Metal powder and continuous cast rods

DEUTSCHE EDELSTAHLWERKE

Providing special steel solutions

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Special materials division

The Deutsche Edelstahlwerke GmbH, is a leading company in the production of specialty steel long products. The approximately 4,000 employees produce about a million tons of alloy steel at its four works in Witten, Siegen, Krefeld and Hagen per annum.

In the special materials division based in Krefeld, wear resistant powder metallurgically produced materials (Ferro-Titanit) and dental alloys are produced. In addition to this, gas atomised powders and continuous cast rods are produced.

All from the same source: The know-how of metallurgy, production technology and welding technology

Powder atomisation

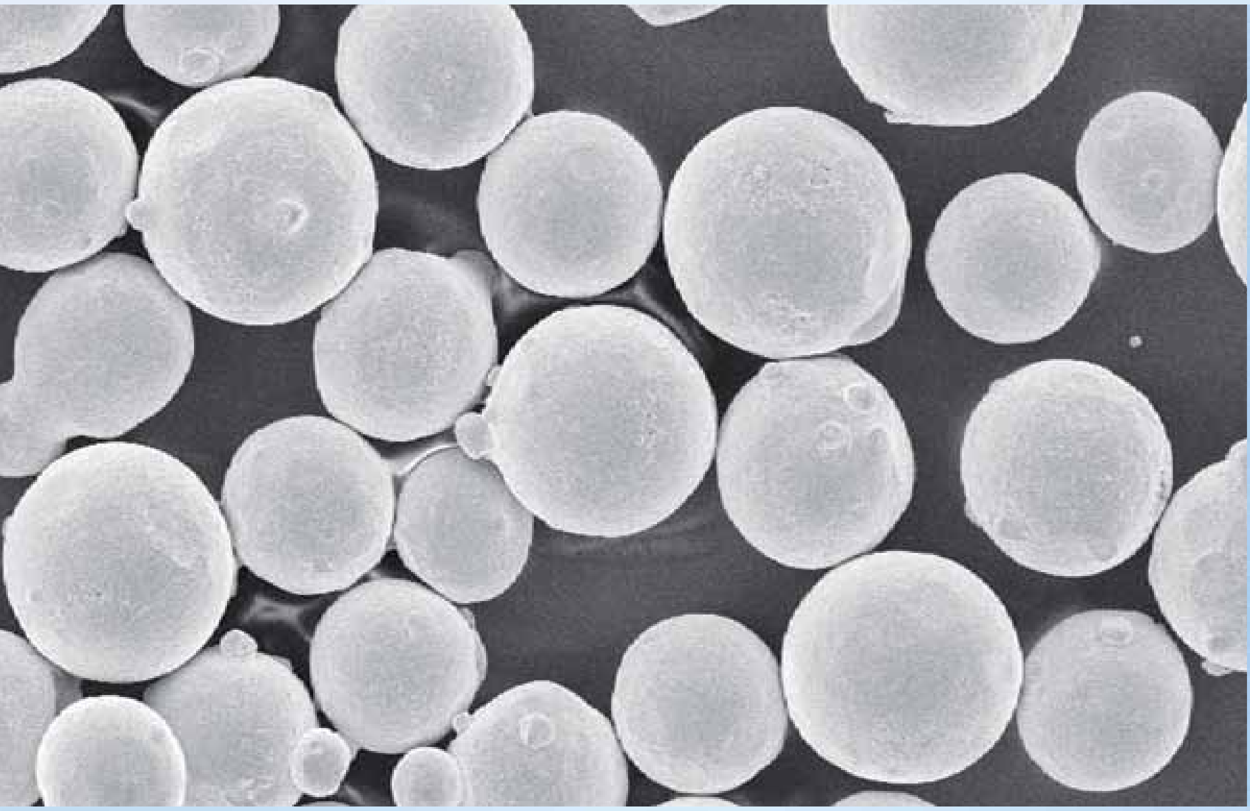
Weld cladding is an important process when the surfaces of a work piece need to be modified to improve the wear and/or corrosion properties.

The Deutsche Edelstahlwerke offer a wide pallet of Co, Ni and Fe base gas atomised metal powders and continuous cast rods which are suited for cladding, welding and thermal spraying processes. These products are produced using modern production facilities and benefit from more than 160 years of metallurgical knowledge in steel production.

In the gas atomising process, the raw materials are melted in an induction furnace prior to being atomised with high pressure inert gas, nitrogen, in the atomising tower. The nitrogen atomises the metal stream entering the closed tower and the resultant fine metal droplets fall to the bottom of the tower where they are collected. During the relatively slow solidification process, compared with water atomisation, the surface tension of the metal droplet pulls the drop together to form the spherical ball which is so characteristic of gas atomised powders. The spherical shape of the gas atomised powders guarantees the good flow characteristics of this powder and also allows for accurate and measuring of the powder quantities.

The powder is collected under inert gas to ensure that no detrimental oxidation occurs. This enables powders with low oxygen contents to be produced.

Prior to the use of this powder for plasma welding, thermal spraying or sinter applications, it has to be sieved to the required grain size fractions. This is performed on modern mechanical sieves and air classifiers.



Scanning electron micrograph (SEM), showing spherical metal powder grains produced via gas atomising

Composition of Deutsche Edelstahlwerke metal powders

Cobalt base

Grade	Alloy type	Typical analysis of the powder in weight % C	Si	Cr	Mo	Ni	W	Fe	B	Other
Celsit V-P	Alloy 6	1,1		28,0			4,5			
Celsit SN-P	Alloy 12	1,4		30,0			8,5			
Celsit N-P	Alloy 1	2,4		31,0			13,0			
Celsit 21-P	Alloy 21	0,25		28,0	5,0	2,8				
Celsit FN-P	Alloy F-mod.	1,6	1,0	28,0		22,0	13,0	1,0		
Celsit F-P	Alloy F	1,8		26,0		23,0	12,5	1,0		
CN20Co50-P	Alloy 25	<0,1		20,0		10,0	15,0			
Celsit T4-P	Alloy T400	<0,08	2,0	8,7	28,0	1,0		1,0		
Coborit 45-P	Alloy SF 6	0,8	2,3	19,0		13,0	8,0	3,0	1,7	Cu 0,6
Coborit 50-P	Alloy SF 12	0,2	3,5	18,0	6,0	27,0			3,0	
Coborit 60-P	Alloy SF 1	1,3	2,8	19,0		13,0	15,0		3,0	

Nickel base

Grade	Alloy type	Typical analysis of the powder in weight % C	Si	Cr	Mo	Co	W	Fe	B	Other
Niborit 20-P		0,05	3,0					2,5	2,0	
Niborit 4-P	Alloy 40	0,3	3,5	8,0				3,0	1,6	
Niborit 45-P	Alloy 45	0,4	3,5	9,0				3,0	2,0	
Niborit 5-P	Alloy 50	0,6	3,8	11,0				4,0	2,5	
SZW 5029	Alloy 56	0,6	4,0	12,5				4,0	2,8	
Niborit 6-P	Alloy 60	0,8	4,3	16,0				4,5	3,5	
Niborit 7-P	Alloy M 16C	0,50	3,7	17,0	4,5			2,0	3,75	Cu 2
Niborit Al 0,8-P		0,3	3,1	4,2				1,0	0.8	Al 1,2
Niborit Al 1-P		0,2	2,7	6,5				2,0	1,1	Al 1,2
Niborit 234-P	Alloy 234	0,2	2,8	4,3	3,0			0,2	1,1	P 1,8
Niborit 237-P	Alloy 237	0,2	2,8	4,4	3,7			0,3	1,3	P 1,8
SZW 5050	Ni 105	<0,06	10,0	19,0						
SZW 5052	Ni 102	<0,06	4,5	7,5				3,0	3,0	
HTL 6-P	Ni 106	<0,06								P 11
HTL 7-P	Ni 107	<0,06		14,0						P 10
Nibasit Al 5-P	NiAl 95-5	<0,03								Al 5
Nibasit C-276-P	Alloy C-276	<0,02		16,0	15,5	0,7	3,5	6,0		V 0,2
Nibasit 625-P	Alloy IN 625	<0,05		22,0	9,0			4,0		Nb 3,6
Nibasit T7-P	Alloy T700	<0,08	3,4	15,5	32,0	0,8		1,0		
NiCr70Nb-P	Nicro 82	<0,03	0,3	20,0				< 1,5		Mn 3; Nb 2,5
Nibasit P 60-P	Alloy Ni 60	0,55	3,2	17,5				17,0		

Iron base

Grade	Alloy type	Typical analysis of the powder in weight % C	Si	Cr	Mo	Ni	W	Co	B	Other
KW 10-P	1.4009	0,08	0,9	14,0		0,4				Mn 0,6;
KW 40-P		0,4	0,4	13,0						
KWA-P	1.4015	0,04	0,7	17,0						Mn 0,5
SKWAM-P	1.4115	0,2	0,6	17,0	1,1					Mn 0,5
AS 4-P	Alloy 316	0,1	0,8	17,0	2,2	13,0				
AS 4-P/LC	Alloy 316 L	0,02	0,8	17,0	2,2	13,0				
A7CN-P	1.4370	0,08	0,7	19,0		9,0				Mn 7,0
Antinit DUR 300-P		0,12	5,0	21,0		8,0		<0,07		Mn 6,5

Iron base

Grade	Alloy type	Typical analysis of the powder in weight % C	Si	Cr	Mo	Ni	W	Co	B	Other
EVT 50S-P	Everit 50S	2,0	0,4	25,5	3,2			<0,07		V 0,5
Ledurit 40-P		2,0	0,6	31,0						
SEO-P		3,9	0,5	31,0						
Ledurit 64CA-P		3,8	1,2	22,0			0,8		1,0	V 0,8
SZW 5033	Alloy E 6	2,0	1,25	29,0	5,5	12,0				
Fesit V-P	TS-1	1,2	5,0	30,0		10,0		12,0		
Fesit SN-P	TS-2	2,0	5,0	35,0		10,0		12,0		
Fesit N-P	TS-3	3,0	5,0	35,0		10,0		12,0		

Mixed powders

Grade	Alloy type	Typical analysis of the powder in weight % C	Si	Cr	Mo	Ni	W	Fe	B	Other
Super DUR WC-P	WSC-Ni/60-40	0,1	3,0			Rest			3,0	WSC 60 %
Super DUR W 6 Ni-P	WSC-Ni/40-60	0,8	4,3	16,0		Rest		4,5	3,5	WSC 40 %

Further powder qualities are available upon request.

Deliverable grain sizes of Deutsche Edelstahlwerke metal powders

Powder grain sizes from ... to	Coating processes PTA	FSW	FSF	FSC	PS/HVOF
20 – 45 µm					•
20 – 106 µm		•	•	•	
32 – 106 µm		•	•	•	
45 – 90 µm					•
45 – 125 µm	•	•	•	•	
50 – 150 µm	•				
50 – 160 µm	•				
50 – 180 µm	•				
63 – 150 µm	•				
63 – 160 µm	•				
63 – 180 µm	•				
63 – 200 µm	•				

Other grain sizes are available upon request.
Packing is in plastic bottles in units of 5 or 9 kg or in tin buckets in units of 25 kg.

Coating processes
PTA: Plasma transferred arc welding, FSW: Flame spray welding, FSF: Flame spraying (melt fusion)
FSC: Flame spraying (cold spraying), PS/HVOF: Plasma spraying / High-velocity flame spraying

Use of Deutsche Edelstahlwerke metal powders

Cobalt based

Grade	Alloy type	Coating process PTA	FSW	FSF	FSC	PS/HVOF
Celsit V-P	Alloy 6	•				•
Celsit SN-P	Alloy 12	•				•
Celsit N-P	Alloy 1	•				•
Celsit 21-P	Alloy 21	•				•
Celsit FN-P	Alloy F-mod.	•				•
Celsit F-P	Alloy F	•				•
CN20Co50-P	Alloy 25	•				•
Celsit T4-P	Alloy T400	•				•
Coborit 45-P	Alloy SF 6	•	•	•		•
Coborit 50-P	Alloy SF 12	•	•	•		•
Coborit 60-P	Alloy SF 1	•	•	•		•

Use of Deutsche Edelstahlwerke metal powders

Nickel base

Grade	Alloy type	Coating process PTA	FSW	FSF	SOL	PS/HVOF
Niborit 20-P		•	•	•		•
Niborit 4-P	Alloy 40	•	•	•		•
Niborit 45-P	Alloy 45	•	•	•		•
Niborit 5-P	Alloy 50	•	•	•		•
SZW 5029	Alloy 56	•	•	•		•
Niborit 6-P	Alloy 60	•	•	•		•
Niborit 7-P	Alloy M 16C	•	•	•		•
Niborit Al 0,8-P		•				
Niborit Al 1-P		•				
Niborit 234-P	Alloy 234		•	•		
Niborit 237-P	Alloy 237		•	•		
SZW 5050	Ni 105				•	
SZW 5052	Ni 102				•	
HTL 6-P	Ni 106				•	
HTL 7-P	Ni 107				•	
Nibasit Al 5-P	NiAl 95-5					•
Nibasit C-276-P	Alloy C-276	•				•
Nibasit 625-P	Alloy IN 625	•				•
Nibasit T7-P	Alloy T700	•				•
NiCr70Nb-P	Nicro 82	•				•
Nibasit P 60-P	Ni 60	•				

Iron base

Grade	Alloy type	Coating process PTA	FSW	FSF	FSC	PS/HVOF
KW 10-P	1.4009	•			•	•
KW 40-P		•			•	•
KWA-P	1.4015	•			•	•
SKWAM-P	1.4115	•			•	•
AS 4-P/LC	Alloy 316 L	•				•
A7CN-P	1.4370	•				•
Antinit DUR 300-P		•				
EVT 50S-P	Everit 50S	•				
Ledurit 40-P		•				•
SEO-P		•				•
Ledurit 64CA-P		•				
SZW 5033	Alloy E 6	•				
Fesit V-P	TS-1	•				
Fesit SN-P	TS-2	•				
Fesit N-P	TS-3	•				

Mixed powders

Grade	Alloy type	Coating process PTA	FSW	FSF	FSC	PS/HVOF
Super DUR WC-P	WSC-Ni/60-40	•				
Super DUR W 6 Ni-P	WSC-Ni/40-60		•	•		

Coating process
PTA: Plasma transferred arc welding, FSW: Flame spray welding, FSF: Flame spraying (melt fusion), FSC: Flame spraying (cold spraying)
PS/HVOF: Plasma spraying / High-velocity flame spraying, SOL.: Powder for the production of high temperature solder pastes

Continuous rod casting

The special materials division utilises two modern horizontal continuous casters to produce hard facing rods. The raw materials are melted in an induction furnace and the molten metal is then poured into a tundish from which the continuous cast strands are withdrawn. The cast is continuously purged with inert gas during the casting process to ensure optimal quality. The resultant continuous cast rods are then straightened and cut to the required length. These rods can also be ground prior to packaging, depending upon the customer requirements. These continuous casters are also used to produce dental alloys.

Composition of Deutsche Edelstahlwerke continuous cast rods

Cobalt base

		Typical analysis of the rod in weight %								
Grade	**Alloy type**	**C**	**Si**	**Cr**	**Mo**	**Ni**	**W**	**Fe**	**B**	**Other**
Celsit V	Alloy 6	1,1	1,3	27,0		1,0	4,5	1,0		
Celsit SN	Alloy 12	1,8	1,3	29,0		1,0	8,5	1,0		
Celsit N	Alloy 1	2,4	1,1	32,0		1,0	13,0	1,0		
Celsit 20	Alloy 20	2,2		32,0		1,0	16,5	1,0		
Celsit 21	Alloy 21	0,25	0,5	28,0	5,0	2,8		1,0		
Celsit F	Alloy F	1,6	1,2	26,5		23,0	12,5	1,0		
SZW 6002	Alloy 4H	1,7	0,8	32,0		0,5	11,0	1,0		
SZW 6014	Alloy 12 AWS	1,45	1,2	29,0		0,5	8,5	1,0		
SZW 6043	Alloy T-400	0,08	2,4	8,5	27,5	1,5		1,5		

Nickel base

		Typical analysis of the rod in weight %								
Grade	**Alloy type**	**C**	**Si**	**Cr**	**Mo**	**Co**	**W**	**Fe**	**B**	**Other**
Nibasit T-7	Alloy T-700	0,04	2,9	15,0	32,0	0,5		0,5		
SZW 36	Ni 60	0,8	3,6	16,0				17,0		
Niborit 4		0,3	3,5	7,5				3,0	1,5	
SZW 6026	Alloy 60-soft	0,7	2,0	14,5				4,5	3,2	
SZW 6024	Alloy 60-hard	0,75	2,0	14,5				4,0	3,8	
SZW 6037	Alloy 50	0,6	3,5	11,5				3,7	1,9	

Iron base

		Typical analysis of the rod in weight %								
Grade	**Alloy type**	**C**	**Si**	**Cr**	**Mo**	**Ni**	**W**	**Co**	**B**	**Other**
Antinit DUR 300		0,08	5,5	21,5		7,8		<0,05		Mn 6,2
EVT 50 S	Everit 50 S	2,0	0,4	25,5	3,2			<0,07		V 0,5
SEO		3,9	0,6	31,0						
Fe-CNB		1,2	2,1	10,0	1,7	5,5		1,5	2,7	
Fesit V-P	TS-1	1,2	5,0	30,0		10,0		12,0		
Fesit SN-P	TS-2	2,0	5,0	35,0		10,0		12,0		
Fesit N-P	TS-3	3,0	5,0	35,0		10,0		12,0		

Other continuous cast rod qualities are available upon request.

Applications for Deutsche Edelstahlwerke continuous cast rods

Cobalt base

Grade	**Alloy type**	**Hard facing Gas**	**TIG**	**used as core wire**
Celsit V	Alloy 6	•	•	•
Celsit SN	Alloy 12	•	•	•
Celsit N	Alloy 1	•	•	•
Celsit 20	Alloy 20	•	•	•
Celsit 21	Alloy 21		•	•
Celsit F	Alloy F	•	•	
SZW 6002	Alloy 4H	•	•	
SZW 6014	Alloy 12 AWS	•	•	•
SZW 6043	Alloy T-400		•	

Nickel base

Grade	Alloy type	Hard facing Gas	TIG	used as core wire
Nibasit T-7	Alloy T-700		•	
SZW 36	Ni 60		•	
Niborit 4	Alloy 40	•	•	
SZW 6026	Alloy 60-soft	•	•	
SZW 6024	Alloy 60-hard	•	•	
SZW 6037	Alloy 50	•	•	

Iron base

Grade	Alloy type	Hard facing Gas	TIG	used as core wire
Antinit DUR 300			•	
EVT 50 S	Everit 50 S		•	•
SEO			•	•
Fe-CNB (***)				
Fesit V-P	TS-1		•	
Fesit SN-P	TS-2		•	
Fesit N-P	TS-3		•	

Remarks

Hard facing: Gas: Gas welding (oxyacetylene welding)
TIG: Tungsten inert gas welding

Core wires: Used with coated electrodes
***: Used in centrifugal casting (e.g. Plastics industry)

Deliverable dimensions of Deutsche Edelstahlwerke continuous cast rods

Cobalt base

Grade	rod diameter in mm Ø 3,0/3,2	Ø 4,0	Ø 5,0	Ø 6,0/6,4	Ø 8,0
Celsit V	•	•	•	•	•
Celsit SN	•	•	•	•	•
Celsit N	•	•	•	•	•
Celsit 20		•	•	•	•
Celsit 21	•	•	•	•	•
Celsit F	•	•	•	•	•
SZW 6002		•	•		
SZW 6014	•	•	•	•	•
SZW 6043			•		

Nickel base

Grade	rod diameter in mm Ø 3,0/3,2	Ø 4,0	Ø 5,0	Ø 6,0/6,4	Ø 8,0
Nibasit T-7			•		
SZW 36			•		
Niborit 4		•	•	•	•
SZW 6026		•	•	•	
SZW 6024		•	•	•	
SZW 6037		•	•	•	

Iron base

Grade	rod diameter in mm Ø 3,0/3,2	Ø 4,0	Ø 5,0	Ø 6,0/6,4	Ø 8,0
Antinit DUR 300		•	•	•	
SEO		•	•	•	•
Fesit V	•	•	•	•	•
Fesit SN	•	•	•	•	•
Fesit N	•	•	•	•	•

Rod lengths
Rods in standard production are straightened and available in lengths of 350, 400, 450, 500, 1.000 and 2.000 mm. Other lengths are available upon request.

Rod surface
Rods in standard production have a continuous cast finish. Ground rods are available upon request.

Typical properties of metal powder coatings and hardfacings

Coating and overlay welding process	Coating thickness	Dilution (%)	Work piece heating during coating	Distortion potential
Plasma-transferred-arc welding (PTA)	2,0 – 6,0 mm per layer	5 – 20 %	high but local	high
Flame spray welding	up to 2,0 mm	< 5 %	medium	medium
Flame spraying (melt fusion)	0,5 – 2,0 mm	0 %	high	low
Flame spraying (cold spraying)	0,5 – 2,0 mm	0 %	very low	no distortion
Plasma and HVOF-spraying	up to 0,8 mm	0 %	very low	no distortion
Gas welding	1,5 – 5,0 mm per layer of	< 5 %	very high	high
TIG welding	1,5 – 5,0 mm per layer	10 – 30 %	high but local	high

Reference values for weld metal hardness at room temperature and the hardness of the pure weld metal at elevated temperatures

Cobalt base

Grade	Hardness (HRC) at RT	elevated temperature hardness in HV10 at									
		20 °C	100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	700 °C	800 °C	900 °C
Celsit V, ... V-P	41	410	394	344	330	322	311	272	197	180	152
Celsit SN, ... SN-P	48	485	447	412	401	388	368	357	333	285	230
Celsit N, ... N-P	53	626	605	571	523	487	451	445	386	304	263
Celsit 20	56										
Celsit 21, ... 21-P	32	325	291	271	254	239	222	201	186	166	150
Celsit FN-P	43										
Celsit F, ... F-P	45	446	442	400	355	333	315	304	295	271	228
CN20Co50-P	230 HB										
Celsit T4-P	55										
Coborit 45-P	45	447	447	428	409	390	361	295	238	271	
Coborit 50-P	50										
Coborit 60-P	60	760	740	700	650	580	500	420	225		
SZW 6002	53										
SZW 6014	46										
SZW 6043	54										

Reference values for weld metal hardness at room temperature and the hardness of the pure weld metal at elevated temperatures

Nickel base

Grade	Hardness (HRC) at RT	elevated temperature hardness in HV10 at 20 °C	100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	700 °C	800 °C	900 °C
Nibasit T-7	47										
Niborit 20-P	42										
Niborit 4-P	40	400	388	377	366	344	285	222	120		
Niborit 45-P	45										
Niborit 5-P	50	540	515	471	447	420	380	280	138		
SZW 5029	55										
Niborit 6-P	60	740	674	657	626	580	502	368	170		
Niborit 7-P	62										
Niborit Al 0,8-P	34										
Niborit Al 1-P	32										
Niborit 234-P	33										
Niborit 237-P	34										
Nibasit Al 5-P	Bond layer										
Nibasit T7-P	47										
NiCr70Nb-P	170 HB										
SZW 36	250 HV										
SZW 6026	54										
SZW 6024	58										

Iron base

Grade	Hardness (HRC) at RT	elevated temperature hardness in HV10 at 20 °C	100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	700 °C	800 °C	900 °C
KW 40-P	44-55										
KWA-P	20-40										
SKWAM-P	30-55										
AS 4-P	170 HB										
AS 4-P/LC	170 HB										
A7CN-P	170 HB										
Antinit DUR 300, ...-P	30	420	381	351	326	278					
EVT 50 S	48										
Ledurit 40-P	43										
SEO, ... -P	57	650	650	650	526	428	435	335	238	222	141
Ledurit 64CA-P	> 60										
Fesit V-P	38										
Fesit SN-P	45										
Fesit N-P	51										
Super DUR WC-P	> 60										
Super DUR W 6 Ni-P	> 60										

Note:
The hardness values given are valid for the alloying type, independent of the product form or the coating processes.

Physical properties

Thermal expansion

Grade	Thermal expansion in 10^{-6} m/m °C within the temperature ranges (°C) 20-100	20-200	20-300	20-400	20-500	20-600	20-700	20-800	20-900
Celsit V, ... V-P	11,9	13,5	14,0	14,4	14,7	15,3	15,8	16,0	16,1
Celsit SN, ... SN-P	11,3	12,5	12,9	13,3	13,7	14,2	15,0	15,1	15,3
Celsit N, ... N-P	11,1	11,6	12,3	12,8	13,0	13,3	14,0	14,4	14,6
Celsit 21, ... 21-P	11,3	12,3	13,0	13,6	14,0	14,3	14,9	15,2	15,5
Celsit F, ... F-P	11,5	12,6	13,0	13,2	13,5	13,9	14,5	14,9	15,4
Coborit 45-P	9,7	10,8	11,9	12,3	12,8	13,4	13,8	14,1	
Coborit 60-P	11,5	13,6	14,2	14,9	15,2	15,5	15,9	16,7	
Niborit 4-P	11,4	12,7	12,9	13,3	13,5	13,9	14,5	14,9	15,4
Niborit 5-P	11,4	12,1	12,2	12,5	12,7	12,9	13,4	13,8	14,2
Niborit 6-P	11,0	11,6	12,0	12,3	12,5	12,8	13,1	13,5	14,0
KW 40-P	10,5	11,0	11,0	11,5	12,0				
KWA-P	10,0	10,0	10,5	10,5	11,0				
SKWAM-P	10,5	11,0	11,0		12,0				
AS 4-P	16,5	17,5	17,5	18,5	18,5				
A7CN-P					18,0				
Antinit DUR 300, ...-P						15,7			
SEO, ... -P	11,3	12,5	13,1	13,3	13,5	13,6	14,4	14,5	14,5

Specific density, melting range and thermal conductivity

Grade	Specific density g/cm³	Melting range °C	°F	Thermal conductivity W/mK
Celsit V, ... V-P	8,30	1240-1340	2265-2445	15,0
Celsit SN, ... SN-P	8,40	1220-1310	2228-2390	15,0
Celsit N, ... N-P	8,70	1230-1290	2245-2355	15,0
Celsit 21, ... 21-P	8,35	1360-1405	2480-2560	
Celsit F, ... F-P	8,40	1230-1290	2245-2355	
CN20Co50-P	9,15	1345-1395	2455-2545	10,5
Coborit 45-P	8,30	1080-1150	1975-2100	
Coborit 50-P	8,30	1040-1120	1905-2050	
Coborit 60-P	8,40	1005-1210	1840-2210	
Niborit 4-P	8,20	1000-1150	1830-2100	
Niborit 45-P	8,20	990-1130	1815-2065	
Niborit 5-P	8,10	980-1070	1795-1960	
Niborit 6-P	7,90	960-1030	1760-1885	
KW 40-P	7,70			30,0
KWA-P	7,70	1476-1501	2690-2735	25,0
SKWAM-P	7,70	1435-1470	2615-2680	25,0
AS 4-P	7,80	1412-1441	2575-2625	15,0
A7CN-P	7,90			15,0
Antinit DUR 300, ...-P	7,80	1360-1390	2480-2535	
SEO, ... -P	7,50	1230-1325	2245-2415	

Properties of hard facing and coatings with Deutsche Edelstahlwerke metal powders and continuous cast rods

Grade	Adhesive wear	Abrasive wear	Impact loading	Corrosion resistance*	Inter-crystalline corrosion	Heat-resistance	High temperature resistance	Resistance to thermal shock	Magnetic
Celsit V, ... V-P	•		•	•	•	•	•	•	
Celsit SN, ... SN-P	•	•	•	•		•	•		
Celsit N, ... N-P		•		•		•	•		
Celsit 20		•		•		•	•		
Celsit 21, ... 21-P	•		•	•	•	•	•	•	
Celsit FN-P	•		•	•		•	•	•	
Celsit F, ... F-P	•		•	•		•	•	•	
CN20Co50-P	•		•	•	•	•	•	•	
Coborit 45-P	•		•	•			•		
Coborit 50-P	•	•		•			•		
Coborit 60-P	•	•		•			•		
SZW 6002	•	•	•	•		•	•		
SZW 6014	•	•	•	•		•	•		
SZW 6043	•	•	•	•	•	•	•	•	
Nibasit T-7	•	•	•	•	•	•	•	•	
Niborit 20-P	•		•	•			•	•	
Niborit 4-P	•		•	•			•	•	
Niborit 45-P	•		•	•			•		
Niborit 5-P	•	•	•	•			•		
SZW 5029	•	•		•			•		
Niborit 6-P	•	•		•			•		
Niborit 7-P	•	•		•					
Nibasit Al 5-P				•				•	
NiCr70Nb-P	•			•	•	•	•	•	
Nibasit P 60-P	•			•		•	•	•	
SZW 36	•			•		•	•	•	
SZW 6026	•	•		•			•		
SZW 6024	•	•		•			•		
SZW 6037	•	•	•	•			•		
KW 40-P	•		•	•	•	•			•
KWA-P	•		•	•		•			•
SKWAM-P	•		•	•		•			•
AS 4-P				•				•	
AS 4-P/LC				•	•			•	
A7CN-P			•	•	•				
Antinit DUR 300, ...-P	•			•	•	•	•	•	•
Ledurit 40-P	•	•	•	•		•	•		•
SEO, ... -P	•	•	•			•			•
SZW 5013	•		•	•		•	•	•	
SZW 5033	•		•	•		•	•	•	
Super DUR WC-P		•	•						
Super DUR W 6 Ni-P		•	•						

• = stable / yes

*) The corrosion resistance depends essentially on medium and temperature (see the table on page 16).

Corrosion behaviour of Deutsche Edelstahlwerke metal powders and continuous cast rods

Corrosive medium	Concen-tration in weight%	Tempe-rature °C	Celsit 21	Celsit V	Celsit SN	Celsit N	Niborit 4	Niborit 6
Phosphoric acid H_3PO_4	10	RT		1		1		2
	85	RT		1		1		2
	10	65		1		1		4
Nitric-acid HNO_3	10	RT		1	1	1	4	4
	70	RT		1	1	1	4	4
	10	65	1	2	1	1	4	4
Sulphuric acid H_2SO_4	10	RT	1	1	1	1	3	2
	90	RT	1	2	1	1	4	4
	10	65	1	4	4	1	4	4
Hydrochloric acid HCL	5	RT	1	3	3	1		2
	37	RT	2	4	4	3-4		
	10	ST		4	4	4		
Acetic acid CH_3COOH	20	RT	1	1	1			
	90	RT	1	1	1			
	30	ST	1	1	1	1	4	4
Hydrofluoric acid HF	6	RT		4	4	2		
	40	ST				4		
Chromic acid	10	RT		1		1		1
	10	ST		4		4		4
Caustic soda NaOH	10	RT		1	1	1		
	40	RT		1				1
	5	ST				1		1
Copper chloride $CuCl_2$	2	RT		1		1		
	10	RT		1		1		
Ferric chloride $FeCl_3$	2	RT		1	1	1		
Ammonium nitrate NH_4NO_3	10		1		1			
Strauss test			1	1	3	1		2

Ledgend
RT: Room temperature
ST: Boiling point

Weight loss rates
1 = < 1 g/m²Day
2 = 1-10 g/m²Day
3 = 11-25 g/m²Day
4 = > 25 g/m²Day

Application of Deutsche Edelstahlwerke metal powders and continuous cast rods

Branch	Parts for hard facing or coating	Metal powder or continuous cast rods
Automotive industry	Engine valves, seats	Celsit FN-P, Celsit F-P, Celsit V-P, Celsit SN-P, SZW 5013, SZW 5033, Celsit F
Shipbuilding	Engine valves, seats	Celsit V-P, Celsit SN-P, Nibasit P 60-P, Celsit V, Celsit SN, Nibasit T-7, SZW 36, SZW 6002, SZW 6024, SZW 6026, SZW 6043
Glass industry	Press-press/blow-press dies, die plates, press moulds	Niborit 4-P, Niborit Al 0,8-P, Niborit Al 1-P, Niborit 234-P, Niborit 237-P
Power generation	Valves, spindles, bushes, cones, other wear parts, corrosion/ oxidation resistant cladding	Celsit V-P, Celsit SN-P, Celsit 21-P, Celsit V, Celsit SN, Celsit 21, Antinit DUR 300-P, KWA-P, SKWAM-P
Plastic industry	Extruder shafts, housings and bushes	Celsit V-P, Celsit SN-P, Celsit N-P, Niborit 5-P, Celsit V, Celsit SN, Celsit N
Pumps/Fittings	Seat and guiding surfaces, cones, spindles, other wear parts	Celsit V-P, Celsit SN-P, Celsit 21-P, KWA-P, SKWAM-P, Celsit V, Celsit SN, Celsit 21
Wood/Paper industry	Motor saw rails, cutting rails and strips, cutting knifes, agitator blades	Celsit V-P, Celsit SN-P, Celsit N-P, Niborit 5-P, Niborit 6-P, Celsit V, Celsit SN, Celsit N
Steel/Metal processing	Transport rollers, guide rollers, hot shears, grates, rolling mill rolls	Celsit V-P, Celsit SN-P, Celsit N-P, Celsit 21-P, SEO-P, Niborit 6-P, Coborit 60-P, Celsit V, Celsit SN, Celsit N, Celsit 21, SEO
Agriculture	Plough blades, knifing discs, disc harrows, soil engaging parts	SEO-P, Niborit 5-P, Niborit 6-P, Super DUR W-6 Ni-P, Super DUR WC-P, SEO, SZW 6024
Cement/Mining/ Quarrying	High-pressure dies, conveyors, dredger teeth, cutters, crusher jaws, grinding bodies, wear plates,	Niborit 6-P, SEO-P, Super DUR WC-P, Super DUR 6 Ni-P, SEO, SZW 6024
Chemical industry	Bushes, seat surfaces, rotor shafts, bearing and sealing surfaces, agitators	AS4-P/LC-P, Celsit 21-P, Celsit V-P, Celsit 21, Celsit V
Buffer material	Crack formation during hardfacing can to be reduced by buffer layers	CN20Co50-P, Celsit 21-P, NiCr70Nb-P, A7CN-P, Celsit 21
Bond layer material	Bond layer for thermal spraying to improve adhesion and coating properties	Nibasit Al 5-P

Practical tips regarding hardfacing

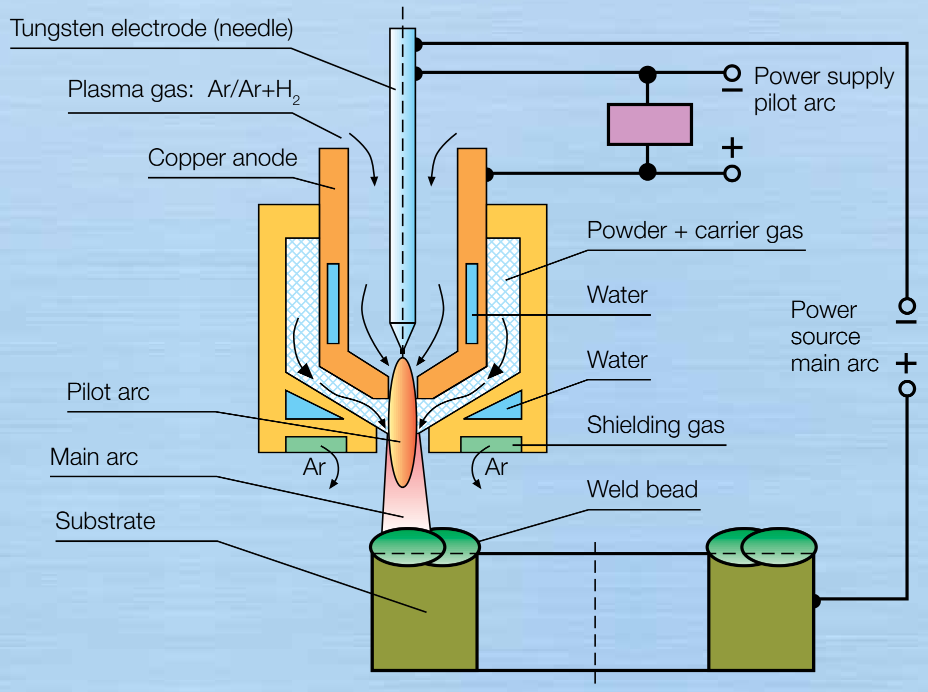
Problems	Possible cause	Corrective action
Lack of fusion	Unsuitable welding parameters	Optimisation of the welding parameters.
Lack of sidewall fusion	Side walls too steep, no radius	Flat position with sidewall angle 30 -45 ° turned with radius of (R 1 - 3).
Lack of dimensional accuracy	Base material delivered to final size, little or no over-size of the base matal.	Edge construction (e.g. copper shoe), similar welding material construction, buffering.
Shrinkage or distortion	High welding stresses, high welding and intermediate layer temperature, large number of layers.	Welding positioner, number of layers as low as possible, low welding and intermediate layer temperature (if no cracks).
Cracking	Very hard welding material, base material with a high C content, low welding and intermediate layer temperature, larger number of layers.	Buffering, base material with a low C content, adjustment of the thermal expansion, high welding and intermediate layer temperature, lower number of layers, suitable welding process.
Hot cracking	Overheating of the weld pool, high welding and intermediate layer temperature, surface contamination, unwanted trace elements.	Prevent overheating, low welding and intermediate layer temperature, no grease or dirt on the surface, no unwanted trace elements.
Pore formation	Overheating of the weld pool, surface contamination, unwanted trace elements, flame adjustment, reactions which promote gas formation.	No overheating of the weld pool, no grease or dirt on the surface, no unwanted trace elements, optimal flame adjustment, no reactions to promote gas formation, moisture free surfaces.
Oxide skin / Slag formation	Base metal surface scale and/or contamination, oxide and slag creator in the analysis (e.g. Al, Ti), insufficient shielding gas.	Metallically clean base metal surface, no oxide or slag formers in the powder or base metal, more shielding gas.

Further information and consulting is available from our technical team.

Metal powder coating and hardfacing processes

Plasma transferred arc welding (PTA)
This is a plasma welding process in which metal powder is continuously fed into the weld zone. The powder may be added separately or fed into the arc directly via the torch.
The arc is initiated between the tungsten electrode and the work piece. It is ignited and stabilized with the aid of a pilot arc between the tungsten electrode, which is enveloped in argon, and the copper nozzle (anode).
The primary arc and pilot arc are supplied independently from their own power source. Within the arc, the argon is ionized to form a plasma with high beam energy. Argon shielding gas is supplied via the outer nozzle and protects the molten pool against the ingress of oxygen and is also used to carry the powder. The powder grains can pass into the molten pool via a mechanical metering device either in solid or molten form. This depends upon the size, the shape, the quantity, the thermo-physical properties of the powder and the plasma, as well as upon the transfer time of the powder grains in the plasma.
Plasma transferred arc welding has gained in importance in recent years since this process facilitates a build-up of powder alloys, which in the form of rods or wire, is difficult to produce or often cannot be produced. The advantages of plasma powder transferred arc welding are the precise adjustment of the penetration depth and the build-up thickness (dilution) as well as the high energy density of the plasma arc. As a result of the continuous addition of powder, it is possible to automate this welding process to produce reproducible and uniform weld layers with low porosity. This welding process is thus ideally suited for mass production processes.

The pre-heat and intermediate layer temperatures during plasma transferred arc welding are dependant on the base material, the size of the work piece and the number of layers.



Schematic diagram of a plasma transferred arc (PTA) welding torch.

Flame spray welding

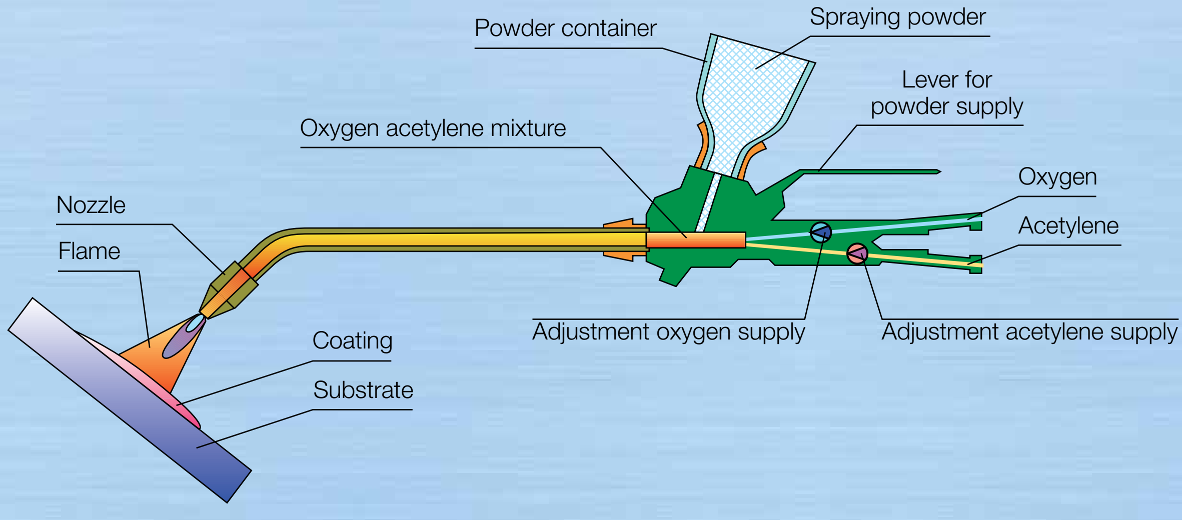
Deutsche Edelstahlwerke metal powders are used for hard facing of bearing and sealing surfaces of gas, water, steam and acid fittings. These powders are also used in the production of hard facings on valves for vehicle and ship engines as well as for highly stressed and wear resistant hard facings on hot work, crushing, stirring, extracting and drilling tools.

Flame spray cladding is a surface coating process in which the metal powder is sprayed over a short distance onto the base material via a torch. The flame simultaneously melts and transports the metal powder particles to the surface of the work piece where they build up a wear and/or corrosion resistant layer. This produces fusion between the sprayed layer and the base material comparable to welding. With flame spray cladding, the surface of the work piece has to be cleaned thoroughly of rust, grease and oil. A roughening of the cleaned surface should be performed by blasting or rough grinding in order to facilitate a good bond, keying, of the sprayed layer. Spraying should be immediately carried out after this surface preparation.
This method is suitable for applying thin layers to small areas, edges and for repair work. Low and high alloy steels, stainless steels, cast steels, malleable cast iron, flake and spheroidal graphite cast iron can be sprayed. Powder having significant additions of Cr-Si-B and powder-mix qualities are available.

Flame spraying

Powder flame spraying is a coating process, during which the powder is melted by means of an oxy-fuel gas flame and sprayed onto the surface of the work piece. This process is based upon a flame temperature of about 3,100 °C. The powder particles reach a speed up to 250 m/s, depending on particle size, spraying distance and operational parameters of the spray gun. Whilst passing through the flame, the powder particles are melted and/or heated to a plastic state.

Schematic representation of the flame spray welding process.



Powder flame spraying can be divided into two processes:

- Powder flame spraying without secondary thermal treatment (cold spraying process)
- Powder flame spraying with subsequent fusing-in (melt fusion)

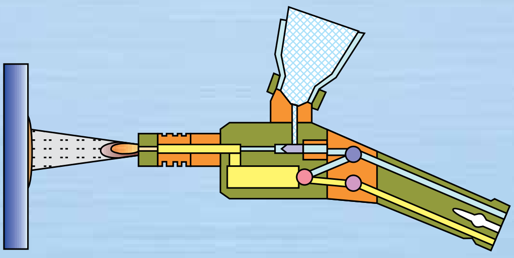
With flame spraying the surface of the work piece has to be cleaned thoroughly prior to spraying in order to remove rust, grease and oil. To ensure better adhesion between the coating and the substrate, the cleaned substrate surface should be roughened by blasting or rough grinding. Spraying should be carried out immediately after the surface preparation.

With powder flame spraying without secondary thermal treatment (cold spraying process), the work piece temperature does not exceeded 300 °C. The advantage of this is that no changes in the microstructure of the component occur. With cold spraying processes, the problem of distortion can be eliminated. All conventional powder alloys used industrially can be sprayed.

With the powder flame spraying process with subsequent fusing-in (melt fusion), the applied metallic sprayed layers are subsequently sintered at temperatures of 1,000 to 1,200 °C. This subsequent treatment can either be carried out with the aid of torches, furnaces or by induction. For this process only the so-called self-flowing alloys with a nickel base or cobalt base are used. In these alloys the addition of boron and silicon aid the fusing process. Through the fusing process dense sprayed layers are produced and have considerably improved properties in respect of homogeneity, adhesion and surface roughness. Fields of application for these powder flame spraying processes are to be found, in the chemical, glass, plastic and electrical industry as well as in machine, pump and compressor constructions.

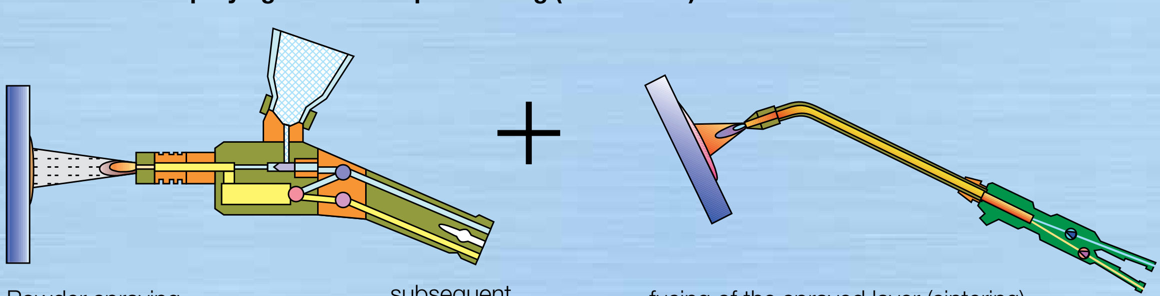
Schematic representation of flame spraying

Powder flame spraying without secondary thermal treatment (cold spraying process)



Just powder spraying

Powder flame spraying with subsequent fusing (melt fusion)



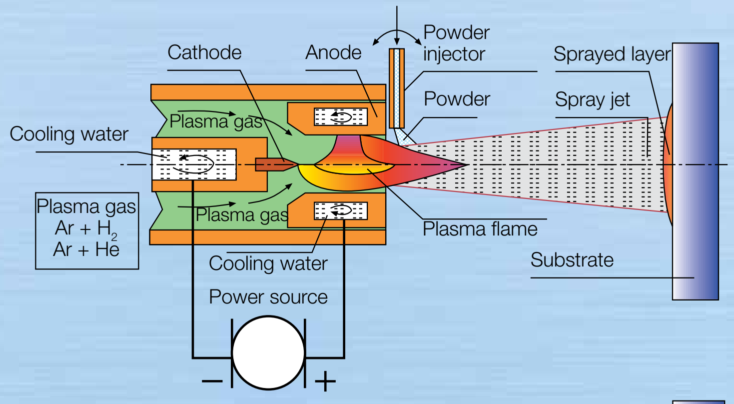
Powder spraying — subsequent → fusing of the sprayed layer (sintering)

Plasma and high-velocity flame spraying (HVOF)

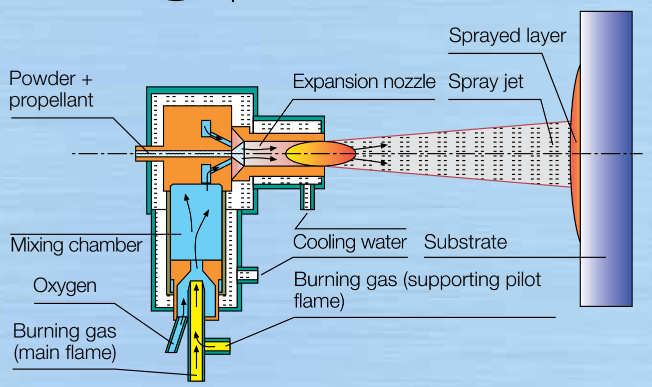
Plasma spraying belongs to the group of so-called arc spraying processes.
In a plasma torch, an electrical arc is ignited by high frequency between a water-cooled tungsten cathode located centrically and a water-cooled jet shaped copper anode.
Gasses such as argon, helium, nitrogen or hydrogen or mixtures thereof are forced under high pressure into the arc. The supplied gasses are ionised in the arc to form plasma which can reach temperatures up to 30,000 °C.

This hot plasma flow leaves the torch nozzle with high speed (approx. 1,000 m/s) as a brightly glowing plasma beam. The spraying powder is added, by means of a conveying gas, in controlled doses to the plasma gas stream either inside or outside the torch. In the plasma beam the spraying powder is accelerated to very high speeds (approximately 400 m/s), melted and shot onto the surface of the work piece. Upon striking the pretreated surface, the powder particles, which have become molten or at least plastic, form flat lamellas and solidify instantaneously. The plasma stream, rich in energy, and the high impact speed of the powder particles upon the surface of the work piece, result in a high quality, dense, firmly adhesive spraying layers which have a lamellar structure.

Schematic representation of plasma spraying.

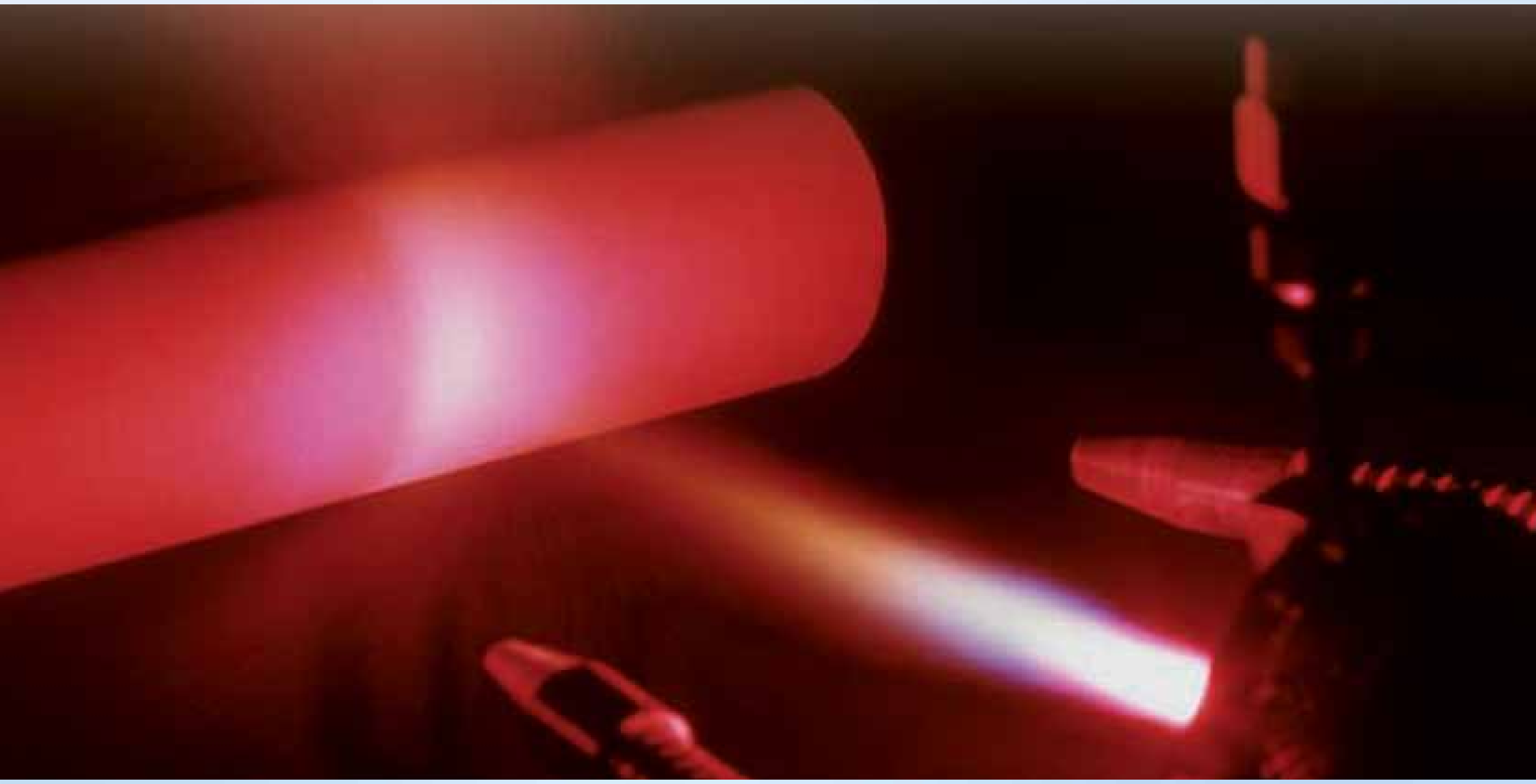


Schematic representation of high-velocity flame spraying (HVOF).



The high-velocity flame spraying (HVOF) process distinguishes itself from the conventional flame spraying processes due to the high flow speed of the flame, which is above the speed of sound. A HVOF system consists of a spray gun, control unit, gas supply and a powder supply. The spray gun is the heart of the system. It consists of a gas mixing chamber, combustion chamber and an expansion nozzle. The spraying powder is supplied by the feeding system and is transported centrically by the conveying gas through the combustion chamber to the HVOF flame. The flame is formed using a combustible gas and oxygen mixture in a water-cooled pistol. Inside the expansion nozzle the powder particles are heated up and the powder particles are accelerated to very high speeds. As in the case of plasma spraying, high-quality sprayed layers are achieved, due to the high impact speed of the powder particles and high-energy flame.

When plasma and HVOF spraying, the surface condition of the work piece is very important and this has to be cleaned carefully to remove rust, grease and oil. The cleaned surface should then be roughened to produce good bonding between the spayed layer and the substrate. This is usually accomplished by grit blasting the surface. The spraying process should be carried out immediately after the surface preparation. The main areas of application of the plasma and HVOF spraying are for the production of protective layers against wear, corrosion, erosion, heat and abrasion and thermal insulation, in the chemical, textile, paper and automotive industry, as well as in the construction of gas turbines, aircraft engines, ovens, pumps and reactors.



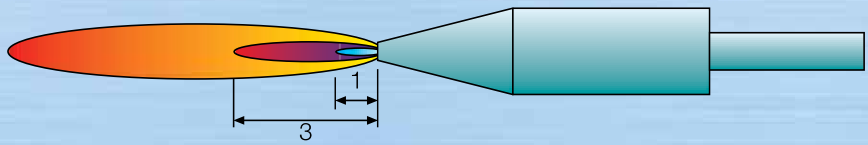
Hardfacing processes using continuous cast rods

Gas welding (Oxy-acethylene method)
The gas welding process is carried out with an oxygen acetylene flame. The chemical composition of the weld metal and the properties of the deposit are dependant on the composition of the welding rod and the dilution with the base material.

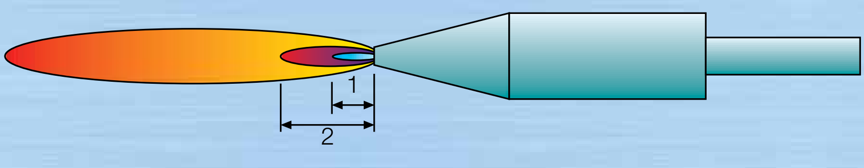
When gas welding with hardfacing, the low melting point of the hard alloys means that the base material is not melted but only heated enough to allow the hardfacing to melt and fuse with the surface. The dilution with the base material is thus negligibly small. It is usual to weld hard alloys with a reducing flame, which means with an acetylene gas surplus. With a neutral flame, a thick oxide film would form, making welding difficult.
When using a reducing flame adjustment, the flame consists of three zones, the flame core, flame feather and the outer sheath of the flame. With an increasing acetylene gas surplus, carbon is induced into the liquid weld pool. This carbon can lead to strong carburising and pore formation in the weld metal. Carburising of the weld metal can also increase hardness of the overlay. To reduce, or to avoid carburisation and pore formation, the hard alloys are welded with the following flame adjustment: hard Co base alloys proportionally 3:1 (flame feather to flame core) and hard Ni base alloys (Ni-Cr Si-B alloys) proportionally 2:1.

Gas welding flame adjustment.

Celsite (Co-Cr-W-C alloys)



Niborite (Ni-Cr-Si-B alloys)



TIG welding

In the TIG welding process, a burn-off of carbon or other alloying elements doesn‘t occur because of the argon shielding gas. The weld metal composition depends on the composition of the alloy used and the dilution with the base material. To keep the dilution with the base material as low as possible, it is recommended to blunten the tip of the tungsten electrode so that it is not as pointed as usual. This procedure avoids a strongly concentrated arc, which would cause more melting of the base material and lead to a higher dilution with the welding material. During the overlay process the arc has to be turned towards the liquid weld pool and not to the base material so that a lower dilution can be achieved.

The investigations into the mechanism of pore formation have shown that during TIG welding, the main cause lies in the oxygen content. During the welding process, however, the shielding gas (argon) prevents oxygen from reaching the weld pool. If pore formation is still found to take place, then the source of the oxygen must originate from an oxide film (scale) present on the base material and/or with oxidation of the welding rod. Therefore, it is important that the base material is cleaned sufficiently and the welding rod does not leave the shielding gas too early.

If necessary, the base material can be coated with a buffer layer before hard facing.

Quality management

Our metal powders and continuous cast rods are subjected to the most stringent quality control measures. The chemical compositions are determined using modern equipment in our accredited laboratory.

Standard equipment in our laboratories for the determination of powder quality includes, sieve analysis, flow property determination and the determination of apparent and tap densities.

All of the powders produced fulfil at least the minimum property requirements of the norms and specifications.

Apart from the wide range of customer approvals, the Deutsche Edelstahlwerke also boasts approvals from the following independent organisations:

Quality management system – DIN EN ISO 9001:2008

Quality management system – ISO/TS 16949:2009 – Krefeld

Laboratory approval – DIN EN ISO/IEC 17025:2005

Approved welding consumable supplier in accordance with KTA 1408 – Nuclear applications –

Environmental management system – DIN EN ISO 14001:2004

A world wide presence

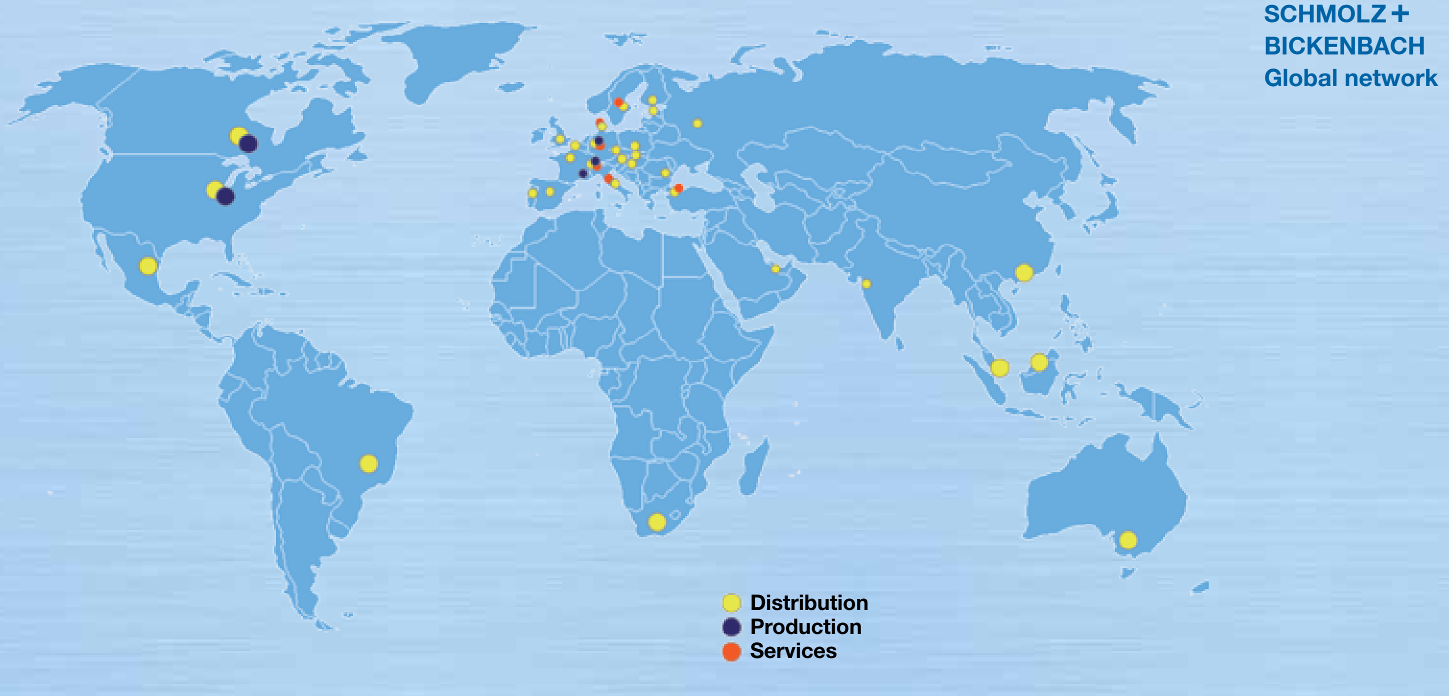
The Deutsche Edelstahlwerke GmbH a company of the world wide present SCHMOLZ + BICKENBACH group. The sales offices are located in all important global regions. The unique company structure and the concept with the three tiers comprising production, service and distribution, qualifies us as a solution and technology provider, especially, however as a reliable and quality conscience partner for our customers around the globe.

Sales and distribution network

As providers of special solutions, know-how and service within the steel industry, we strive to continuously expand and strengthen our global position. The SCHMOLZ + BICKENBACH distribution ensures a close customer presence – all over the world.

Please do not hesitate to contact our competent sales and technical team.

For further information or assistance:
powder@dew-stahl.com



General note (liability)

Information about the quality or usability of materials or products is for descriptive purposes only. Confirmations in relation to the existence of certain characteristics or with reference to a certain application always require a special written agreement. Printing errors, omissions and changes excepted.

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