Welding Alloys

STELLOY Cobalt Cored Wires

Cobalt based superalloys for cladding and hardfacing

For Welding **Professionals**

Contents

Our company

Welding Alloys has been a global leader in the production of advanced welding consumables for more than 50 years. We formulate new fit-for-purpose welding consumables and produce wires tailored to suit more advanced welding processes, such as laser, arc spraying and additive manufacturing. We provide innovative wear protection solutions for even the most challenging service conditions in a range of industries.

Complementary to our welding consumables, we manufacture a range of automated equipment for hardfacing, joining and cladding. We also offer engineered wear solutions, Integra™ services, in our workshops, or in situ, as well as a wide range of wear plates, pipes and components. Since 1966, the Welding Alloys name has been synonymous with excellence in research and development (R&D), resulting in a steady stream of innovative products and advanced technical solutions and services.

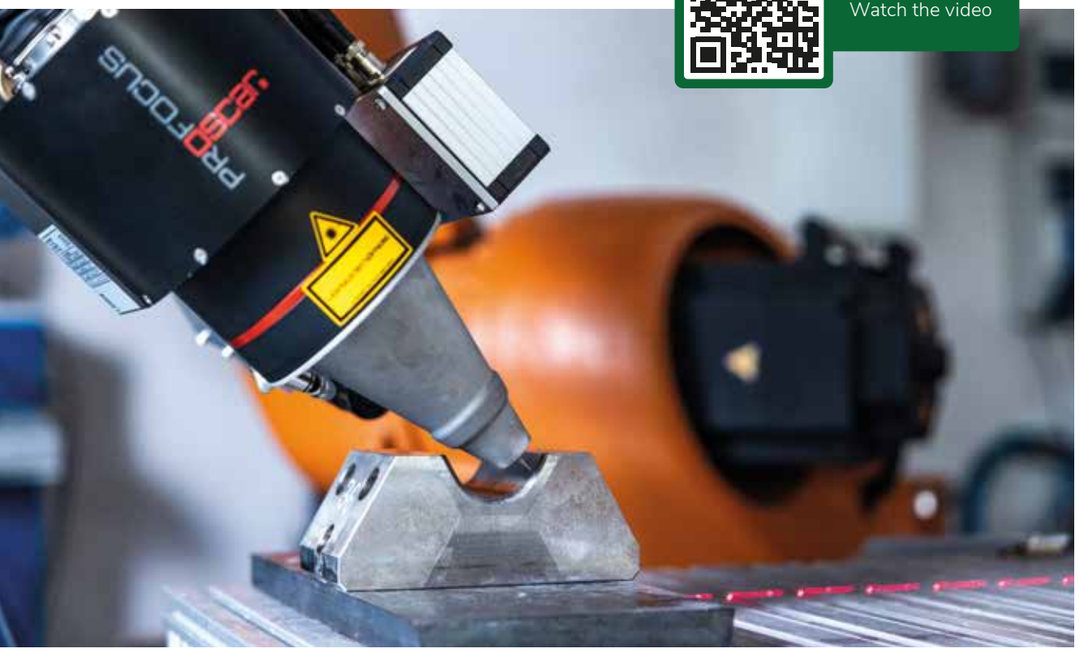
Welding Alloys is a participating member of the United Nations Global Compact and supports all principles relating to the environment, labour, human rights, and anti-corruption. Reflecting this, we have developed welding wires that emit less harmful fumes, and we manufacture a range of our wires using processes that produce less harmful waste for the environment. We continue to improve our products and processes in order to reduce the negative impact on both the welder and the environment.

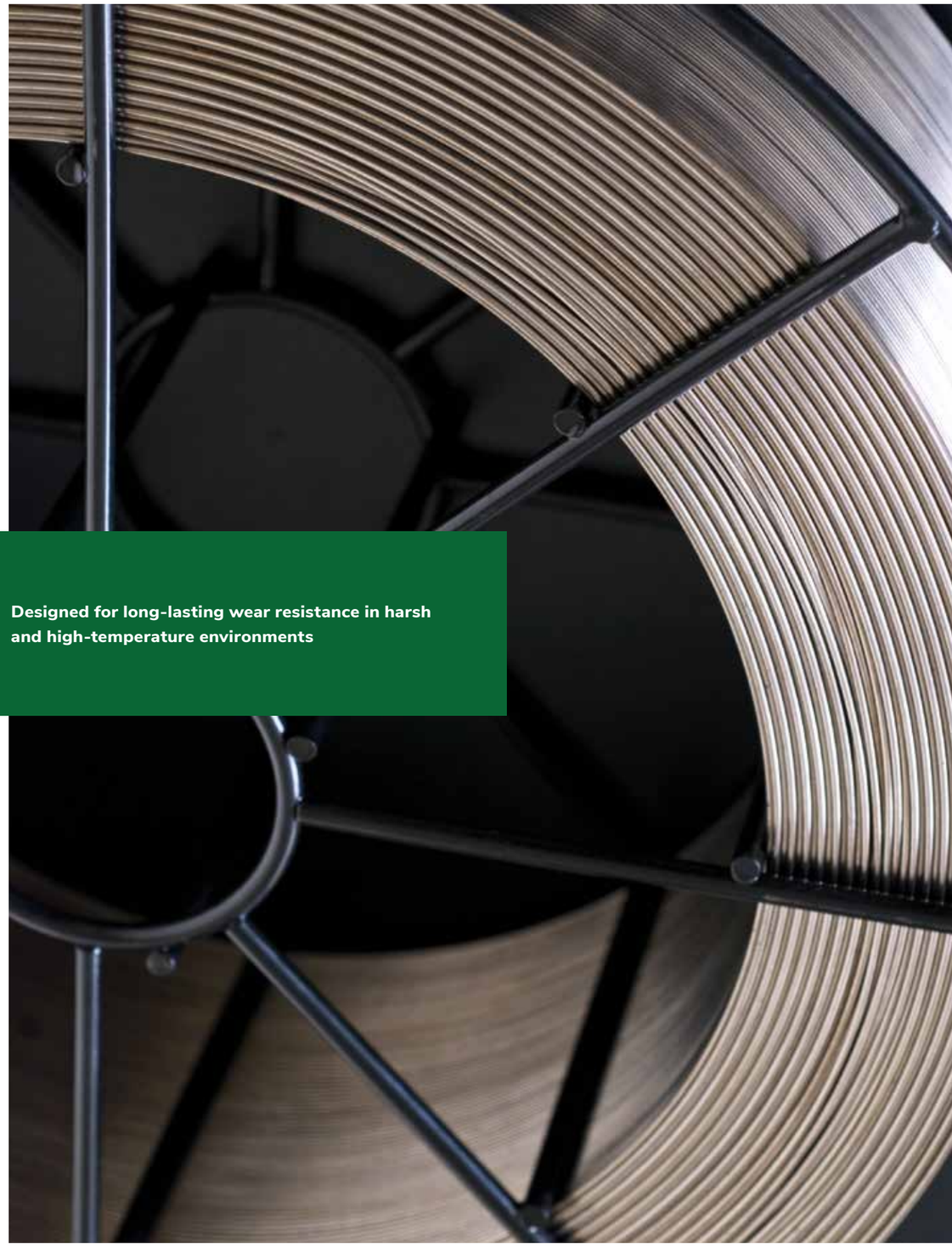
Grades and processes

STELLOY metal cored wires are engineered for exceptionally clean, high-quality weld deposits, regardless of the welding process. Our range includes grades, 1, 6, 12, 21 and 25, and our wires are designed for different welding processes, including gas metal arc welding (GMAW), automatic gas tungsten arc welding (GTAW) and laser, ensuring versatility across applications. Their advanced formulation ensures a virtually slag-free deposit with minimal silicate residue, reducing interpass cleaning and allowing for easy multi-layer welding. This improves productivity and efficiency in critical applications.

STELLOY wires provide superior arc stability, enhanced deposition rates, and optimised fusion characteristics, resulting in high-integrity welds with excellent properties, reduced porosity, and minimal post-weld finishing. These qualities make our range of cobalt based consumables the preferred choice for industries requiring precision, durability, and efficiency.

Watch the video





Designed for long-lasting wear resistance in harsh and high-temperature environments

Cobalt based alloys selection guide

Product	Composition [%] - Co balance							Hardness -3 layers		All weld metal hardness				
	C	Mn	Si	Cr	W	Fe	Others	HRC as welded	HRC work hardened	HB at 20°C	HB at 200°C	HB at 400°C	HB at 600°C	HB at 800°C
STELLOY 25	0.15	1.5	1	20	14	4	Ni: 9.5	21	38 - 42	210 - 260	180	145	130	120
STELLOY 21	0.35	1	1	28		3	Ni: 3.2 Mo: 5.5	33	45 - 48	300 - 340	280	255	235	220
STELLOY 6 BC	0.9	1	1.2	29	5	3.5	Ni: < 3	36 - 40		350 - 380				
STELLOY 6	1.1	1	1.2	29	5	3.5	Ni: < 3	40 - 44		380 - 415	370	320	255	240
STELLOY 6 HC	1.2	1	1.2	29	5	3.5	Ni: < 3	42 - 46		410 - 430				
STELLOY 12	1.5	1	1	30	7.5	3.5	Ni: < 3	44 - 48		415 - 455	410	370	315	275
STELLOY 1	2.4	1	1.2	28.5	12.5	3.5	Ni: < 3	52 - 55		495 - 560	465	420	370	330

The technical datasheets for these products are available on our website. The safety datasheets are also available on request.

Product	Welding process	Standard diameters [mm]	AWS A5.21	Metal-to-metal friction	Mineral abrasion	Abrasion under pressure	Hot abrasion	Erosion	Cavitation	Impact	Mechanical fatigue	Thermal fatigue	Hot oxidation	Corrosion	Cutting	Work hardening	Machining	Description and applications
STELLOY 25	-G	1.2 - 1.6	-	◆					◆	◆◆	◆◆	◆◆	◆◆	◆◆		◆	◆◆	Low carbon cobalt base. Easy to apply due to its low cracking tendency. Highly resistant to temperature and metal-to-metal wear. Maintains a good level of hardness at high temperatures. **Applications:** extrusion dies, nozzles, pump shafts.
STELLOY 21	-G -TIG -LD	1.2 - 1.6	ERCCoCr-E	◆◆					◆◆	◆◆	◆	◆◆	◆◆	◆◆	◆◆	◆	◆◆	Low carbon cobalt base. Low cracking tendency. Ideal choice for resistance to multiple combinations of stress, such as corrosion and cavitation. Maintains a good level of hardness at high temperatures. Can be work hardened and polished. Low coefficient of friction. **Applications:** industrial valve work, forging dies and hot shearing blades.
STELLOY 6 BC	-G	1.2 - 1.6	ERCCoCr-A	◆			◆	◆		◆	◆◆	◆◆	◆◆	◆◆			◆◆	Combines all the outstanding properties of cobalt based alloys, including abrasion and erosion resistance. Medium hardness deposit with good machinability. Tailored compositions are also possible by adjusting the carbon content. A lower carbon content facilitates machining. A higher carbon content allows the required hardness to be obtained on low alloy steels from the first layer. **Applications:** hot shearing tools, petrochemical and industrial valves, valves and valve seats of marine engines, pump sleeves and shafts.
STELLOY 6	-G -TIG -LD	1.2 - 1.6		◆			◆	◆		◆	◆◆	◆◆	◆◆	◆◆	◆◆		◆	
STELLOY 6 HC	-G	1.2 - 1.6		◆			◆◆	◆◆		◆	◆	◆◆	◆◆	◆◆			◆	
STELLOY 12	-G -TIG -LD	1.2 - 1.6	ERCCoCr-B	◆			◆◆	◆◆		◆	◆	◆	◆◆	◆◆	◆◆		◆	Good resistance to mineral abrasion due to its high hardness. Particularly suited for use on cutting tools. **Applications:** wood cutting tools, screw conveyors and augers for rubber and plastics, saw blades.
STELLOY 1	-G	1.2 - 1.6	ERCCoCr-C	◆			◆◆	◆◆					◆◆	◆◆	◆◆		◆	Highest hardness of the cobalt based alloy range, offering excellent resistance to abrasion and corrosion. Self polishing, promotes scratch free sliding of abrasive materials. **Applications:** rubber kneaders, mixer blades, plastic extrusion screws.

◆ **suitable** ◆◆ **highly suitable** Gas shielded (-G) Laser deposit (-LD) Gas tungsten arc welding (-TIG)

Welding procedure

Preheating is key to ensure high-quality welds and reduce the risk of cracking. The need for preheating depends on factors such as base metal composition, base material thickness, the specific cobalt grade, and the number of weld layers.

Cobalt based alloys have lower ductility than other materials, making them more prone to cracking during welding, especially when welded onto base materials like low-alloy or stainless steels.

These metals have different coefficients of thermal expansion, which can lead to thermal stresses during the heating and cooling cycles of welding. The resulting difference in expansion rates can cause cracking in the weld deposit.

Proper preheating helps reduce thermal gradients, minimising residual stresses and the potential for cracking. This ensures a sound, defect-free weld when working with cobalt based alloys and dissimilar base metals.

- Base metal composition
- Base metal thickness
- Specific Cobalt grade
- Number of weld layers
- Preheating temperature

Recommended preheating temperature (°C) - single layer, welded on different base metals

Product	Base metal grade							
	< 0.3% carbon steels	0.3-0.5% carbon steels	Up to 3% total alloy steels	3-10% total alloy steels	Martensitic high alloy steels e.g. 12% Cr	Ferritic high alloy steels e.g. 17% Cr	Austenitic high alloy steels e.g. 316	Nickel alloys
STELLOY 25	100	150	150	200	200	100	100	100
STELLOY 21	100	150	150	200	200	100	100	100
STELLOY 6 BC	150	200	200	250	300	100	100	100
STELLOY 6	200	250	250	250	300	150	150	150
STELLOY 6 HC	200	250	250	300	300	200	150	150
STELLOY 12	275	300	300	300	300	250	200	200
STELLOY 1	350	350	350	350	350	350	250	250

Welding demo video

GMAW welding process

Typical welding procedure - Ø 1.2mm:

Polarity:	DC+
Welding technique:	Pulsed
Wire speed:	6 - 7 m/min
Current:	180 - 200 A
Voltage:	23 - 25 V
Welding speed:	37 - 39 cm/min
Stick-out:	15 mm
Gas shielding:	I1 (100% Ar)
Gas flow:	16 - 19 l/min

GTAW welding process

Typical welding procedure - Ø 1.2mm:

Polarity:	DC-
Welding technique:	CC
Wire speed:	1.5 - 2.5 m/min
Current:	200 - 210 A
Voltage:	13 - 15 V
Welding speed:	15 - 19 cm/min
Gas shielding:	I1 (100% Ar)

TIG hot wire technology is also possible and increases the deposition rate

Process control to prevent porosity and cracking

Preventing porosity and cracking starts with proper surface preparation and process control. Thoroughly cleaning the base metal removes contaminants such as oil, rust and grease, which can introduce gases into the weld pool and lead to porosity. It is also important to inspect the base metal for existing cracks, as these can propagate during welding. Additionally, managing arc length is crucial – a shorter arc length reduces the exposure of the molten weld pool to atmospheric gases, minimising the risk of porosity.

Preheating and material selection to reduce cracking

To reduce cracking, it is important to manage thermal stresses through preheating and select appropriate materials. Adequate preheating helps reduce thermal gradients, minimising residual stresses that could lead to cracking. Uniform, global preheating is preferable to localised methods, as it ensures even temperature distribution across the workpiece. Controlling weld deposit thickness is also important, as excessive thickness in hardfacing layers can induce high residual stresses, increasing the likelihood of cracking. Adjusting the deposit thickness as needed or selecting a material with more suitable properties can help mitigate this risk. Material selection also plays a crucial role – choosing a filler material with the right mechanical properties can improve crack resistance. For example, a grade with lower hardness may be beneficial in applications where impact loading is a concern.

Metallurgy and performance

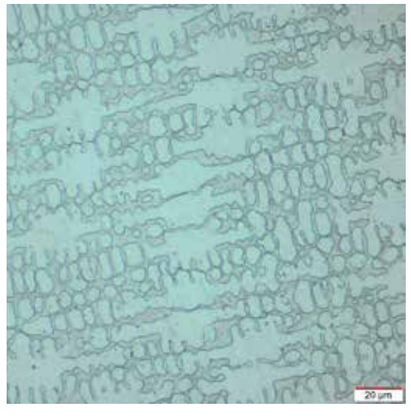
Cobalt based superalloys are designed for wear resistance, corrosion resistance, and high-temperature performance. These alloys primarily consist of cobalt, with significant additions of chromium, tungsten, molybdenum, and carbon.

Key alloying elements and their roles:

- **Chromium (Cr):** enhances corrosion resistance, typically comprising 25-35% of the alloy.
- **Tungsten (W) and Molybdenum (Mo):** contribute to solid-solution strengthening, improving the alloy's high-temperature strength and hardness.
- **Carbon (C):** facilitates the formation of hard carbides, significantly increasing wear resistance and hardness.

The microstructure of cobalt based superalloys features complex carbides dispersed within a tough, cobalt-rich matrix. This unique structure imparts outstanding hardness and toughness, enabling the alloys to maintain their properties even under elevated temperatures. The inherent low stacking fault energy of the cobalt matrix promotes work hardening, further enhancing wear resistance.

During welding or cladding operations, adhering to recommended procedures is crucial to achieve minimal dilution and maintain the desired chemical composition of the deposited layer. Carbon serves as the primary element for increasing hardness, with tungsten and chromium providing secondary effects. While higher carbon content improves abrasion resistance, it may reduce impact resistance, necessitating a balanced approach based on specific application requirements.



Typical microstructure of STELLOY cobalt

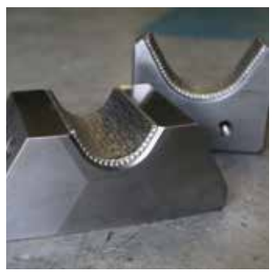
Exhaust valve seat hardfaced with STELLOY 6-G

The combination of these alloying elements and their microstructural properties makes STELLOY cobalt based superalloys well suited for applications requiring wear resistance, corrosion resistance, and high-temperature stability.

Even with low carbon cobalt alloys like STELLOY 6BC or 21, differences in thermal expansion between cobalt and steel can cause stress-related defects. In some cases, a buffer layer helps reduce residual stresses, lower the risk of cracking, and improve metallurgical transition and compatibility. Nickel based buffer layers offer better stress absorption and transition control than cobalt based alternatives.

Key considerations in buffer layer selection:

- **Dilution effects:** the first layer of STELLOY weld deposit is particularly prone to iron dilution, reducing its hardness, wear resistance, and corrosion resistance. A well-chosen buffer layer helps to minimise iron content in the final wear-resistant surface.
- **Nickel based buffer layer:** applying a ductile nickel based buffer layer, such as 625, with low preheat and interpass temperature, ensures a smoother transition, reducing embrittlement and cracking risks. Nickel 276 is even more effective than 625, as its lower niobium content prevents the formation of low-melting eutectic phases, which can contribute to hot cracking in the first weld layer.
- **Austenitic stainless steel base metals:** while stainless steels generally do not form brittle martensite, hardfacing with cobalt based cored wires can lead to carbon migration, causing sensitisation and reduced corrosion resistance. A nickel based buffer layer can help mitigate this effect.



Hot shear blade hardfaced with STELLOY 21-LD

Ball valve hardfaced with STELLOY 6-TIG

Rubber mixer hardfaced with STELLOY 6-G

STELLOY cored wires extend the service life of key components across industries, even in the toughest conditions.

Plug valve hardfaced with STELLOY 6-LD

Quality & innovation

Welding Alloys has a wealth of experience and expertise in the design and manufacture of flux and metal cored welding wires. We have globally located R&D teams capable of designing a large range of hardfacing cored wires, based on a culture of continuous development and innovation.

Since inception in 1966, innovation has always played a key role at Welding Alloys. We partner with customers globally to develop new opportunities and unique solutions. Our R&D and technical teams remain at the heart of the business, able to solve the most complex industrial wear protection challenges.

We have total control over design, development and production. Our wires are produced using our own manufacturing equipment, which is installed in our production plants worldwide. This means we can ensure the highest quality is maintained throughout the manufacturing process. We pride ourselves on our stringent quality control measures. Regular laboratory tests and quality checks are carried out at various stages of production.

Welding Alloys backs its products and services with teams of technical experts active in 150 countries across the world who work closely with customers to deliver best-in-class solutions to every major industrial sector.

Watch the video

Innovation is at the core of everything we do, we never stop learning.

Our global footprint

Our specialists and industry experts are active in 150 countries across the world and have an in-depth understanding of the operating conditions and customer requirements across a wide range of sectors.

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Welding Alloys

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