, more dependable drilling operations.

To protect these highly sophisticated and costly components, drill bit manufacturers employ the infiltration process to infuse hard phases into the substrate of the drill bit body. The infiltration process is tailored by the manufacturer to suit their individualized drill bit design and the drill bit service environment.

The materials used for the infiltration process must be carefully chosen to ensure reliable processing and optimum downhole results. The resulting bit body must resist a complex combination of mechanisms, that includes abrasion, erosion, impact and fatigue. At the same time, the diamonds used as the bit cutters must bond well to the bit body substrate material.

The choice of these materials is neither straightforward nor simple. It is therefore advantageous to work with a supplier that has the consultative expertise and manufacturing flexibility to produce the materials that will fully fulfill the requirements needed for the specific PDC drill bit design..



PDC drill bits require high performance surface solutions to operate in demanding environments.

## Solution Description and Validation

### Area of application

#### Hard matrix materials

Areas of the bit exposed to the harshest service conditions require infiltration of a hard, carbide matrix material into the surface that are chosen for:

- High abrasion resistance
- High impact resistance
- High fatigue resistance
- Good infiltration behavior

#### Soft matrix materials

Softer matrix materials are infiltrated in areas where good machining characteristics are required, such as on the bit bevel area, to maintain media flush-out characteristics. The necessary characteristics for these materials include:

- Machinable overlays
- Good flow characteristics
- Good infiltration behavior

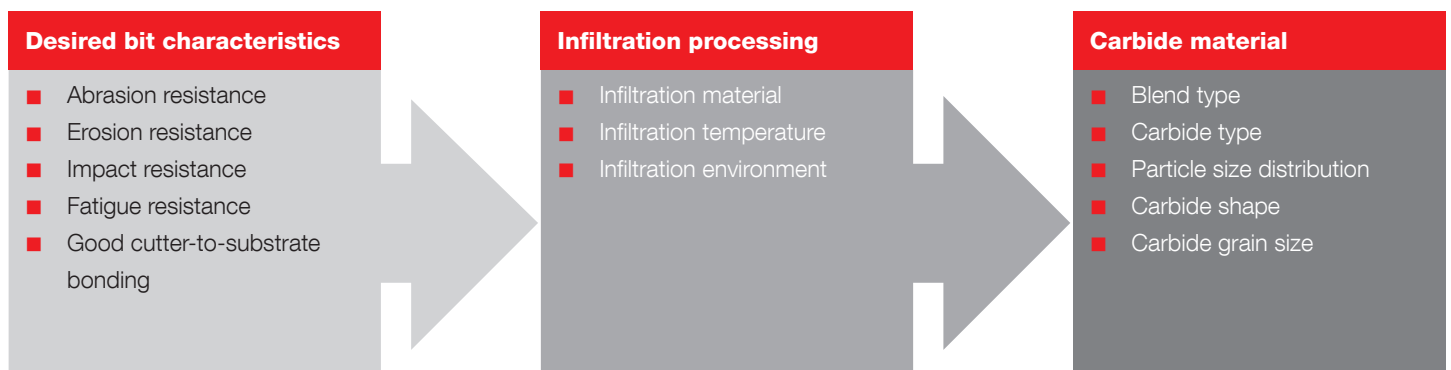
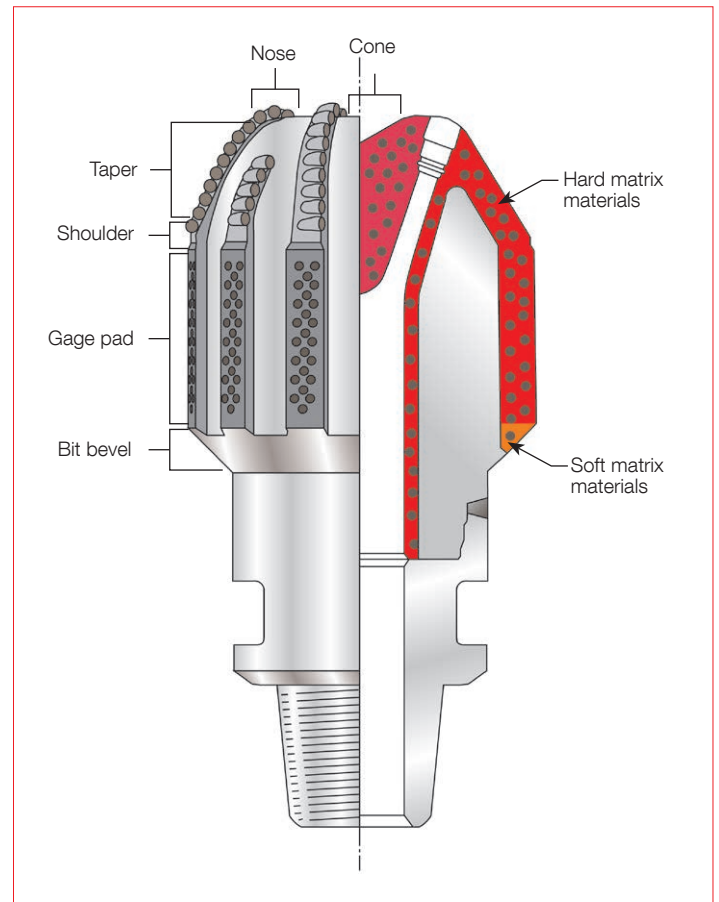
#### Infiltration materials

The infiltration materials are copper alloys that allow processing at temperatures of 850 to 1050 °C (1560 to 1920 °F) and exhibit characteristics such as:

- Good substrate diffusion behavior
- Good wetting characteristics
- Good fatigue resistance

#### Examples of these materials are:

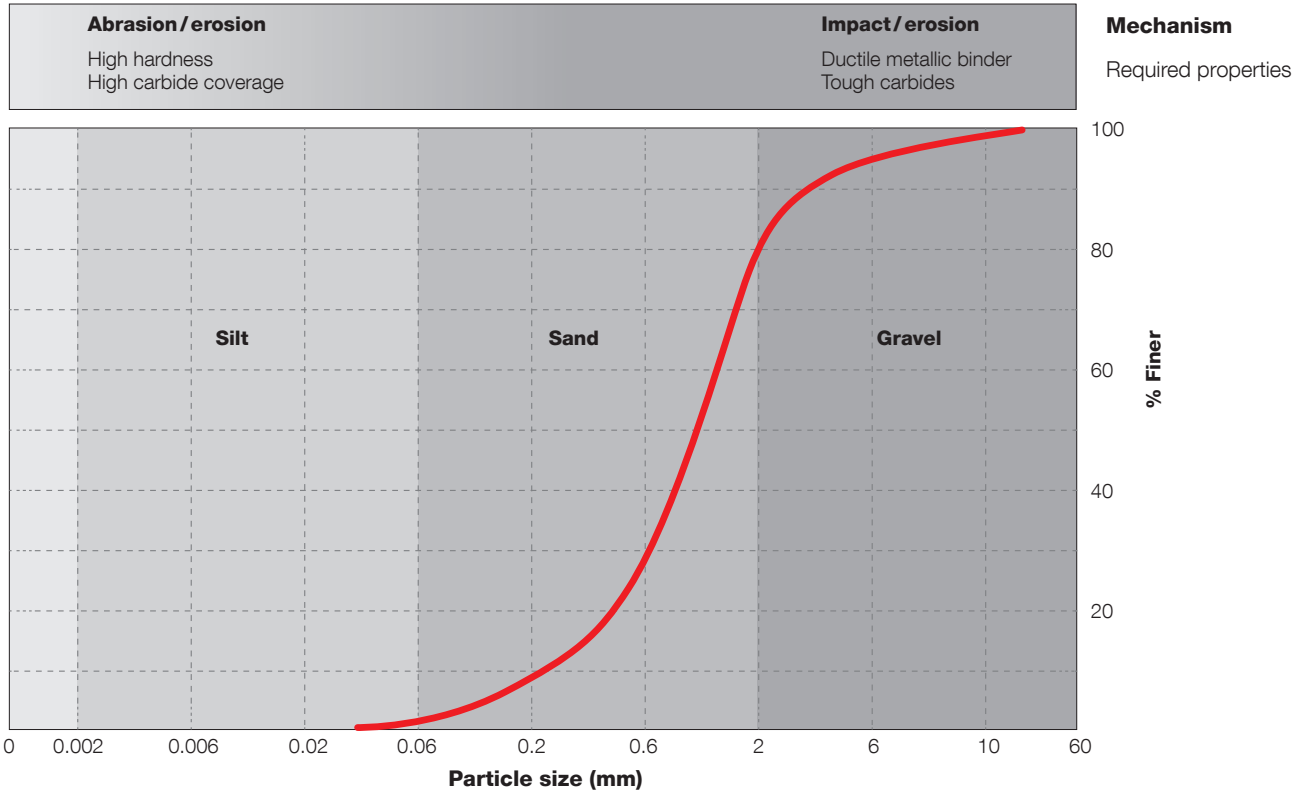
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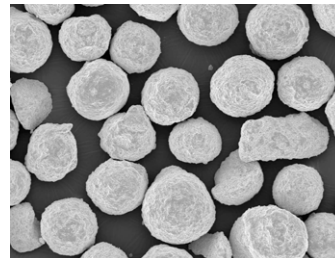
### Site properties versus wear conditions

Of primary importance when choosing infiltration materials is the type of media the bit will be in contact with in service. Finer media causes higher abrasion, whereas coarser media causes higher impact stress.

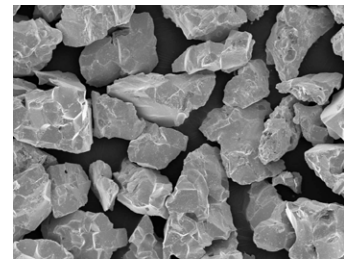


### Oerlikon Metco Tungsten carbide matrix materials

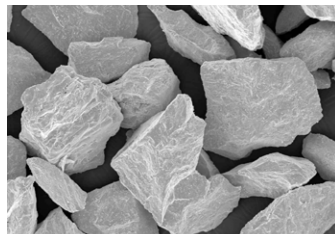
Oerlikon Metco has a wide range of in-house manufacturing processes for tungsten carbide powders. Thus, we are able to supply hard matrix materials that are well-suited for the PDC drill bit service application. We have stable sources of supply for our raw materials, ensuring we can continuously supply your materials in the quantities you need.



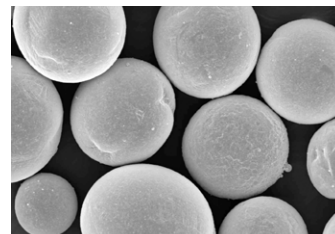
Tungsten carbide pellets



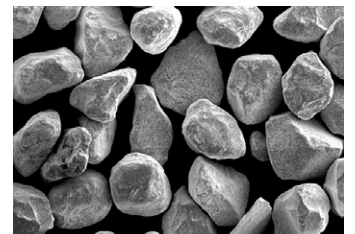
Macrocrystalline Tungsten carbide



Fused Tungsten carbide



Spherical fused Tungsten carbide



Hard metal grit

## Examples of Tungsten infiltration matrix materials supplied by Oerlikon Metco

The table below shows some examples of hard and soft matrix materials Oerlikon Metco has supplied to meet specific customer specifications for infiltration into PDC bit bodies. Particle size distributions can be tailored to the

customer's infiltration process. We can also supply customized blends of carbide materials for even greater flexibility to meet or exceed the requirements for the PDC bit service environment.

	Material	Hardness HV0.3	Particle size
<b>Hard matrix materials</b>	Spherical fused Tungsten carbide	2900 – 3100	–200 +400 mesh
	Macrocrystalline Tungsten carbide	2100 – 2300	–70 +100 mesh
	Fused Tungsten carbide	2000 – 2200	–100 +200 mesh
			–100 +150 mesh
			–150 +200 mesh
			–200 +400 mesh
Hard carbide pellets	1400 – 1600	–325 mesh	
Hard metal grit	1400 – 1500	–150 +75 µm	
<b>Soft matrix materials</b>	Tungsten powder	250 (approx.)	–60 +325 mesh
	Cobalt powder	200 (approx.)	–60 +100 mesh
	Iron powder	200 (approx.)	–150 mesh
	Nickel powder	200 (approx.)	–60 mesh
			–100 mesh
		–200 mesh	

## Material testing

Using a variety of tests Oerlikon Metco can perform in-house, combined with testing by the customer, candidate infiltration blends can be evaluated for suitability in service. The table below shows an example of a test panel on a number of different custom material blends.

		Blend 1	Blend 2	Blend 3	Blend 4	Blend 5
<b>Blend composition</b>						
Macrocrystalline Tungsten carbide		56 %	56 %	–	–	–
Fused Tungsten carbide		22 %	22 %	98 %	78 %	27 %
Spherical fused Tungsten carbide		15 %	20 %	–	10 %	71 %
Hard carbide pellets		5 %	–	–	10 %	–
Nickel		2 %	2 %	2 %	2 %	2 %
Spiral test <sup>a</sup>	cm	56.1	52	57	56.8	57
Density	g/cm <sup>3</sup>	11.81	11.73	11.47	12.05	12.78
Abrasion ASTM G65-04	vol. loss mm <sup>3</sup>	47.77	42.1	26.45	34.46	12.36
	wt. loss mg	564.13	493.87	303.40	415.23	153.2
Abrasion ASTM B611-85 (2008)	vol. loss mm <sup>3</sup>	1085.03	1094.72	993.75	993.33	849.36
Abrasion ASTM G75-07	vol. loss mm <sup>3</sup>	14.74	14.07	15.49	16.62	10.48
Impact strength	J	2.46	2.36	2.72	2.46	2.84
Transverse rupture strength	MPa	509.3	464.9	374.7	431.2	409

<sup>a</sup> Used to determine the penetration of the infiltration material into the drill bit body

■ Blend Composition    ■ Customer Testing    ■ Oerlikon Metco In-House Testing

### **Customer benefits**

- Oerlikon Metco has extensive experience in the supply of hard and soft matrix materials for infiltration on PDC drill bits
- In-house engineers and material scientists available for consultation on specific customer requirements
- Flexible manufacturing that allows production of carbide powders best suited for the PDC drill bit service environment
- Materials can be produced with particle size distributions tailored to the customer's infiltration process
- Extensive in-house facilities to test candidate materials for customers
- Ability to precision blend materials to further customize powder products that meet or exceed customer requirements
- Stable sources of raw materials ensures we can continuously produce materials in desired quantities
- Quality system certified to ISO 9001
- Environmental management system certified to ISO 14001
- Health and safety system certified to OHSAS 18001