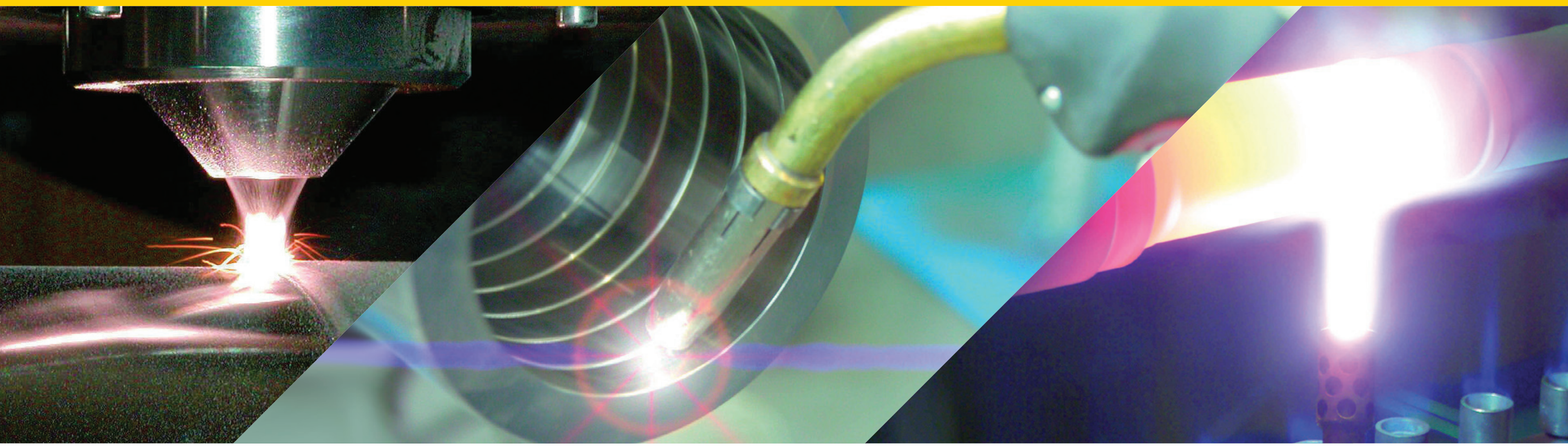
STELLITE ALLOYS



KENNAMETAL™
STELLITE

Stellite Alloys

With over 100 years of proven performance, Kennametal's Stellite™ alloys have become known as the worldwide material solution in wear, heat and corrosion applications. These hardfacing alloys are offered in form of rod, wire, powder, & electrodes and can be tailored to meet individual customer needs.

In addition to welding consumables, Kennametal also offers its expertise

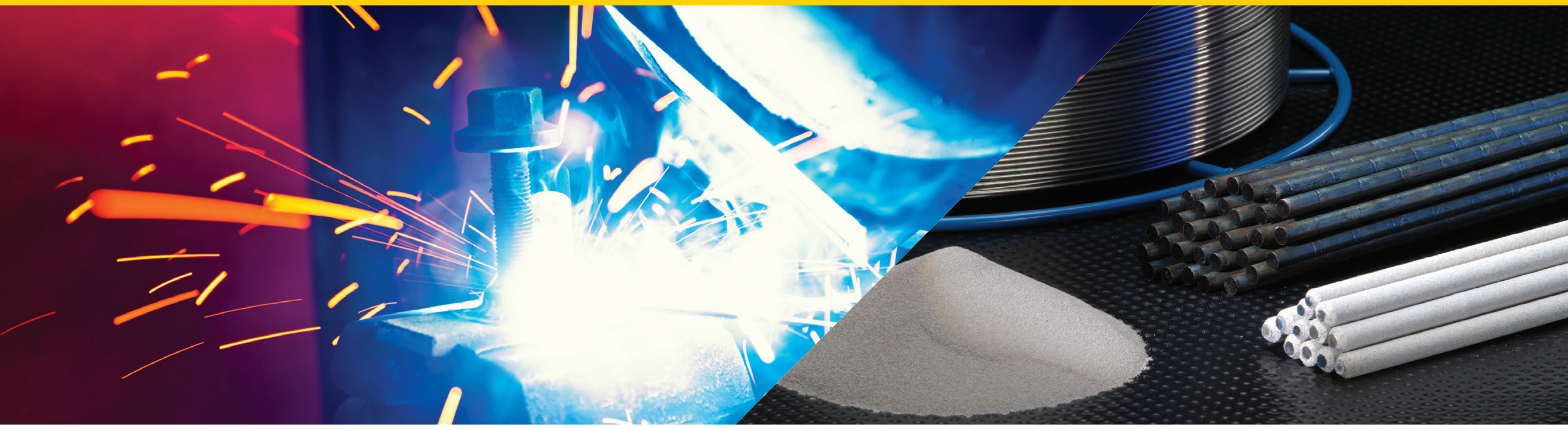
and experience in coating services and technologies such as HVOF, PTA, and spray fuse.

Industries Served

Kennametal utilizes its proven heat, wear, and corrosion experience to create cost effective solutions in some of the most hostile operating environments. As a result, the Stellite™ family of alloys have been become standardized solutions to a broad range of industries, including:

- Aerospace
- Oil & Gas
- Automotive
- Power Generation
- Steel
- Timber
- Glass
- Forging
- Dental
- Food Processing

Table of Contents



The Stellite Family

Stellite™ Alloys

The cobalt-based Stellite™ alloys are our most well-known and successful alloys, with the best "all-round" properties. They combine excellent mechanical wear resistance, especially at high temperatures, with very good corrosion resistance. The Stellite™ alloys are mostly cobalt based with additions of Cr, C, W, and/or Mo. They are resistant to cavitation, corrosion, erosion, abrasion, and galling. The lower carbon alloys are generally recommended for cavitation, sliding wear, or moderate galling. The higher carbon alloys are usually selected for abrasion, severe galling, or low-angle erosion. Stellite™ 6 is our most popular alloy as it provides a good balance of all of these properties. The Stellite™ alloys retain their properties at high temperatures where they also have excellent oxidation resistance. They are typically used in the temperature range 315 – 600° C (600 – 1112° F). They can be finished to exceptional levels of surface finish with a low coefficient of friction to give good sliding wear.

Deloro™ Alloys

The Deloro™ alloys are nickel based with additions of typically Cr, C, B, Fe, and Si. They cover a very wide range of hardness from soft, tough, build-up alloys that are easily machined or hand finished to exceptionally hard, wear-resistant alloys. They can be selected for hardnesses of between 20 and 62 HRC depending on the application. Their low melting point makes these powders ideal for spray/fuse or powder welding applications. The lower hardness Deloro™ alloys are typically used for glass forming molds. The higher hardness Deloro™ alloys are used in severe wear applications, such as rebuilding the flights of feeder screws, and they can be blended with carbides for an even harder deposit. They maintain their properties up to temperatures of about 315° C (600° F) and also offer good oxidation resistance.

Tribaloy™ Alloys

Tribaloy™ alloys, with either nickel or cobalt base, were developed for applications in which extreme wear is combined with high temperatures and corrosive media. Their high molybdenum content accounts for the excellent dry-running properties of Tribaloy™ alloys and makes them very suitable for use in adhesive (metal-to-metal) wear situations. Tribaloy™ alloys can be used up to 800–1000° C (1472–1832° F).

Nistelle™ Alloys

Nistelle™ alloys are designed for corrosion resistance rather than wear resistance, particularly in aggressive chemical environments where their high chromium and molybdenum contents provide excellent pitting resistance. As a class, they are also generally resistant to high-temperature oxidation and hot gas corrosion. Care should be taken to select the correct alloy for any given corrosive environment.

Stelcar™ Alloys

Stelcar™ alloys are mixtures of carbide particles and nickel- or cobalt-based powders. Due to their construction, Stelcar™ materials are available only in powder form, for application by thermal spraying or weld hardfacing.

Jet Kote™ Powders

Jet Kote™ powders feature a variety alloys developed specifically for HVOF operations. These powders are designed to produce well-bonded, high-density coatings through most HVOF systems.

The JetKote™ portfolio includes powders based on the Stellite™ family and an offering of unique carbide-metal (e.g., WC-Co or Cr3Cr2-NiCr) composite powders which provide exceptional wear resistance.

Delcrome™ Alloys

These iron-based alloys were developed to resist abrasive wear at lower temperatures, typically up to 200° C. When compared with our cobalt- and nickel-based alloys, their corrosion resistance is also comparatively low.

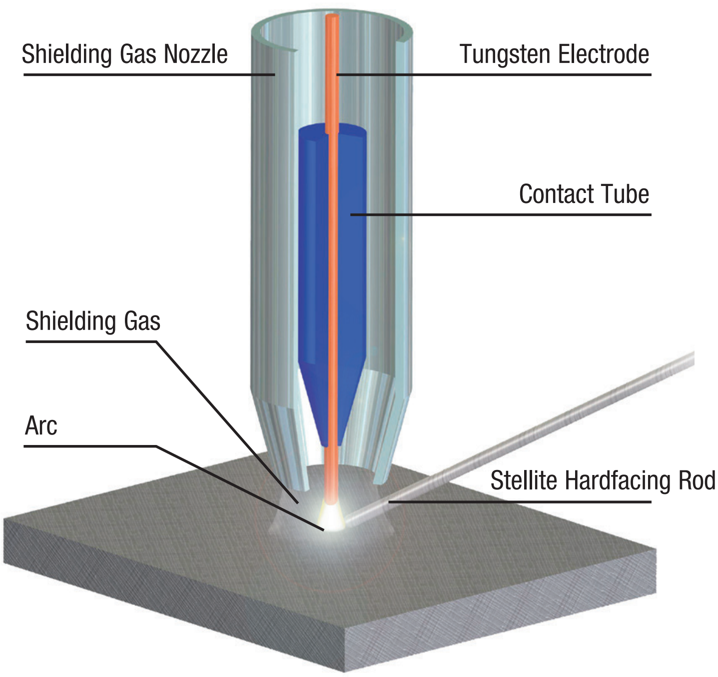
Selection Table

Resistance
■ Low
■ ■ Satisfactory
■ ■ ■ Very Good
■ ■ ■ ■ Excellent

ALLOY	MECHANICAL WEAR	CORROSION	HIGH OPERATING TEMPERATURE
Stellite™	■ ■ ■	■ ■ ■	■ ■ ■ ■
Deloro™	■ ■ ■	■ ■	■ ■
Tribaloy™	■ ■ ■	■ ■ ■	■ ■ ■ ■
Nistelle™	■	■ ■ ■ ■	■ ■ ■
Delcrome™	■ ■ ■	■	■ ■
Stelcar™	■ ■ ■ ■	■ ■	■ ■

TIG and Oxy-Acetylene Welding

In TIG (Tungsten Inert Gas), also known as Gas Tungsten Arc Welding (GTAW), an arc is drawn between a non-consumable tungsten electrode and the workpiece. The electrode, the arc, and the weld-pool are protected from the atmosphere with an inert shielding gas. The hardfacing material is in the form of a rod. Advantages of the TIG process include simple manual operation and good control of the welding arc. The process can also be mechanised, in which case a manipulator is used to move the workpiece in relation to the welding torch and the hardfacing rod or wire.



Welding rods used for TIG welding are also used for hardfacing with the oxy-acetylene welding process. With the correct operation, a very low level of iron dilution can be achieved in the overlay.

Rod is available in these standard diameters:

- 2.4mm
- 3.2mm (1/8")
- 4.0mm (5/32")
- 5.0mm (3/16")
- 6.4mm (1/4")
- 8.0mm (5/16")

Rod inventory held in North America is typically in 36" lengths. Other rod sizes may be available by special request.

Rod is typically packaged in 10kg (22lb) bundles. Other bundling available upon request.

TIG and Oxy-Acetylene Welding

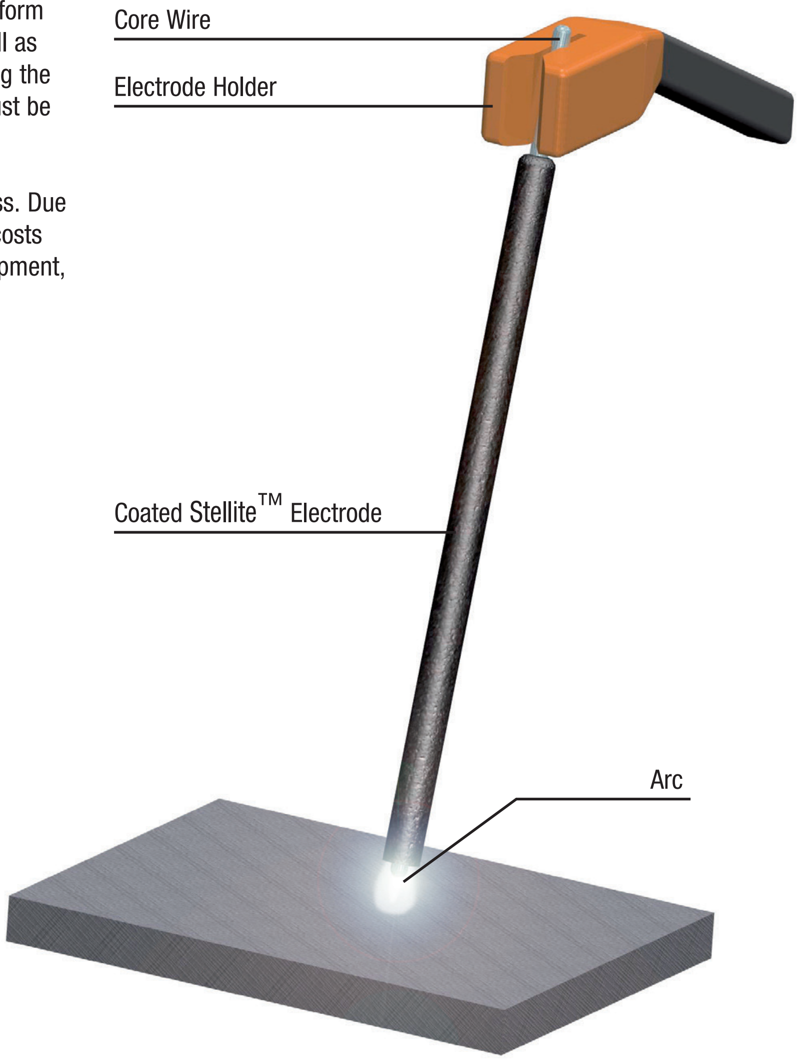
ALLOY	NOMINAL ANALYSIS OF WELDING ROD[1]								Others	UNS	ASME/ AWS[2]	Hardness (HRC)[3]
	Co	Cr	W	C	Ni	Mo	Fe	Si				
COBALT-BASED ALLOY BARE WELDING RODS												
Stellite™ alloy 1	Bal.	32	12	2.45	<3.0	<1.0	<3.0	<2.0	<0.5	R30001	(SF)A 5.21 ERCoCr-C	51–56
Stellite™ alloy 6	Bal.	30	4–5	1.2	<3.0	<1.0	<3.0	<2.0	<0.5	R30006	(SF)A 5.21 ERCoCr-A	40–45
Stellite™ alloy 12	Bal.	30	8	1.55	<3.0	<1.0	<3.0	<2.0	<0.5	R30012	(SF)A 5.21 ERCoCr-B	46–51
Stellite™ alloy 20	Bal.	33	16	2.45	<3.0	<1.0	<3.0	<2.0	<0.5	–	–	53–59
Stellite™ alloy 21	Bal.	28	–	0.25	3	5.2	<3.0	<1.5	<0.5	R30021	(SF)A 5.21 ERCoCr-E	28–40*
Stellite™ alloy 25	Bal.	20	14	0.1	10	<1.0	<3.0	<1.0	<0.5	–	–	20–45*
Stellite™ alloy F	Bal.	26	12	1.7	22	<1.0	<3.0	<2.0	<0.5	R30002	(SF)A 5.21 ERCoCr-F	40–45*
Stellite™ alloy 706	Bal.	31	–	1.2	<3.0	4	<3.0	<1.0	<1.0	–	–	39–44
Stellite™ alloy 712	Bal.	31	–	1.55	<3.0	8	<3.0	<2.0	<1.0	–	–	46–51
ULTIMET™ **	Bal.	26	2	0.06	9	5	3	–	<1.0	R31233	–	28–45*
NICKEL-BASED ALLOY BARE WELDING RODS												
Nistelle™ alloy C	–	17	5	0.1	Bal.	17	6	–	0.3%V	N30002	–	17–27*
Deloro™ alloy 40	–	12	–	0.4	Bal.	–	2–3	2.9	1.6% B	N99644	(SF)A 5.21 ERNiCr-A	36–42
Deloro™ alloy 50	–	12	–	0.5	Bal.	–	3–5	3.5	2.2% B	N99645	(SF)A 5.21 ERNiCr-B	48–55
Deloro™ alloy 55	–	12	–	0.6	Bal.	–	3–5	4.0	2.3% B	–	–	52–57
Deloro™ alloy 60	–	13	–	0.7	Bal.	–	3–5	4.3	3.0% B	N99646	(SF)A 5.21 ERNiCr-C	57–62
INTER-METALLIC LAVES PHASE ALLOY WELDING RODS (TRIBALOY™ ALLOYS)												
Tribaloy™ alloy T-400	Bal.	8.5	–	<0.08	<1.5	28	<1.5	2.5	<1.0	R30400	–	54–58
Tribaloy™ alloy T-400C	Bal.	14	–	<0.08	<1.5	27	<1.5	2.6	<1.0	–	–	54–59
Tribaloy™ alloy T-700 (Ni based)	<1.5	16	–	<0.08	Bal.	32	<1.5	3.4	<1.0	–	–	50–58
Tribaloy™ alloy T-800	Bal.	18	–	<0.08	<1.5	28	<1.5	3.4	<1.0	–	–	55–60
Tribaloy™ alloy T-900	Bal.	18	–	<0.08	16	22	–	2.7	<1.0	–	–	52–57

1 Nominal analysis is a guideline only for standard product. Does not include all incidental elements and may differ depending on the exact specification/standard used when ordering.
2 When written certification to a standard is required, please specify this when ordering. Certain products can also be certified to AMS, SAE, and other standards. Please contact us for more details.
3 Undiluted weld metal.
* Depending upon the degree of work hardening.
**ULTIMET™ is a registered trademark of Haynes International.

Manual Metal Arc (MMA) Weld Deposition

In this process, an arc is drawn between a coated consumable electrode and the workpiece. The metallic core is melted by the arc and is transferred to the weld pool as molten droplets. The electrode coating also melts to form a gas shield around the arc and the weld pool as well as a slag on the surface of the weld pool, thus protecting the cooling weld-pool from the atmosphere. The slag must be removed after each layer.

MMA welding is still a widely used hardfacing process. Due to the low cost of the equipment, the low operating costs of the process, and the ease of transporting the equipment, this flexible process is ideally suited to repair work.



MMA Weld Deposition

ALLOY	NOMINAL ANALYSIS OF UNDILUTED WELD METAL[4]								Others	UNS	ASME/ AWS[5]	Hardness (HRC)[6]
	Co	Cr	W	C	Ni	Mo	Fe	Si				
COBALT-BASED ALLOY ELECTRODES												
Stellite™ alloy 1	Bal.	31	12	2.45	<3.0	<1.0	<3.0	<2.0	<1.0	W73001	(SF)A 5.13 ECoCr-C	51–56
Stellite™ alloy 6	Bal.	29	4	1.2	<3.0	<1.0	<3.0	<2.0	<1.0	W73006	(SF)A 5.13 ECoCr-A	39–43
Stellite™ alloy 12	Bal.	30	8	1.55	<3.0	<1.0	<3.0	<2.0	<1.0	W73012	(SF)A 5.13 ECoCr-B	45–50
Stellite™ alloy 20	Bal.	32	16	2.45	<3.0	<1.0	<3.0	<2.0	<1.0	–	–	53–57
Stellite™ alloy 21	Bal.	28	–	0.25	3	5.5	<3.0	<1.5	<1.0	W73021	(SF)A 5.13 ECoCr-E	28–40*
Stellite™ alloy 25	Bal.	20	14	0.1	10	<1.0	<3.0	<1.0	<1.0	–	–	20–45*
Stellite™ alloy 706	Bal.	30	–	1.2	<3.0	4	<3.0	<1.0	<1.0	–	–	39–44
Stellite™ alloy 712	Bal.	30	–	1.55	<3.0	8	<3.0	<2.0	<1.0	–	–	46–51
ULTIMET™ **	Bal.	26	2	0.06	9	5	3	–	<1.0	–	–	28–45*
NICKEL-BASED ALLOY ELECTRODES												
Nistelle™ alloy C	–	17	5	0.1	Bal.	17	6	–	0.3%V	W80002	–	17–27*

[4] Nominal analysis is a guideline only for standard product. Does not include all incidental elements and may differ depending on the exact specification/standard used when ordering.
[5] When written certification to a standard is required, please specify this when ordering. Certain products can also be certified to AMS, SAE, and other standards. Please contact us for more details.
[6] Undiluted weld metal.

Electrodes are available in these standard diameters:

- 2,6mm (3/32") (special order)
- 3,2mm (1/8")
- 4,0mm (5/32")
- 5,0mm (3/16")
- 6,4mm (1/4")

Electrodes are supplied in lengths of 350mm (14") and are boxed in 5.0 kg (11 lb) boxes.

Depending upon the process parameters, the hardness of the welded deposit can vary from the values provided in the table above.

* Depending upon the degree of cold-working
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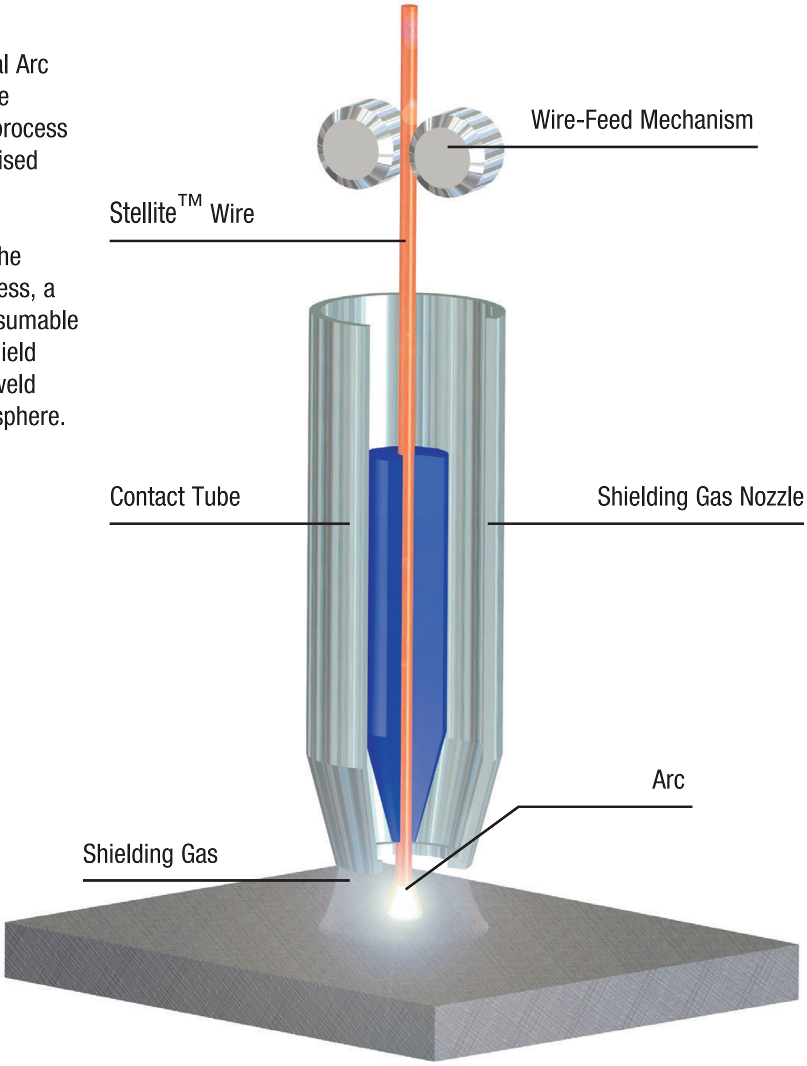
MIG Weld Deposition, Submerged Arc Welding

In these arc welding processes, consumable hardfacing wire is fed continuously from a spool through the welding torch into the arc, where it is melted and transferred to the workpiece.

In the case of MIG welding, also known as Gas Metal Arc Welding (GMAW), the weld pool is protected from the atmosphere by a stream of shielding gas. The MIG process is very flexible — it can be partially or fully mechanised and is suitable for a wide range of applications.

Wire is also used as the hardfacing consumable in the Submerged Arc Welding (SAW) process. In this process, a mineral-based fluxing powder flows around the consumable wire and is melted by the arc. It forms a gaseous shield around the arc and also forms a slag on top of the weld pool, shielding the cooling weld pool from the atmosphere.



MIG Weld Deposition

ALLOY	NOMINAL ANALYSIS OF UNDILUTED WELD METAL[7]								Others	UNS	ASME/ AWS[8]	Hardness (HRC)[9]
	Co	Cr	W	C	Ni	Mo	Fe	Si				
COBALT-BASED ALLOY CORED WIRE												
Stellite™ alloy 1	Bal.	28	11.5	2.45	<3.0	<1.0	<5.0	<2.0	<1.0	W73031	(SF)A 5.21 ERCCoCr-C	50–55
Stellite™ alloy 6	Bal.	30	4.5	1.2	<3.0	<1.0	<5.0	<2.0	<1.0	W73036	(SF)A 5.21 ERCCoCr-A	38–44
Stellite™ alloy 12	Bal.	29	8	1.55	<3.0	<1.0	<5.0	<2.0	<1.0	W73042	(SF)A 5.21 ERCCoCr-B	45–50
Stellite™ alloy 21	Bal.	28	–	0.25	3	5.2	<5.0	<1.5	<1.0	W73041	(SF)A 5.21 ERCCoCr-E	28–40*
Stellite™ alloy 21 LC	Bal.	26	–	0.1	4	6.0	<5.0	<1.5	<1.5	Proprietary crack-resistant alloy specially developed for hardfacing of forging dies		25–40*
Stellite™ alloy 25	Bal.	20	14	0.1	10	<1.0	<3.0	<1.0	<1.0	–	–	20–45*
Stellite™ alloy 706	Bal.	31	–	1.2	<3.0	4	<3.0	<1.0	<1.0	–	–	39–44
Stellite™ alloy 712	Bal.	31	–	1.55	<3.0	8	<3.0	<2.0	<1.0	–	–	46–51
ULTIMET™ **	Bal.	26	2	0.06	9	5	3	–	<1.0	R31233	–	28–45*

7 Nominal analysis is a guideline only for standard product. Does not include all incidental elements and may differ depending on the exact specification/standard used when ordering.
8 When written certification to a standard is required, please specify this when ordering. Certain products can also be certified to AMS, SAE, and other standards. Please contact us for more details.

Electrodes are available in these standard diameters:

- 1,2mm (0.045") — supplied in 15 kg (33 lb) spools
- 1,6mm (0.062") — supplied in 15 kg (33 lb) spools
- 2,4mm (0.093") — supplied in 15 kg (33 lb) or 20kg (44lbs) spools
- 3,2mm (0.126") (special order) — supplied in 15 kg (33 lb) or 20kg (44lbs) spools

Depending upon the process parameters, the hardness of the welded deposit can vary from the values provided in the table above.

* Depending on the degree of_cold working.
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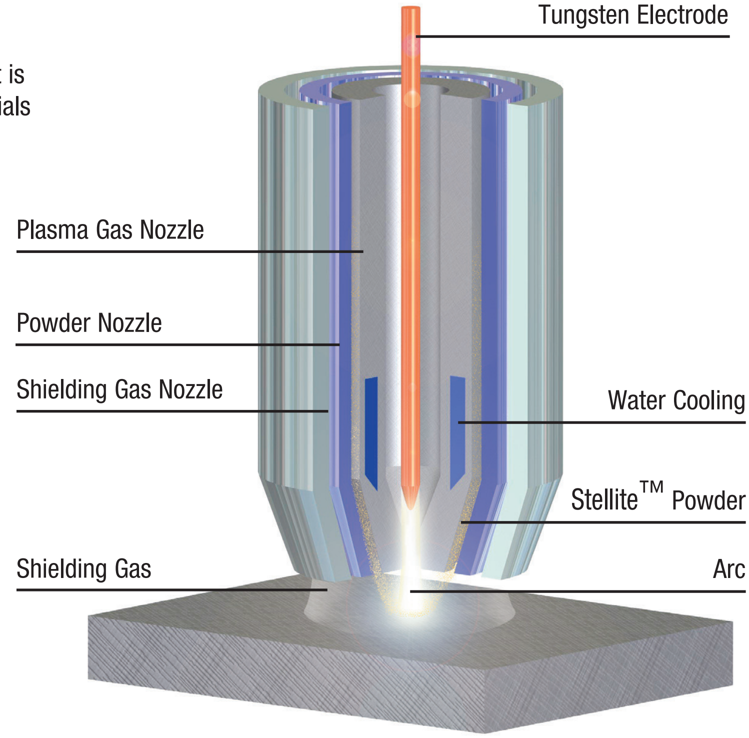
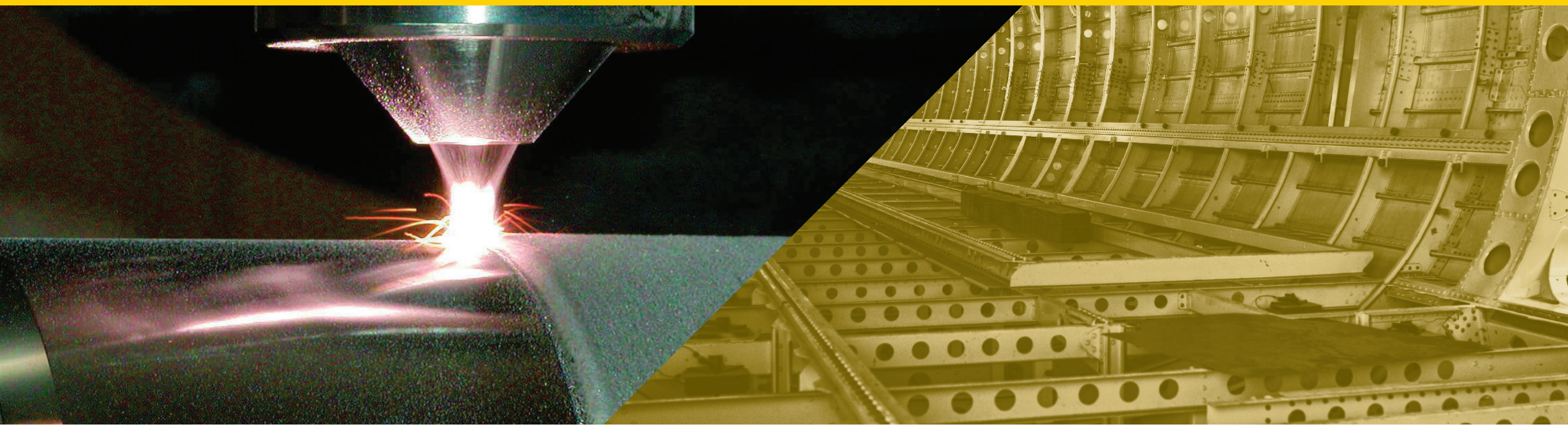
Plasma Transferred Arc (PTA) Weld Deposition

The PTA process is easily automated, providing a high degree of reproducibility of the weld overlays. In addition, because of the highly concentrated heat source, this process benefits from high powder utilization and can achieve a very low level of iron dilution in the overlay.

Because the hardfacing materials are in powder form, it is possible to produce overlays from many different materials and combinations of materials with a wide range of hardness and other properties.



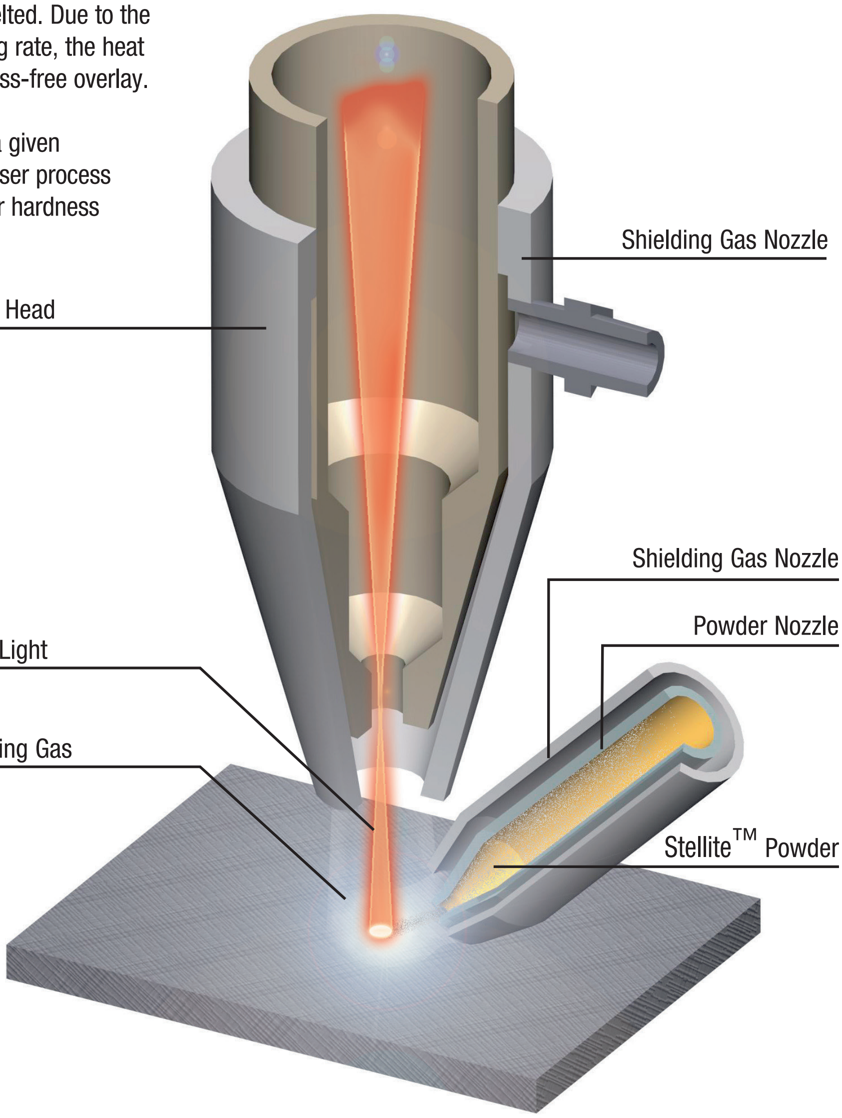
Kennametal manufactures fit-for-purpose PTA equipment packages.
Please see contact information on page 25 for any questions or requests.



Laser Weld Deposition

When overlaying with a laser, an optical arrangement is used to focus the laser beam on the workpiece and heat it. Simultaneously, hardfacing material in the form of powder or wire is introduced into the laser beam and melted. Due to the narrow heat-affected zone and the fast cooling rate, the heat input is low, thereby producing an almost stress-free overlay.

Compared with other welding processes, for a given hardfacing alloy, the fast cooling rate of the laser process produces an overlay with a significantly higher hardness and finer microstructure.



PTA Weld Deposition

ALLOY	NOMINAL ANALYSIS OF POWDER[1]								Others	UNS	Hardness (HRC)[2]
	Co	Cr	W	C	Ni	Mo	Fe	Si			
COBALT-BASED ALLOY (GAS-ATOMIZED POWDERS)											
Stellite™ alloy 1	Bal.	30	13	2.5	<2.0	<1.0	<2.0	<2.0	<1.0	R30001	51–60
Stellite™ alloy 4	Bal.	30	13.5	0.7	<2.5	<1.0	<2.5	<1.0	<1.0	R30404	40–50
Stellite™ alloy 6	Bal.	28.5	4.6	1.2	<2.0	<1.0	<2.0	<2.0	<1.0	R30106	40–46
Stellite™ alloy 6LC	Bal.	29	4.5	1.1	<2.0	<1.0	<2.0	<2.0	<1.0	–	38–44
Stellite™ alloy 6HC	Bal.	28.5	4.6	1.35	<2.0	<1.0	<2.0	<2.0	<1.0	–	43–53
Stellite™ alloy 156	Bal.	28	4	1.7	<2.0	<1.0	<0.5	<2.0	<1.0	–	46–54
Stellite™ alloy 12	Bal.	30	8.5	1.45	<2.0	<1.0	<2.0	<2.0	<1.0	R30012	43–53
Stellite™ alloy 20	Bal.	32.5	17.5	2.55	<2.0	<1.0	<2.0	<1.0	<1.0	–	52–62
Stellite™ alloy 21	Bal.	27.5	–	0.25	2.6	5.4	<2.0	<2.0	<1.0	R30021	27–40 *
Stellite™ alloy 22	Bal.	28	–	0.30	1.5	12	<3.0	<2.0	<0.5	–	41–49 *
Stellite™ alloy 25	Bal.	20	15	0.1	10	<1.0	2	<1.0	1.9%Mn	–	20–45 *
Stellite™ alloy 31	Bal.	26	7.5	0.5	10.5	<1.0	<2.0	<1.0	<0.5	R30031	20–35 *
Stellite™ alloy F[3]	Bal.	26	12.5	1.8	22	<1.0	<2.0	1.1	<0.5	R30002	40–45
Stellite™ alloy 190	Bal.	26	14	3.4	<2.0	<1.0	<2.0	<1.0	<1.0	R30014	55–60
Stellite™ alloy 694	Bal.	28.5	19.5	0.9	5	–	<3.0	<1.0	1%V	–	46–52
Stellite™ alloy 706	Bal.	29	–	1.25	<2.0	4.5	<2.0	<1.0	<1.0	–	39–44
Stellite™ alloy 712	Bal.	29	–	2.0	<2.0	8.5	<2.0	<1.0	<1.0	–	46–53
ULTIMET™ **	Bal.	26	2	0.07	9.4	5	3	<1.0	<1.0	R31233	20–45 *
COBALT-BASED TRIBALOY™ ALLOYS (GAS-ATOMIZED POWDERS)											
Tribaloy™ alloy T-400	Bal.	8.5	–	<0.08	<1.5	29	<1.5	2.8	<1.0	R30400	51–57
Tribaloy™ alloy T-400C	Bal.	14	–	<0.08	<1.5	27	<1.5	2.6	<1.0	–	51–57
Tribaloy™ alloy T-401	Bal.	17	–	0.2	<1.5	22	<1.5	1.3	<1.0	–	45–50
Tribaloy™ alloy T-800	Bal.	17	–	<0.08	<1.5	29	<1.5	3.7	<1.0	–	53–61
Tribaloy™ alloy T-900	Bal.	18	–	<0.08	16	23	<1.5	2.8	<1.0	–	48–55
NICKEL-BASED SUPERALLOYS (GAS-ATOMIZED POWDERS)											
Nistelle™ alloy C	–	17	4.5	0.1	Bal.	17	6	<1.0	0.3%V	–	17–27 *
Nistelle™ alloy C22	<2.0	21.5	3	–	Bal.	13.5	4	–	0.15%V	–	
Nistelle™ alloy C276	–	15.5	3.7	–	Bal.	16	5.5	<1.0	0.15%V	–	
Nistelle™ alloy 305	–	42	–	–	Bal.	–	–	0.5	<1.0%	–	
Nistelle™ alloy 2315	–	20	–	–	Bal.	–	–	<1.0	<1.0%	–	
Nistelle™ alloy 600	–	15.5	–	–	Bal.	–	8	<0.5	<1.0%	N06600	
Nistelle™ alloy 625	–	21.5	–	<1.0	Bal.	9	<1.0	<0.5	3.5% Nb	N06625	
Nistelle™ alloy 718	<2.0	21.5	3	–	Bal.	13.5	4	–	0.15%V	N07718	

[1] Nominal analysis is a guideline only for standard product. Does not include all incidental elements and may differ depending on the exact specification/standard used when ordering.
[2] Undiluted weld metal.
[3] Stellite™ Alloy F usually made to customer specification.
* Depending upon the degree of work hardening.
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Laser Weld Deposition

ALLOY	NOMINAL ANALYSIS OF POWDER[1] Co	Cr	W	C	Ni	Mo	Fe	Si	Others	UNS	Hardness (HRC)[2]
NICKEL-BASED ALLOY (GAS-ATOMIZED POWDERS)											
Deloro™ alloy 22	–	–	–	<0.05	Bal.	–	<1.0	2.5	1.4%B	–	20–22
Deloro™ alloy 30	–	9	–	0.2	Bal.	–	2.3	3.2	1.2%B	–	27–31
Deloro™ alloy 38	–	–	–	0.05	Bal.	–	0.5	3.0	2.1%B	–	35–39
Deloro™ alloy 40	–	7.5	–	0.3	Bal.	–	2.5	3.5	1.7%B	N99644	38–42
Deloro™ alloy 45	–	9	–	0.35	Bal.	–	2.5	3.7	1.9%B	–	44–47
Deloro™ alloy 46	–	–	–	0.05	Bal.	–	–	3.7	1.9%B	–	32–40
Deloro™ alloy 50	–	11	–	0.45	Bal.	–	3.3	3.9	2.3%B	N99645	48–52
Deloro™ alloy 55	–	12	–	0.6	Bal.	–	4.0	4.0	2.7%B	–	52–57
Deloro™ alloy 60	–	15	–	0.7	Bal.	–	4.0	4.4	3.1%B	N99646	57–62
Extrudalloy 50	15	21	–	1.3	Bal.	6	<1.0	3.0	2.3%B	–	–
NICKEL-BASED TRIBALOY® ALLOYS (GAS-ATOMIZED POWDERS)											
Tribaloy™ alloy T-700	<1.5	16	–	0.08	Bal.	32	<1.5	3.4	<1.0	–	45–52
IRON-BASED HARDFACING ALLOYS (GAS-ATOMIZED POWDERS)											
Delcrome™ 90	–	27	–	2.9	–	–	Bal.	<1.0	0.5%Mn	–	Depends on heat treatment
Delcrome™ 92	<0.5	<1.0	–	3.8	<1.0	10	Bal.	<1.0	<1%Mn	–	55–63
Delcrome™ 253	<0.5	28	–	1.9	16.5	4.5	Bal.	1.3	0.8%Mn	–	
Delcrome™ 316	<0.5	17	–	0.05	11	2.6	Bal.	2.5	0.4%Mn	–	<180 DPH
Delcrome™ 316L Delcrome™ 317	<0.5	18	–	<0.03	13	2.6	Bal.	1.8	0.7%Mn	–	<180 DPH
Delcrome™ 6272	<0.5	25	–	2.5	14	7	Bal.	1.8	<1.0%	–	
CARBIDES IN A CORROSION-RESISTANT HARD ALLOY MATRIX											
Super Stelcar™ alloy 9365	WC in an alloy matrix										
Super Stelcar™ alloy 50 plus	WC in a Deloro™ 50 alloy matrix										
Super Stelcar™ alloy 60 plus	WC in a Deloro™ 60 alloy matrix										

[1] Nominal analysis is a guideline only for standard product. Does not include all incidental elements and may differ depending on the exact specifications/standard used when ordering.
[2] Undiluted weld metal.

PTA and laser hardfacing powders are available in these standard powder particle size ranges and custom sizes upon request.

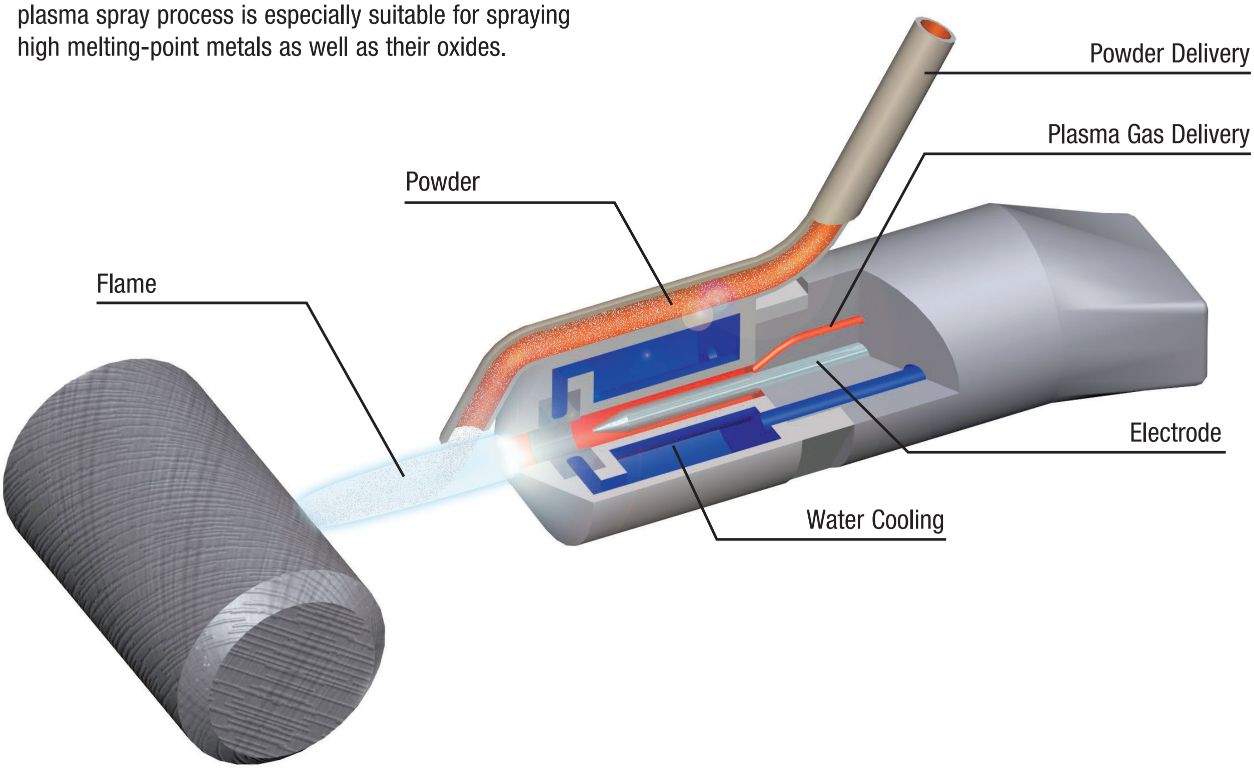
Depending upon the process parameters and extent of dilution, the hardness of the weld deposit may vary from that provided in the above table.

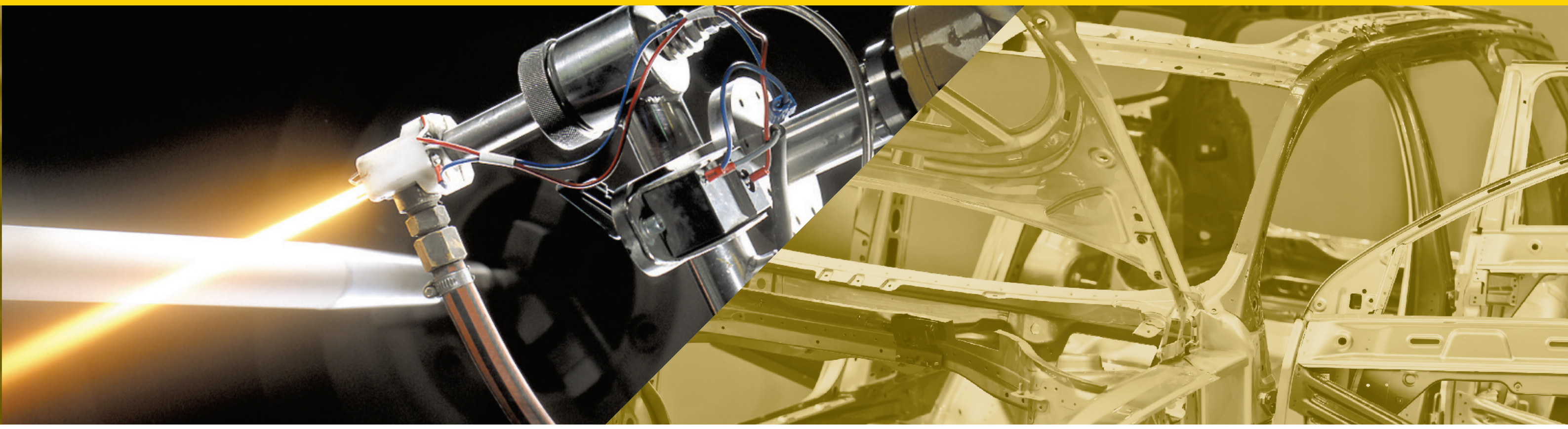
Plasma Spraying

In the Plasma Spraying process, powder is softened or melted in the plasma gas stream, which also transfers the particles to the workpiece.

The plasma arc is not transferred to the workpiece, it is contained within the plasma torch between an axial electrode and a water-cooled nozzle. The process is operated in normal atmosphere, in a shielding gas stream (e.g., argon), in a vacuum, or under water.

Due to the high temperature of the plasma gas stream, the plasma spray process is especially suitable for spraying high melting-point metals as well as their oxides.

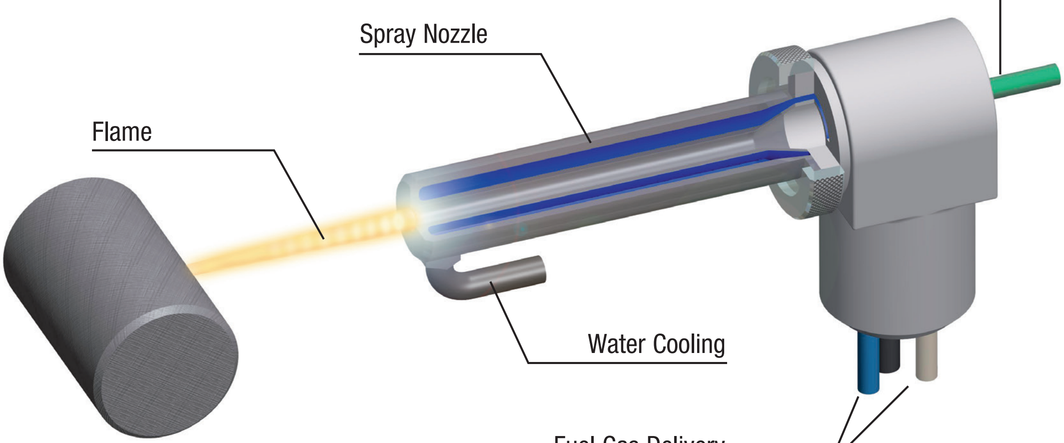


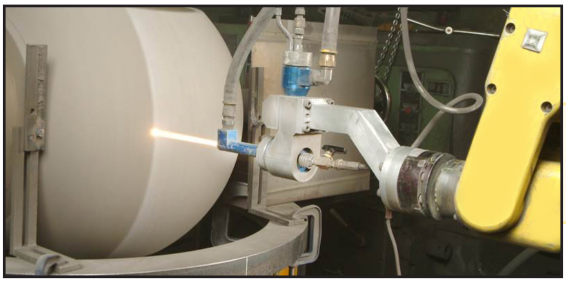


High-Velocity Oxy-Fuel Spray (HVOF)

In the HVOF process, powder is introduced axially into a chamber in which a gas flame is constantly burning under high pressure. The exhaust gas exits through an expansion nozzle which produces a high-velocity gas stream. The powder particles are heated in this gas stream and transferred by it with high kinetic energy to the surface of the workpiece, forming a dense coating with excellent bonding properties.

Due to the moderate transfer of heat to the powder particles and to the workpiece, which remains relatively cool, there is little metallurgical change to the sprayed material and the workpiece.





Kennametal manufactures fit-for-purpose Jet Kote™ HVOF equipment packages. Please see contact information on page 25 for any questions or requests.

Tungsten Carbide HVOF Powders

PRODUCT	POWDER TYPE	NOMINAL COMPOSITION (mass %)					HARDNESS (depends on deposition method & parameters)	Nominal size (µm) and manufacturing method
		Co	Ni	Cr	W	C		
JK™ 112H	WC-12Co with fine carbides	12	–	–	Bal.	5.5	1140–1296 DPH 92.7–94.6 R15N	53/10 Agglomerated, sintered & densified.
JK™ 112P / JK™ 7112	WC-12Co with fine carbides	12	–	–	Bal.	5.5	960–1150 DPH 89–93 R15N (equiv. to HRC: ~67–71)	45/10 Agglomerated, sintered & densified.
JK™ 114 / JK™ 7114	WC-12Co with coarse carbides	12	–	–	Bal.	4	1000–1150 DPH 87–94 R15N (equiv. to HRC: ~68–71)	45/10 Agglomerated, sintered & crushed.
JK™ 117 / JK™ 7117	WC-17Co with intermediate carbides	17	–	–	Bal.	5.2	960–1240 DPH 90–95 R15N (equiv. to HRC: ~67–72)	53/15 Agglomerated & sintered.
JK™ 119	WC-9Co with coarse carbides	9	–	–	Bal.	4.2	860–1170 DPH 89–94 R15N (equiv. to HRC: ~65–71)	45/5 Sintered & crushed, blocky.
JK™ 120H / JK™ 7109	WC-10Co-4Cr	10	–	4	Bal.	5.4	1160–1370 DPH 93–95 R15N (equiv. to HRC: ~71–73)	45/5 Agglomerated, sintered & densified.
JK™ 120P / JK™ 7109	WC-10Co-4Cr	10	–	4	Bal.	5.4	825–1030 DPH 89–91 R15N (equiv. to HRC: ~65–71)	53/10 Agglomerated, sintered & densified.
JK™ 125 / JK™ 7178	A mixed carbide with nickel 70%(W, Cr)xCy 25%WC 6%Ni	–	6	20	Bal.	5	900–1100 DPH 89–92 R15N (equiv. to HRC: ~66–70)	53/10 Agglomerated sintered & densified.
JK™ 6189	WC 10Ni with large carbides	–	10	–	Bal.	3.7	Not available	53/10 Sintered & crushed.

Chromium Carbide HVOF Powders

PRODUCT	POWDER TYPE	NOMINAL COMPOSITION (mass %)			HARDNESS (depends on deposition method & parameters)	Nominal size (µm) and manufacturing method
		Ni	Cr	C		
JK™ 135 / JK™ 7184	75% Cr_3C_2 25% NiCr	20	Bal.	9.7	610–910 DPH 87.5–91.5 R15N (equiv. to HRC: ~58–65) (varies srongly depending on spray parameters)	53/10 Agglomerated, sintered & densified.

Gas-Atomized Stellite™ Cobalt-Based HVOF & Plasma Spray Powders

PRODUCT	STELLITE™ ALLOY NO.	NOMINAL COMPOSITION (mass %)							HARDNESS (depends on deposition method & parameters)	Nominal size (µm)
		Co	Ni	Cr	W	Mo	C	Others		
JK™ 571 / JK™ 7221	21	Bal.	2.5	28	–	5.5	0.25	Si 2	400–520 DPH 80.5–84.5 R15N (equiv. to HRC: ~40–50)	53/10
JK™ 572 / JK™ 7212	12	Bal.	–	29.5	8	–	1.4	Si 1.5	680–675 DPH 88.1–89.5 R15N	53/10
JK™ 573 / JK™ 7231	31	Bal.	10.5	25.5	7.5	–	0.5	–	32 HRC	45/10
JK™ 575 / JK™ 7201	1	Bal.	–	30	12	–	2.5	–	Not available	53/10
JK™ 576 / JK™ 7206	6	Bal.	–	28	4.5	–	1.1	Si 1.1	495–580 DPH 81.5–86.5 R15N (equiv. to HRC: ~43–54)	53/10
JK™ 577	SF6	Bal.	14.5	19	7.5	–	0.7	Si 2.5 B 1.6	635–790 DPH (505-525 when fused) ~ 85.5 R15N (equiv. to HRC: ~50–51)	53/10
JK™ 579 / JK™ 7225	25	Bal.	10	20	15	1	0.1	Si 1 Mn 1.5	450–490 DPH 82–85.5 R15N (equiv. to HRC: ~43–50) (varies strongly depending on spray parameters)	53/10

Gas-Atomized Tribaloy™ Cobalt-Based HVOF & Plasma Spray Powders

PRODUCT	TRIBALOY™ ALLOY NO.	NOMINAL COMPOSITION (mass %)							HARDNESS (depends on deposition method & parameters)	Nominal size (µm)
		Co	Ni	Cr	W	Mo	C	Others		
JK™ 554 / JK™ 7560	T-400	Bal.	–	8.5	–	29	<0.08	Si 2.6	450–600 DPH 86–87.5 R15N (equiv. to HRC: ~52–55)	53/10
JK™ 558H Typically used with hydrogen fuel	T-800	Bal.	–	18	–	28	<0.08	Si 3.4	670–780 DPH 89–92 R15N (equiv. to HRC: ~58–64)	45/5
JK™ 558P / JK™ 7580 Typically used with carbon fuel	T-800	Bal.	–	18	–	28	<0.08	Si 3.4	455–620 DPH 83.5–88.5 R15N (equiv. to HRC: ~46–56)	53/10
JK™ 559H (Special order)	T-900	Bal.	16	18	–	23	<0.08	Si 2.7	~ 700 DPH	45/5
JK™ 559P (Special order)	T-900	Bal.	16	18	–	23	<0.08	Si 2.7	~ 500 DPH	53/10
ULTIMET™ for JK™ and Plasma Spray	ULTIMET™	Bal.	9	26	2	5	0.06	Si 0.3	~ 500 DPH	53/20

*ULTIMET™ is a registered trademark of Haynes International.

Gas-Atomized Nickel-Based HVOF & Plasma Spray Powders

PRODUCT	ALLOY NAME	NOMINAL COMPOSITION (mass %)							HARDNESS (depends on deposition method & parameters)	Nominal size (µm)
		Ni	Fe	Cr	W	Mo	C	Others		
JK™ 347	Nistelle™ 2347	Bal.	–	–	–	5	–	Al 6	332–336 DPH 75.3–78.1 R15N	63/15
JK™ 350 / JK™ 7301	Nistelle™ 2350	Bal.	–	–	–	–	–	Al 5	285–335 DPH 71–76 R15N	63/15
JK™ 557 / JK™ 7570	Tribaloy™ T-700	Bal.	–	15.5	–	32.5	<0.08	Si 3.4	~ 700 DPH	45/10
JK™ 584 / JK™ 7640	Deloro™ 40	Bal.	2.5	7.5	–	–	0.25	Si 3.5 B 1.7	~ 40 HRC	53/10
JK™ 585 / JK™ 7650	Deloro™ 50	Bal.	2.9	11	–	–	0.45	Si 4 B 2.3	~ 50 HRC	53/10
JK™ 586 / JK™ 7660	Deloro™ 60	Bal.	4	15	–	–	0.7	Si 4.4 B 3.1	~ 60 HRC	53/10
JK™ 591H	Nistelle™ C	Bal.	5.5	16.5	4.5	17	–	–	400–440 DPH ~ 83 R15N (equiv. to HRC: ~44-45)	45/5
JK™ 591P / JK™ 7391	Nistelle™ C	Bal.	5.5	16.5	4.5	17	–	–	375–390 DPH ~ 80 R15N (equiv. to HRC: ~39-41)	63/15
Nistelle™ Super C (Jet Kote™)	Nistelle™ "Super C"	Bal.	–	23	–	18	–	–	410 DPH (equiv. to HRC: ~ 41)	P: 53/15 H: 45/10
JK™ 594 / JK™ 7392	Nistelle™ C-4C	Bal.	–	16	–	16.5	–	–	380–440 DPH ~ 81–83 R15N (equiv. to HRC: ~40-44)	53/15
JK™ 625 / JK™ 7342	Nistelle™ 625	Bal.	<5	21.5	–	9	–	(Nb+Ta) 3.7	385–460 DPH ~ 79–83 R15N (equiv. to HRC: ~37-46)	53/20
JK™ 718 / JK™ 7341	Nistelle™ 718	Bal.	18	19	–	3	0.06	(Nb+Ta) 5 Al 0.5, Ti 1	275–470 DPH 72.5–81.5 R15N (equiv. to HRC: ~25-45)	45/15

Gas-Atomized Iron-Based HVOF Powders

PRODUCT	POWDER TYPE	NOMINAL COMPOSITION (mass %)						HARDNESS (depends on deposition method & parameters)	Nominal size (µm)
		Co	Ni	Fe	Cr	C	Others		
JK™ 513 (Also sold as JK™ 7330)	316 Stainless Steel	–	13	Bal.	17	0.1	Mo 2.5 Si 1	260–315 DPH 69–75 R15N	53/10

Cobalt Based Plasma Spray Powders

PRODUCT	POWDER TYPE	NOMINAL COMPOSITION (mass %)							HARDNESS (depends on deposition method & parameters)	Nominal size (µm)
		Co	Ni	Cr	W	Mo	C	Others		
Stellite™ 157	–	Bal.	–	21	4.5	–	<0.2	B 2.4 Si 1.5	Not available	45/5
Tribaloy™ T-400 (Not Available)	T-400	Bal.	–	8.5	–	29	<0.08	Si 2.6	52 HRC	45/5
Tribaloy™ T-900 (Not Available)	T-900	Bal.	16	18	–	23	<0.08	Si2.7	52 HRC	75/D 53/10

Nickel-Based Plasma Spray Powders

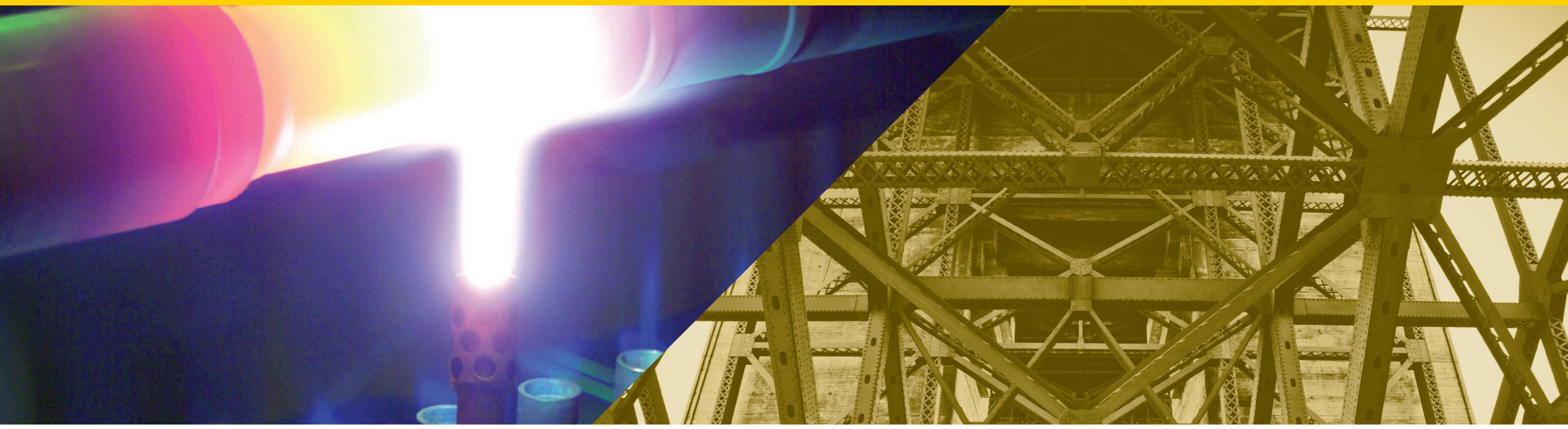
PRODUCT	ALLOY NAME	NOMINAL COMPOSITION (mass %)							HARDNESS (depends on deposition method & parameters)	Nominal size (µm)
		Ni	Fe	Cr	W	Mo	C	Others		
Deloro™ 55	Deloro™ 55	Bal.	4	12	–	–	0.6	Si 4.0 B 2.7	52-57 HRC	Various
Deloro™ 60	Deloro™ 60	Bal.	4	15	–	–	0.7	Si 4.4 B 3.1	58-62 HRC	Various
Nistelle™ C276	Nistelle™ C276	Bal.	5	15.5	3.8	16	–	–	Not Available	106/D 45/5
Nistelle™ 625	Nistelle™ 625	Bal.	<5	21.5	–	9	–	(Nb+Ta) 3.7	385-460 DPH 79-83 R15N (equiv. to HRC: ~37-46)	Various
Nistelle™ 2315	Nistelle™ 2315	Bal.	–	20	–	–	–	–	Not Available	106/D 75/45 45/5
Nistelle™ 2350	Nistelle™ 2350	Bal.	–	–	–	–	–	Al 5	~ 70 HRB	75/45

Gas-Atomized Iron-Based Plasma Spray Powders

PRODUCT	ALLOY NAME	NOMINAL COMPOSITION (mass %)						HARDNESS (depends on deposition method & parameters)	Nominal size (µm)
		Co	Ni	Fe	Cr	C	Others		
Delcrome™ 90	Delcrome™ 90	–	–	Bal.	27	2.8	Si 0.5	Not Available	53/10
Delcrome™ 92	Delcrome™ 92	–	–	Bal.	–	3.7	Mo 10	Not Available	45/D
Delcrome™ 316L/317	316L Stainless Steel	–	13	Bal.	17	0.03	Mo 2.5 Si 1	~ 180 DPH	106/38 106/D 45/5
Tristelle™ TS-3	Tristelle™ TS-3	12	10	Bal.	35	3	Si 5	>55 HRC	45/5

Powders labelled "JK" are intended primarily for HVOF spraying with the Jet Kote™ or Diamond Jet™ torches but can also be used for plasma spraying. Some of these powders may be listed below in different nominal size ranges for other thermal spray processes.

*Diamond Jet™ is a registered trademark of Sulzer Metco.



Flame Spraying with Subsequent Fusing (Spray and Fuse)

Spray and fuse is a two-stage process, the powder alloy being deposited first by flame spraying and then fused. During fusing, the deposit is partially remelted and allowed to resolidify.

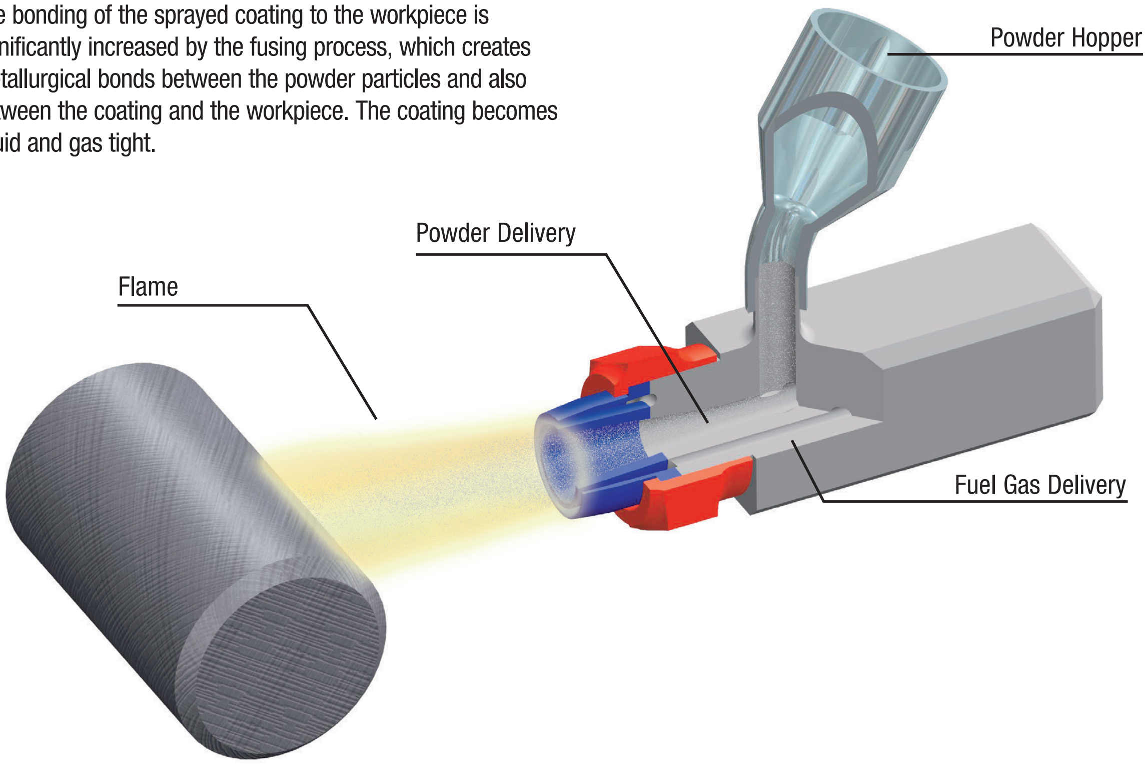
In flame-spraying, the powder particles are softened or melted in an oxyacetylene flame and transferred to a prepared workpiece by the expanding gases. An additional gas stream can be used to assist with powder particle transfer.

The second stage of the process, fusing the sprayed coating to the workpiece, is usually done with an oxyacetylene burner. Alternatively, for mass production, fusing can be carried out by induction heating or in a vacuum furnace.

The bonding of the sprayed coating to the workpiece is significantly increased by the fusing process, which creates metallurgical bonds between the powder particles and also between the coating and the workpiece. The coating becomes liquid and gas tight.

This process is used for the deposition of relatively thin (0.010" to 0.060" or 0,25 to 1,5 mm) layers, usually on the surface of small cylindrical objects such as pump shafts, packing gland sleeves and pistons, as an alternative to the greater deposit thickness obtained from oxy-acetylene and arc processes. The process can also be used for the facing of flat surfaces, but its possibilities for this type of work are limited.

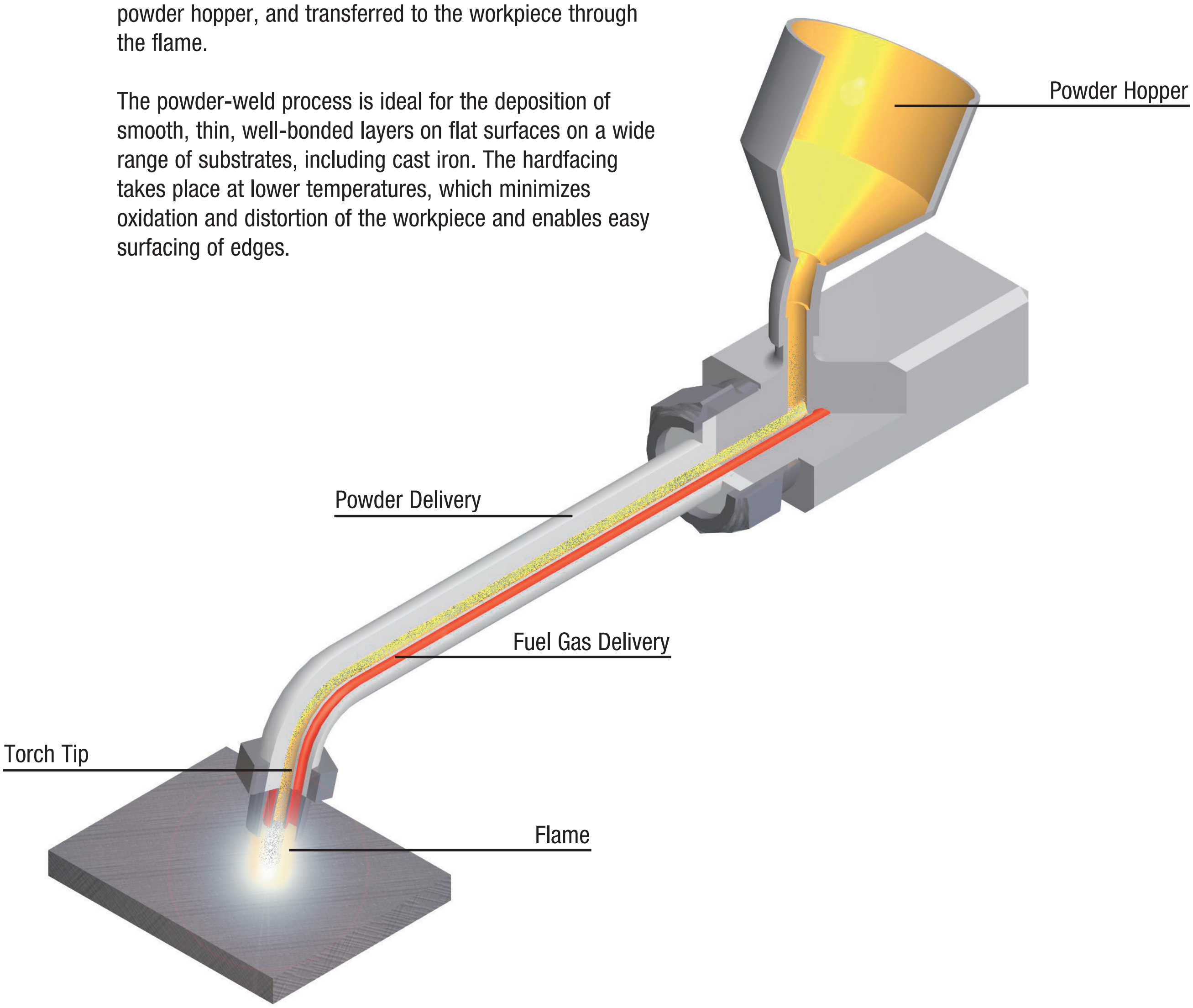
Since the deposit is thinner and more uniform than that obtained by other welding methods and the heat for fusion is applied uniformly and rapidly, shrinkage and distortion of the component is frequently very small. When the fusing operation is carried out correctly, dilution of the deposit by the base metal is negligible.



Powder Welding

A specially-designed oxy-acetylene torch is used for powder welding. The workpiece is heated with the torch, powder is introduced into the gas stream from the integral powder hopper, and transferred to the workpiece through the flame.

The powder-weld process is ideal for the deposition of smooth, thin, well-bonded layers on flat surfaces on a wide range of substrates, including cast iron. The hardfacing takes place at lower temperatures, which minimizes oxidation and distortion of the workpiece and enables easy surfacing of edges.



Spray and Fuse & Powder Welding

ALLOY	NOMINAL ANALYSIS OF WELDING ROD[1]								Others	Hardness (HRC)[2]
	Co	Cr	W	C	Ni	B	Fe	Si		
COBALT-BASED ALLOYS (GAS-ATOMIZED POWDERS)										
Stellite™ alloy SF1	Bal.	19	13	1.3	13.5	2.45	3	2.8	<0.5%Mn	50–60
Stellite™ alloy SF6	Bal.	19	7.5	0.8	14	1.7	3	2.6	<0.5%Mn	40–48
Stellite™ alloy SF12	Bal.	19	9	1.1	14	1.9	3	2.8	<0.5%Mn	42–52
Stellite™ alloy SF20	Bal.	19	15	1.6	14	2.9	3	3.2	<0.5%Mn	55–65
Stellite™ alloy 157	Bal.	21	4.5	0.1	<2.0	2.5	<2	1.6	<0.5%Mn	45–55
NICKEL-BASED ALLOYS (GAS-ATOMIZED POWDERS)										
Deloro™ alloy 15	–	–	–	<0.05	Bal.	1.1	0.5	2.0	20%Cu	180–230 DPH
Deloro™ alloy 21	–	3	–	<0.05	Bal.	0.8	<0.5	2.1	2.2%	240–280 DPH
Deloro™ alloy 22	–	–	–	<0.05	Bal.	1.4	<1.0	2.5	–	18–24
Deloro™ alloy 25	–	–	–	<0.06	Bal.	1.7	<1.0	2.7	–	22–28
Deloro™ alloy 29	–	3	–	<0.05	Bal.	0.9	<0.5	2.2	2.2%	27–30
Deloro™ alloy 30	–	9	–	0.2	Bal.	1.2	2.3	3.2	–	29–39
Deloro™ alloy 34	–	4.5	–	0.15	Bal.	1.2	0.3	2.8	2.5%Mo 2.2% Other	33–37
Deloro™ alloy 35	–	4	–	0.4	Bal.	1.6	1.5	3.4	–	32–42
Deloro™ alloy 36	–	7	–	0.3	Bal.	1.2	3	3.7	–	34–42
Deloro™ alloy 38	–	–	–	0.05	Bal.	2.1	0.5	3.0	–	35–42
Deloro™ alloy 40	–	7.5	–	0.3	Bal.	1.7	2.5	3.5	–	38–45
Deloro™ alloy 45	–	9	–	0.35	Bal.	1.9	2.5	3.7	–	42–50
Deloro™ alloy 50	–	11	–	0.45	Bal.	2.3	3.3	3.9	–	47–53
Deloro™ alloy 55	–	12	–	0.6	Bal.	2.7	4.0	4.0	–	52–60
Deloro™ alloy 60	–	15	–	0.7	Bal.	3.1	4.0	4.4	–	57–65
Deloro™ alloy 75	–	17	–	0.9	Bal.	3.5	4.5	4.5	2%Cu 3%Mo	53–63
Deloro™ alloy 6116	–	15.3	–	0.03	Bal.	4.0	–	–	–	–

Depending upon the process parameters and extent of dilution, the hardness of the weld deposit may vary from that provided in the above table.

PRODUCTIVE
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OUR MISSION

Kennametal delivers productivity to customers seeking peak performance in demanding environments by providing innovative customized and standard wear-resistant solutions, enabled through our advanced materials sciences, application knowledge, and commitment to a sustainable environment.

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STELLITE ALLOYS

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