

Ferro-Titanit®  
Powder-metal-  
lurgical carbide-  
alloyed materials

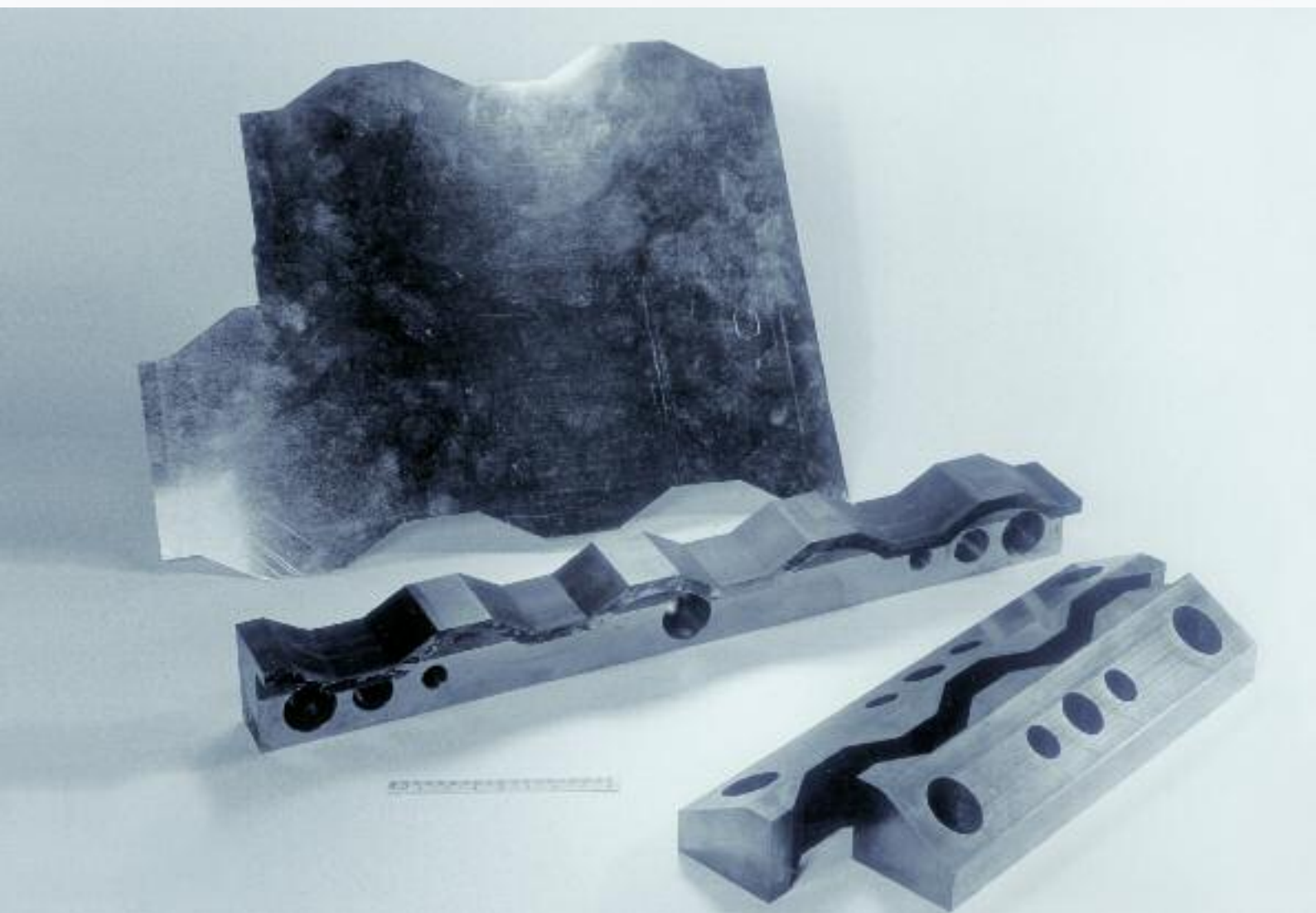
DEUTSCHE EDELSTAHLWERKE

Providing special steel solutions



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Highly wear-resistant, light, machinable, hardenable

Ferro-Titanit® is the trademark used by Deutsche Edelstahlwerke GmbH (WK) for ultrahighalloyed, machinable and hardenable alloys made by powder metallurgy techniques. The materials combine the properties of steel and tungsten-carbide alloys and are highly wear-resistant.

Ferro-Titanit® has a titanium carbide content of around 45% by volume, embedded in an alloyed steel binder phase.

In as-delivered condition, this material can be machined by conventional methods. In heat-treated, hardened condition (up to 69 HRC), Ferro-Titanit® can be used to solve many wear problems economically.



● Ferro-Titanit® is hardenable up to 69 HRC. A simple heat treatment brings about a considerably higher hardness than for steel. The tools have exceptionally long service lives. Appreciable savings are achieved as a result of lower tool costs. Tool changeover costs are reduced through longer machine operating times.

● Ferro-Titanit® can be hardened with extremely little distortion, since titanium carbide has a low thermal expansion and no transformation. The microstructure is free from segregations and fibering due to the powder metallurgy process. Vacuum hardening is advisable, as otherwise the negative influence zones on the tools require a greater machining allowance. In the case of C-Spezial, hardening and tempering cause an increase in the original dimensions.

WFN and S grades are shrink in dimensions due to retained austenite. Deep cooling in liquid nitrogen, on the other hand, increases the dimensions of these grades. The dimensional change is in each case less than 0.1%.

● Ferro-Titanit® offers good possible combinations with steel (e.y. high temperature brazing). When used in combination, Ferro-Titanit® is applied only in areas exposed to wear. The steel, as the substrate, permits material savings, offers higher toughness, and can be machined more cost-effectively.

● Ferro-Titanit® allows reutilisation of used tools. Used tools and wearing parts can be annealed as often as required and processed into new parts (no change in the microstructure). Minimum remachining in the soft-annealed condition permits swift replacement of failed tool or wearing components (example: remachining of a drawing tool to produce a larger profile).

● Ferro-Titanit® is machinable according to given guidelines (siehe Seiten 20, 21). It can be machined in the annealed as-delivered condition by conventional methods, such as turning, planing, milling, drilling, and other means. Company-own tool shops can be employed, producing long-life tools at a relatively low total cost.

● Ferro-Titanit® exhibits minimum pick-up. The titanium carbides in Ferro-Titanit® (45% by vol.) do not alloy with other materials. The hardly detectable pick-up with well-polished tools and dies – especially deep-drawing tools – and the high wear resistance lead to high outputs between remachinings, combined with a best-quality surface finish.

● Ferro-Titanit® has a low specific weight. Ferro-Titanit® is 50% lighter than tungsten carbide and still 15% lighter than steel.

<b>Chemical composition</b>	<b>Carbide phase</b> <b>TiC</b> 33 (guideline values in % by weight)	<b>Binder phase (main components)</b> <b>C</b> <b>Cr</b> <b>Mo</b> <b>Fe</b> 0.65      3.0      3.0      Balance					
<b>Microstructure</b>	Titanium carbide + martensite						
<b>Characteristic properties</b>	The binder phase consists of a cold work steel containing 3% chromium and 3% molybdenum. The relatively low alloy content brings about a low tempering resistance. The hardness decreases above approximately 200 °C. In comparison with the other grades, C-Spezial has the best machining properties.						
<b>Mechanical properties</b> hardened + tempered	<b>Density</b> <b>g/cm<sup>3</sup></b> 6.5	<b>Com- pression strength</b> <b>MPa</b> 3800	<b>Bending fracture</b> <b>MPa</b> 1500	<b>Modulus of elasticity</b> <b>MPa</b> 292000	<b>Shear modulus</b> <b>MPa</b> 117000	<b>Service hardness</b> <b>HRC</b> approx. 69	<b>Further data on the mechanical properties upon request</b>
<b>Physical properties</b>	<b>Thermal expansion coefficient between 20 and ... °C in 10<sup>-6</sup> · °C<sup>-1</sup></b> 100      200      300 9.2      9.1      9.8						
	<b>Thermal conductivity at 20 °C in W · cm<sup>-1</sup> · °C<sup>-1</sup></b> 0.205						
	<b>Measuring frequency (Hz)</b> 2600 7000 22000		<b>Damping Q<sup>-1</sup> (10<sup>-5</sup>)</b> 14 22 16				
	<b>Electrical resistivity at 20 °C in Ω · mm<sup>2</sup> · m<sup>-1</sup></b> 0.75						
<b>Magnetic properties</b>	<b>Magnetic saturation polarisation</b> <b>mT</b> 920			<b>Coercive field strength</b> <b>kA · m<sup>-1</sup></b> 5.0		<b>Remanence</b> <b>mT</b> 315	
<b>Use</b>	All cold work applications in cutting and forming engineering, e.g. for cutting and blanking tools, bending jaws, extrusion punches, deep-drawing dies, form and hobbing punches, clamping jaws, blanking sleeves, tools for the processing of steel, non-ferrous metals, aluminium, etc., as well as machine elements such as pulleys, rollers and guides exposed to heavy wear.						

<b>Annealing</b>	<b>Annealing temperature °C</b> Soft 750 (10 h)	<b>Cooling</b> Furnace	<b>Hardness after annealing HRC</b> approx. 49	<b>Transformation range °C</b> 800 – 852
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**Stress-relieving** If extensive machining is required, it is advisable, after rough-machining, i.e. before finish-machining, to stress-relief anneal at around 600 – 650 °C, followed by cooling in the furnace.

<b>Hardening</b>	<b>Hardening temperature °C</b> 980 – 1100	<b>Hardening medium</b> Vacuum	<b>Quenching</b> min 1 bar N <sub>2</sub>	<b>Transformation range °C</b> 800 – 852
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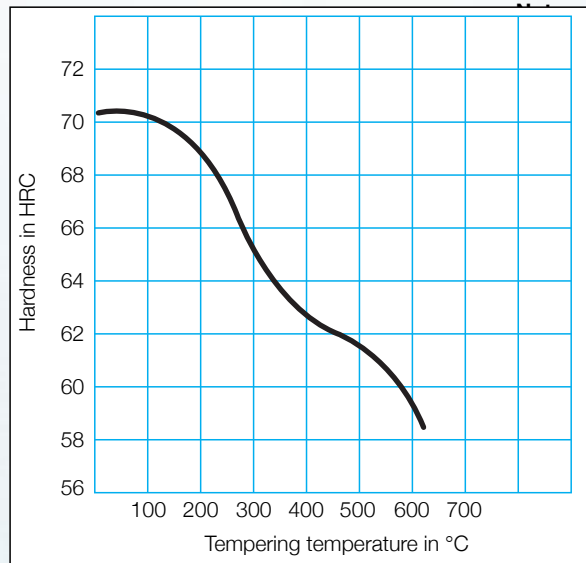
Heating to hardening temperature is advisably performed over several preheating stages (e.g. 400 °C, 600 °C, 800 °C) in order to ensure uniform soaking of the parts that are to be hardened and to avoid any cracking induced by thermal stress. The selected soaking time at hardening temperature must be longer than for steel tools (roughly twice to three times). Because of the rigid titanium carbide skeleton, deleterious grain growth as found in tool steel and high-speed steel cannot occur during the heat treatment. It is hence possible to accept slightly higher hardening temperatures and longer soaking times rather than insufficient hardening.

<b>Tempering</b>	<b>Tempering temperature °C</b> 150	<b>Service hardness HRC</b> approx. 69
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In order to avoid cracking induced by hardening stresses, parts that have been hardened must be tempered immediately after quenching or cooling to around 50 °C and held at tempering temperature for at least 2 hours, followed by cooling in air.

**Dimensional changes** Due to the hardening and tempering of C-Spezial, the original dimensions increase. The change in dimensions is less than 0.1%.

**Tempering curve**



No tempering temperature other than the one indicated should be selected, as the strong, negative influence on the resistance to wear and pick-up does not justify the minor benefit of toughness improvement.

<b>Chemical composition</b>	<b>Carbide phase</b> <b>TiC</b> 33.0 (guideline values in % by weight)	<b>Binder phase (main components)</b> <b>C</b> <b>Cr</b> <b>Mo</b> 0.75      13.5      3.0			<b>Fe</b> Balance		
<b>Microstructure</b>	Titanium carbide + martensite						
<b>Characteristic properties</b>	Because of its 13.5% chromium and 3% molybdenum content, WFN has a high tempering resistance up to around 450 °C, as well as high-temperature hardness and good corrosion resistance. The thermal expansion coefficient is adjusted to that of steel through the 1% aluminium alloy addition. Lower stresses thereby occur when non-permanent and permanent joints are heated, reducing the risk of cracking.						
<b>Mechanical properties</b> hardened + tempered	<b>Density</b> <b>g/cm<sup>3</sup></b> 6.5	<b>Comp- pression strength</b> <b>MPa</b> 3600	<b>Bending fracture</b> <b>MPa</b> 1200	<b>Modulus of elasticity</b> <b>MPa</b> 294000	<b>Shear modulus</b> <b>MPa</b> 122000	<b>Service hardness</b> <b>HRC</b> approx. 69	<b>Further data on the mechanical properties upon request</b>
<b>Physical properties</b>	<b>Thermal expansion coefficient between 20 and ... °C in 10<sup>-6</sup> · °C<sup>-1</sup></b>						
	100	200	300	400	500	600	
	10.6	11.6	12.2	12.4	12.7	12.9	
	<b>Thermal conductivity at 20 °C in W · cm<sup>-1</sup> · °C<sup>-1</sup></b>						
	0.182						
	<b>Measuring frequency (Hz)</b>			<b>Damping Q<sup>-1</sup> (10<sup>-5</sup>)</b>			
	2600			27			
	7100			33			
	22000			27			
	<b>Electrical resistivity at 20 °C in Ω · mm<sup>2</sup> · m<sup>-1</sup></b>						
	0.91						
<b>Magnetic properties</b>	<b>Magnetic saturation polarisation</b> <b>mT</b> 590			<b>Coercive field strength</b> <b>kA · m<sup>-1</sup></b> 9.2		<b>Remanence</b> <b>mT</b> 160	
<b>Use</b>	All cold work applications in cutting and forming engineering. In particular for tools and wearing parts required to have a high tempering resistance up to 450 °C as well as elevated corrosion resistance, e.g. guide rollers for wire rod and bar steel rolling, injection moulds for plastics processing, jets for steam-jet equipment, valve components, tube drawing dies, extrusion dies for the manufacture of aerosol cans, cold rollers.						

<b>Annealing</b>	<b>Annealing temperature °C</b> Soft 750 (10 h)	<b>Cooling</b> Furnace	<b>Hardness after annealing HRC</b> approx. 51	<b>Transformation range °C</b> 890 – 970
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**Stress-relieving** If extensive machining is required, it is advisable, after rough-machining, i.e. before finish-machining, to stress-relief anneal at around 600 – 650 °C, followed by cooling in the furnace.

<b>Hardening</b>	<b>Hardening temperature °C</b> 1080	<b>Hardening medium</b> Vacuum	<b>Quenching</b> min 1 bar N <sub>2</sub>	<b>Transformation range °C</b> 890 – 970
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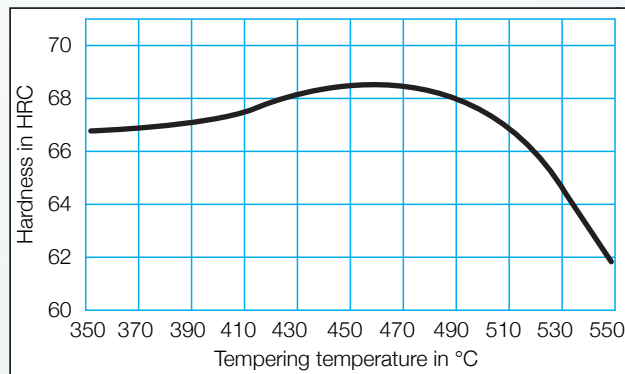
Heating to hardening temperature is advisably performed over several preheating stages (e.g. 400 °C, 600 °C, 800 °C) in order to ensure uniform soaking of the parts that are to be hardened and to avoid any cracking induced by thermal stress. The selected soaking time at hardening temperature must be longer than for steel tools (roughly twice to three times). Because of the rigid titanium carbide skeleton, deleterious grain growth as found in tool steel and high-speed steel cannot occur during the heat treatment. It is hence possible to accept slightly higher hardening temperatures and longer soaking times rather than insufficient hardening.

<b>Tempering</b>	<b>Tempering temperature °C</b> 460	<b>Service hardness HRC</b> approx. 69
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In order to avoid cracking induced by hardening stresses, parts that have been hardened must be tempered immediately after quenching or cooling to around 50 °C and held at tempering temperature for at least 2 hours, followed by cooling in air.

**Dimensional changes** The WFN grade exhibits a reduction in dimensions due to retained austenite. The dimensions are increased in this grade, however, by deep-cooling in liquid nitrogen or also repeated tempering. The change in dimensions is less than 0.1% in each case.

**Tempering curve**



**Note:** No tempering temperature other than the one indicated should be selected, as the strong, negative influence on the resistance to wear and pick-up does not justify the minor benefit of toughness improvement.

<b>Chemical composition</b>	<b>Carbide phase</b>		<b>Binder phase (main components)</b>			
	<b>TiC</b>	<b>C</b>	<b>Cr</b>	<b>Mo</b>	<b>Fe</b>	
	32.0	0.5	19.5	2.0	Balance	
	(guideline values in % by weight)					
<b>Microstructure</b>	Titanium carbide + martensite					
<b>Characteristic properties</b>	Because of its high chromium and reduced carbon content, this grade is recommended in cases requiring elevated corrosion resistance.					
<b>Mechanical properties</b> hardened + tempered	<b>Density</b>	<b>Com- pression strength</b>	<b>Bending fracture</b>	<b>Modulus of elasticity</b>	<b>Shear modulus</b>	<b>Service hardness</b>
	<b>g/cm<sup>3</sup></b>	<b>MPa</b>	<b>MPa</b>	<b>MPa</b>	<b>MPa</b>	<b>HRC</b>
	6.5	3700	1050	290000	116000	approx. 67
<b>Physical properties</b>	<b>Thermal expansion coefficient between 20 and 400 °C in 10<sup>-6</sup> · °C<sup>-1</sup></b>					
	9.7					
	<b>Thermal conductivity at 20 °C in W · cm<sup>-1</sup> · °C<sup>-1</sup></b>					
	0.188					
	<b>Measuring frequency (Hz)</b>			<b>DampingQ<sup>-1</sup> (10<sup>-5</sup>)</b>		
	2600			19		
	7100			25		
	22300			18		
	<b>Electrical resistivity at 20 °C in Ω · mm<sup>2</sup> · m<sup>-1</sup></b>					
	0.77					
<b>Magnetic properties</b>	<b>Magnetic saturation polarisation</b>			<b>Coercive field strength</b>		<b>Remanence</b>
	<b>mT</b>			<b>kA · m<sup>-1</sup></b>		<b>mT</b>
	620			9.8		108
<b>Use</b>	For parts requiring a high resistance to corrosion as well as to wear, e.g. pumps, measuring tools, thrust disks, bearings, etc.					

<b>Annealing</b>	<b>Annealing °C temperature °C</b> Soft 750 (10 h)	<b>Cooling</b> Furnace	<b>Hardness after annealing HRC</b> approx. 51	<b>Transformation range °C</b> 800 – 850
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**Stress-relieving** If extensive machining is required, it is advisable, after rough-machining, i.e. before finish-machining, to stress-relief anneal at around 600 – 650 °C, followed by cooling in the furnace.

<b>Hardening</b>	<b>Hardening °C temperature °C</b> 1080	<b>Hardening medium</b> Vacuum	<b>Quenching</b> min 1 bar N <sub>2</sub>	<b>Transformation range °C</b> 800 – 850
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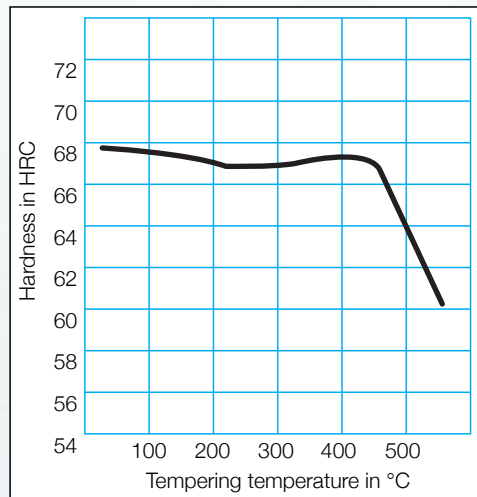
Heating to hardening temperature is advisably performed over several preheating stages (e.g. 400 °C, 600 °C, 800 °C) in order to ensure uniform soaking of the parts that are to be hardened and to avoid any cracking induced by thermal stress. The selected soaking time at hardening temperature must be longer than for steel tools (roughly twice to three times). Because of the rigid titanium carbide skeleton, deleterious grain growth as found in tool steel and high-speed steel cannot occur during the heat treatment. It is hence possible to accept slightly higher hardening temperatures and longer soaking times rather than insufficient hardening.

<b>Tempering</b>	<b>Tempering temperature °C</b> 180	<b>Service hardness HRC</b> approx. 67
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In order to avoid cracking induced by hardening stresses, parts that have been hardened must be tempered immediately after quenching or cooling to around 50 °C and held at tempering temperature for at least 2 hours, followed by cooling in air.

**Dimensional changes** The S grade exhibits a reduction in dimensions due to retained austenite. The dimensions are increased in this grade, however, by deep-cooling in liquid nitrogen or also repeated tempering. The change in dimensions is less than 0.1% in each case.

Tempering curve



<b>Chemical composition</b>	<b>Carbide phase</b> <b>TiC</b> 30 (guideline values in % by weight)	<b>Binder phase (main components)</b> <b>Cr</b> 13.5 <b>Co</b> 9 <b>Ni</b> 4 <b>Mo</b> 5 <b>Fe</b> Balance									
<b>Microstructure</b>	Titanium carbide + nickel martensite										
<b>Characteristic properties</b>	The matrix structure consists of a highly tough, age-hardenable nickel martensite. The chromium content of 13.5 % provides good corrosion resistance. Finish-machining is performed in the solution-annealed, as-delivered condition. Subsequent age-hardening takes place at a relatively low temperature of 480 °C and can be conducted, for example, in a convection air furnace or an electrically heated chamber furnace. The workpiece remains extremely true-to-size and little prone to distortion due to the low age-hardening temperature.										
<b>Mechanical properties</b> age-hardened	<b>Density</b> <b>g/cm<sup>3</sup></b> 6.6	<b>Com- pression strength</b> <b>MPa</b> 2750	<b>Bending rature</b> <b>MPa</b> 1200	<b>Modulus of elasticity</b> <b>MPa</b> 294000	<b>Shear modulus</b> <b>MPa</b> 117000	<b>Service hardness</b> <b>HRC</b> approx. 62	<b>Further data on the mechanical properties upon request</b>				
<b>Physical properties</b>	<b>Thermal expansion coefficient between 20 and ... °C in 10<sup>-6</sup> · °C<sup>-1</sup></b>										
	100 8.3	200 8.9	300 9.3	400 9.6	500 9.9	600 10.2	700 9.2	800 9.5			
	<b>Thermal conductivity at ... °C in W · cm<sup>-1</sup> · °C<sup>-1</sup></b>										
	100 0.171	150 0.178	200 0.188	250 0.199	300 0.212	350 0.226	400 0.242	450 0.259	500 0.276	550 0.295	600 0.315
	<b>Measuring frequency (Hz)</b>			<b>Damping Q<sup>-1</sup> (10<sup>-6</sup>)</b>							
	2600			10.0							
	7100			15.2							
	14000			11.9							
	22000			10.9							
	<b>Electrical resistivity at ... °C in Ω · mm<sup>2</sup> · m<sup>-1</sup></b>										
	20 1.10	100 1.12	200 1.17	300 1.21	400 1.25	500 1.31	600 1.67				
<b>Magnetic properties</b> magnetically clampable	<b>Magnetic saturation polarisation</b> <b>mT</b> 740			<b>Coercive field strength</b> <b>kA · m<sup>-1</sup></b> 3.7		<b>Remanence</b> <b>mT</b> 190					
<b>Use</b>	Good possibilities of use in the processing of abrasive plastics – as pelletizer knives, injection moulding nozzles, dies, worms and bushes. Also as wear-resistant rings in centrifugal pumps, charging heads and circular cutters in preservecan filling machines.										

**Solution annealing**

**Annealing temperature °C**  
850 (2 – 4 h vacuum)

**Cooling**  
1 – 4.5 bar N<sub>2</sub>

**Hardness after annealing HRC**  
approx. 53

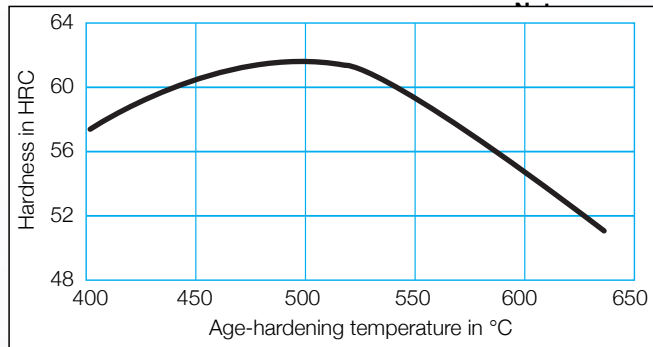
The material is supplied in solution-annealed condition by the producer. Due to this fact, only ageing at 480 °C is still required after finish-machining.

**Age-hardening**

**Age-hardening temperature °C**  
480 (6 – 8 h)

**Hardness after age-hardening HRC**  
approx. 62

**Age-hardening curve**



Carburising atmospheres are to be avoided during heat treatment. Linear shrinkage during age-hardening is generally 0.02 mm/m.

<b>Chemical composition</b>	<b>Carbide phase</b> <b>TiC</b> 30 (guideline values in % by weight)	<b>Binder phase (main components)</b> <b>Ni</b> 15.0 <b>Co</b> 9.0 <b>Mo</b> 6.0				<b>Fe</b> Balance				
<b>Microstructure</b>	Titanium carbide + nickel martensite									
<b>Characteristic properties</b>	The matrix structure consists of a highly tough, age-hardenable nickel martensite. Finishing is performed in the solution-annealed, as-delivered condition. Subsequent age-hardening takes place at a relatively low temperature of 480 °C and can be conducted, for example, in a convection air furnace or an electrically heated chamber furnace. The workpiece remains extremely true-to-size and little prone to distortion due to the low age-hardening temperature.									
<b>Mechanical properties</b> age-hardened	<b>Density</b> <b>g/cm<sup>3</sup></b> 6.7	<b>Compression strength</b> <b>MPa</b> 2400	<b>Bending fracture</b> <b>MPa</b> 1450	<b>Modulus of elasticity</b> <b>MPa</b> 280000	<b>Shear modulus</b> <b>MPa</b> 117000	<b>Service hardness</b> <b>HRC</b> approx. 63	<b>Further data on the mechanical properties upon request</b>			
<b>Physical properties</b>	<b>Thermal expansion coefficient between 20 and ... °C in 10<sup>-6</sup> · °C<sup>-1</sup></b>									
	100	200	300	400	500	600	700	800	900	1000
	8.0	8.7	8.9	9.1	9.4	9.8	9.4	8.5	9.2	9.7
	<b>Thermal conductivity at W · cm<sup>-1</sup> · °C<sup>-1</sup></b>									
	20 – 80 °C 0.181 – 0.189									
	<b>Electrical resistivity at 20 °C in Ω · mm<sup>2</sup> · m<sup>-1</sup></b>									
	0.806									
<b>Magnetic properties</b> magnetically clampable	<b>Magnetic saturation polarisation</b> <b>mT</b> 1580				<b>Coercive field strength</b> <b>kA · m<sup>-1</sup></b> 1.8		<b>Remanence</b> <b>mT</b> 230			
<b>Use</b>	For all types of forming tools, etc. exposed to particularly heavy wear and bending at temperatures up to 500 °C. For wearing parts of machinery and apparatus. Used especially in plastics processing as pelletizer knives, extruder worms, injection moulding nozzles, etc.									

**Solution annealing**

**Annealing temperature °C**  
850 (2 – 4 h vacuum)

**Cooling**  
1 – 4.5 bar N<sub>2</sub>

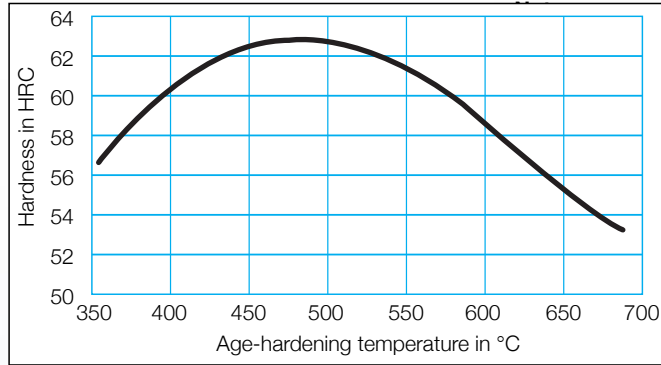
**Hardness after annealing HRC**  
approx. 53

**Age-hardening**

**Age-hardening temperature °C**  
480 (6 – 8 h)

**Hardness after age-hardening HRC**  
approx. 63

**Age-hardening curve**



Carburising atmospheres are to be avoided during heat treatment. Linear shrinkage during age-hardening is generally 0.02 mm/m.

<b>Chemical composition</b>	<b>Carbide phase</b>		<b>Binder phase (main components)</b>			
	<b>TiC</b>		<b>Cr</b>	<b>Mo</b>	<b>Ni</b>	
	22.0		20.0	15.5	Balance	
	(guideline values % by weight)					
<b>Microstructure</b>	Titanium carbide + austenite					
<b>Characteristic properties</b>	Supplied in solution-annealed condition. Ferro-Titanit® Cromoni is non-magnetisable, even after ageing at temperatures up to 900 °C. Besides having a high wear resistance, this alloy is extremely resistant to corrosion and scaling, as well as highly tempering-resistant. This corrosion resistance is at its best with finely ground or polished surfaces.					
<b>Mechanical properties</b> age-hardened	<b>Density</b>	<b>Com- pression strength</b>	<b>Bending fracture</b>	<b>Modulus of elasticity</b>	<b>Service hardness</b>	<b>Further data on the mechanical properties upon request</b>
	<b>g/cm<sup>3</sup></b>	<b>MPa</b>	<b>MPa</b>	<b>MPa</b>	<b>HRC</b>	
	7.4	1500	1300	277000	approx. 54	
<b>Physical properties</b>	<b>Thermal expansion coefficient between 20 and ... °C in 10<sup>-6</sup> · °C<sup>-1</sup></b>					
	100	200	300	400	500	600
	9.0	10.0	10.5	10.8	11.1	11.5
	<b>Thermal conductivity at 20 °C in W · cm<sup>-1</sup> · °C<sup>-1</sup></b>					
	0.124					
	<b>Measuring frequency (Hz)</b>		<b>Damping Q<sup>-1</sup> (10<sup>-5</sup>)</b>			
	2400		6			
	6600		7			
	21000		11			
	<b>Electrical resistivity at 20 °C in Ω · mm<sup>2</sup> · m<sup>-1</sup></b>					
	1.53					
<b>Magnetic properties</b>	<b>Permeability μ</b>					
	< 1.01					
<b>Use</b>	This austenitic grade is used for applications requiring complete non-magnetisability, a high wear resistance and maximum corrosion resistance.					
<b>Solution annealing</b>	<b>Annealing temperature °C</b>		<b>Cooling</b>	<b>Hardness after annealing HRC</b>		
	1200 (2 h vacuum)		4 bar N <sub>2</sub>	approx. 52		
<b>Age-hardening</b>	<b>Age-hardening temperature °C</b>		<b>Hardness after age-hardening HRC</b>			
	800 (6 h vacuum)		approx. 54			
	<b>Note</b>					
	Machining according to guidelines, at lowest cutting speeds.					

**Chemical composition**

Carbide phase	Binder phase (main components)				Fe
TiC	Cr	Ni	Mo		Balance
34	18	12	2		

(guideline values in % by weight)

**Microstructure**

Titanium carbide + austenite

**Characteristic properties**

The binder phase of Ferro-Titanit® U is roughly equivalent to the austenitic CrNiMo steel X 10 CrNiMoNb 18 10 (Mat. No. 1.4580). The material is non-magnetisable and, because of its high Cr and Mo contents, possesses excellent resistance to pitting corrosion in media containing chlorine ions. Its high titanium carbide content of 34 % by weight, or 45 % by volume, provides it with outstanding wear resistance. The Cr and Ni contents simultaneously give the material good scaling resistance and high-temperature strength.  
**The material requires no later postheat treatment.**

**Mechanical properties**  
age-hardened

Density	Com- pression strength	Bending fracture	Service hardness	Further data on the mechanical properties upon request
g/cm <sup>3</sup>	MPa	MPa	HRC	
6.6	2200	950	approx. 51	

**Physical properties**

**Thermal expansion RT-800 °C**  
12.5

**Thermal conductivity at 20 °C in W · cm<sup>-1</sup> · °C<sup>-1</sup>**  
0.180

**Electrical resistivity at 20 °C in Ω · mm<sup>2</sup> · m<sup>-1</sup>**  
0.96

**Magnetic properties**

**Permeability μ**  
< 1.01

**Use**

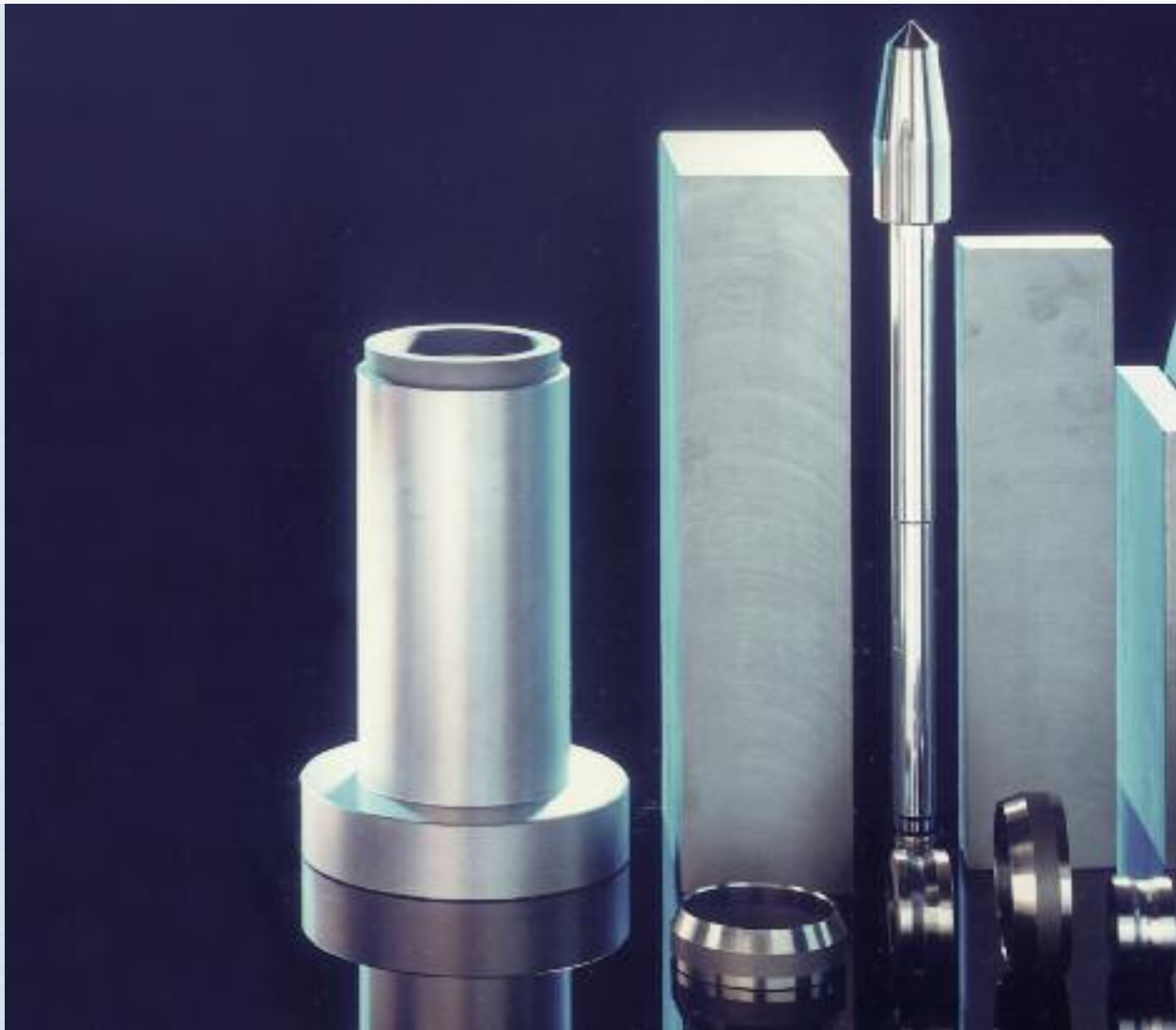
Ferro-Titanit® U is used where non-magnetisable material with a high wear resistance is required. Its excellent corrosion resistance, in particular in media containing chlorine ions, gives it a broad range of applications in the chemical industry.

### **Machining of Ferro-Titanit®**

As a rule, the machinable and hardenable Ferro-Titanit® alloys are supplied as semi-finished material in soft-annealed condition. Despite a titanium carbide content of around 45% by vol. and a hardness of 48 – 53 HRC after annealing, it is possible to machine these materials by conventional methods, such as turning, planing, milling, sawing and drilling, according to the guidelines given below.

Any tool shop therefore has the possibility to machine tools and other wear-exposed parts on equipment normally used for machining steels.

Ferro-Titanit® can be hardened with very little distortion. There is, consequently, extremely little change in the dimensions. Where C-Spezial is concerned, hardening and tempering brings about an increase in the original dimensions.



With the WFN and S grades, retained austenite leads to a reduction in the dimensions.

Deep-cooling in liquid nitrogen makes it possible to increase the dimensions in these grades after hardening.

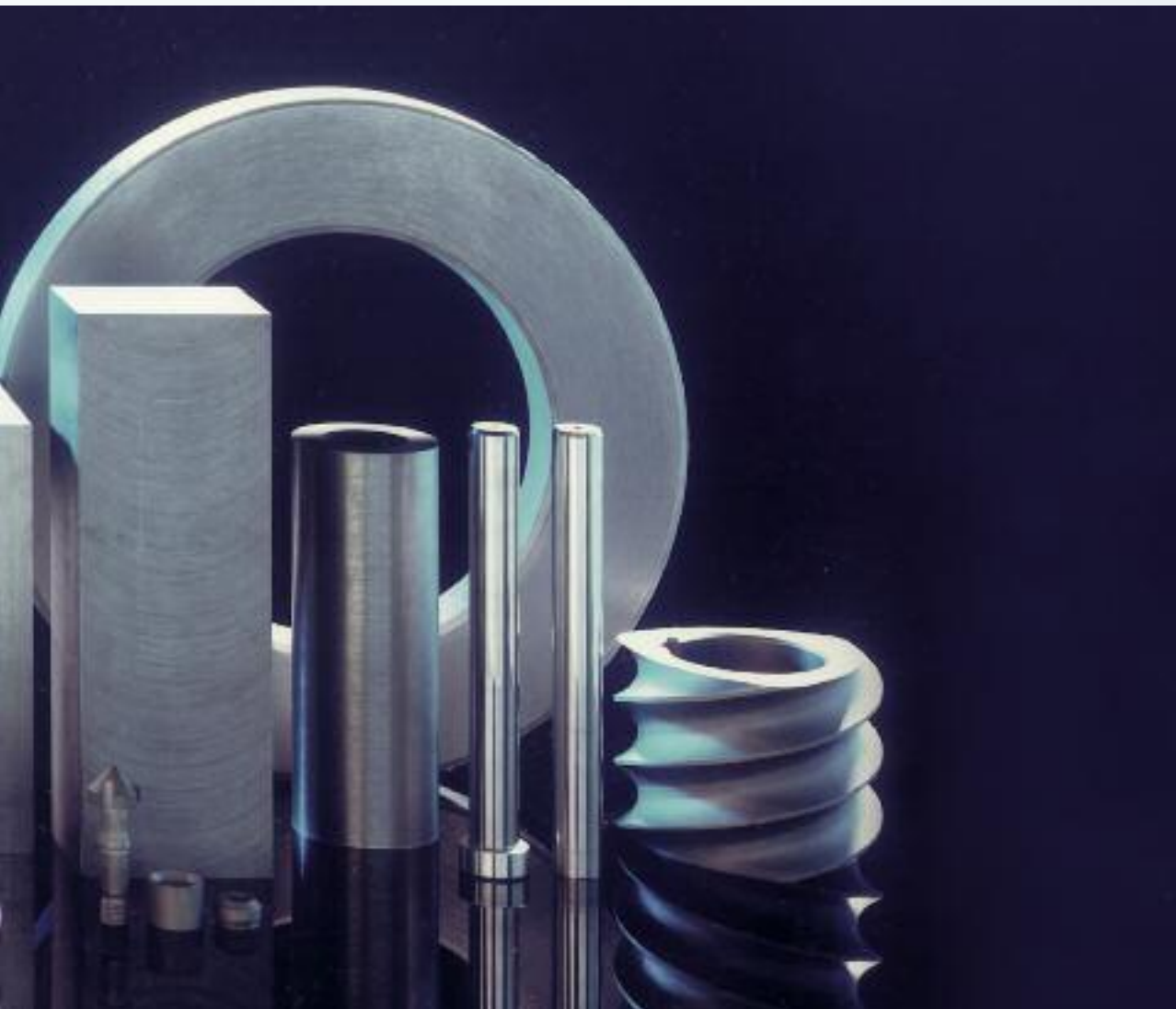
The dimensional changes are less than 0.1% in each case.

Machining in the annealed, as-delivered condition can consequently approximate the nominal size very closely, such that re-machining in hardened condition need amount to only a few

hundredths of a millimetre. A precondition in this respect is that the hardening treatment to achieve the optimum service properties is performed preferably in a vacuum furnace.

The machining of Ferro-Titanit® can only be done with greatly reduced cutting speeds, compared with steel.

All machining operations mentioned on pages 20-23 have to be applied without lubricants or coolants.



## Turning

Ferro-Titanit® grades	tool quality alternatively	feed rate	cutting edge angle			cutting speed m/min
			rake angle	inclination angle	clearance angle	
C-Spezial	tungsten carbide coated, K 10 / K 30, high-speed steel	0.02 – 0.1 mm/rev.	6 ° / 15 °	0 ° / – 6 °	6 ° / – 11 °	10
WFN						8
S						8
Nikro 143						5
Nikro 128						5
U						5
Cromoni	0.02 – 0.04 mm/rev.					2.5
all grades	ceramics, fiber-reinforced	~ 0.1 – 0.5 mm/rev.	– 6 °	– 6 °	+ 6 °	> 25

## Milling

Ferro-Titanit® grades	tool quality alternatively	feed rate	cutting speed m/min
C-Spezial	tungsten carbide coated, K 10 / K 30, high-speed steel	0.01 – 0.07 mm/tooth	6 – 12
WFN			
S			
Nikro 143			
Nikro 128			
U			
Cromoni	~ 0.01 mm/tooth	2 – 5	

## Drilling

Ferro-Titanit® grades	tool quality alternatively	feed rate		cutting speed m/min
all grades	tungsten carbide coated, K 10 / K 30, high-speed steel	0.05 mm/U	rake angle 90 – 120 °	2 – 4

## Thread cutting

Ferro-Titanit® grades	tool quality alternatively	feed rate	rake angle	cutting speed m/min
all grades	tungsten carbide high-speed steel		0 cutting edge chamfer 1.5 – 2 mm wide, extensive undercut	2 – 4

## Sawing\*

Ferro-Titanit® grades	tool quality alternatively	feed rate	constant "a" for calculation of feed rate	cutting speed m/min
C-Spezial WFN S Nikro 143 Nikro 128 U Cromoni	bimetall M 42	$\frac{\text{constant a}}{\text{length of saw notch}}$	800 mm <sup>2</sup> /min 600 mm <sup>2</sup> /min 200 mm <sup>2</sup> /min	~10 < 5

\* band saw (preferably) hack saw (in exceptional cases)

recommended partition of saw bands	length of saw notch	conventional toothing	combi toothing
	up to 30 mm	10 teeth/inch	8/12 teeth/inch
	30 – 70 mm	8 teeth/inch	5/8 teeth/inch
	7 – 120 mm	4 teeth/inch	4/6 teeth/inch
	> 120 mm	3 teeth/inch	2/3 teeth/inch

## Grinding

The high carbide content and the titanium carbide's high hardness make it self-evident that special attention must be paid when grinding. In this respect, it is of decisive importance whether the carbides are present in a soft-annealed or in a hardened steel binder phase. Grinding in hardened condition leads to significantly higher grinding wheel wear.

Corundum wheels with a ceramic bond, porous structure and fine grain have proven a suitable medium. In case of special questions, the grinding wheel manufacturer should be consulted.

Diamond wheels made from plastic-bonded, nickel-coated synthetic diamonds with a concentration of 75 c – 100 c in a diamond grit size of D 107 - D 151 are recommended particularly for the finish-grinding of Ferro-Titanit® in hardened condition.

Attention must be paid to the following basic rules when grinding:

1. Grind with a powerful, rinsing stream of coolant directed as close as possible to the wheel/workpiece contact point.
2. Select the smallest possible in-feed rate.

## Polishing

The surface quality of the high-grade Ferro-Titanit® carbide-alloyed materials is important for tool and machine part durability. Grinding to a best possible surface quality should generally be followed by polishing with a diamond polishing paste in order to achieve an ideal surface quality.

Rough-polishing is performed with diamond fine grit D 15 (10 – 25 µm), and finish-polishing with D 3 (2 – 5 µm). If necessary, this may be followed by polishing with D 1 (1 – 2 µm).

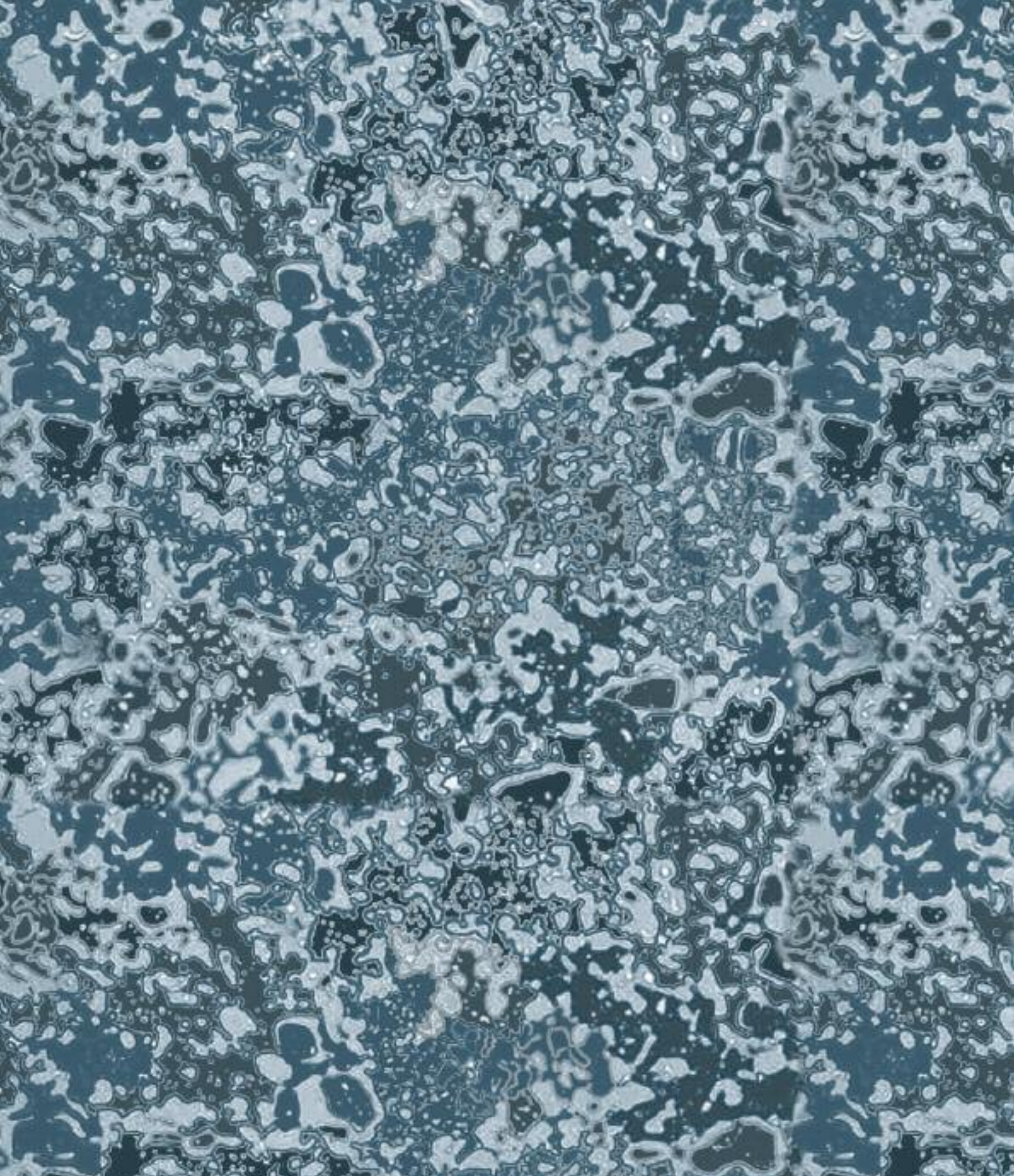
## Spark-erosion machining

During spark erosion, Ferro-Titanit® carbide alloys, tool steels and tungsten carbide alloys are subjected to the same influences. The overall behaviour when Ferro-Titanit® is eroded tends to be similar to that of tool steels. As spark erosion leads to generally strong, negative influences being exerted on tool surfaces, depending on the amperage applied, Ferro-Titanit® should be finish-eroded with a low pulse energy.

Spark-erosion roughing should be followed by a finishing and a fine-finishing operation in order to achieve the lowest possible surface roughness and freedom from cracking. Re-machining is necessary after such erosion including, where possible, stress-relieving treatment to reduce the stresses that have come about during the sintering process.

**General note (liability)**

All statements regarding the properties or utilisation of the materials or products mentioned are for the purposes of description only. Guarantees regarding the existence of certain properties or a certain utilisation are only ever valid if agreed upon in writing.



DEUTSCHE EDELSTAHLWERKE GMBH

Oberschlesienstr. 16  
47807 Krefeld, Germany  
[sales@ferro-titanit.com](mailto:sales@ferro-titanit.com)  
[www.dew-stahl.com](http://www.dew-stahl.com)  
[www.ferro-titanit.com](http://www.ferro-titanit.com)

