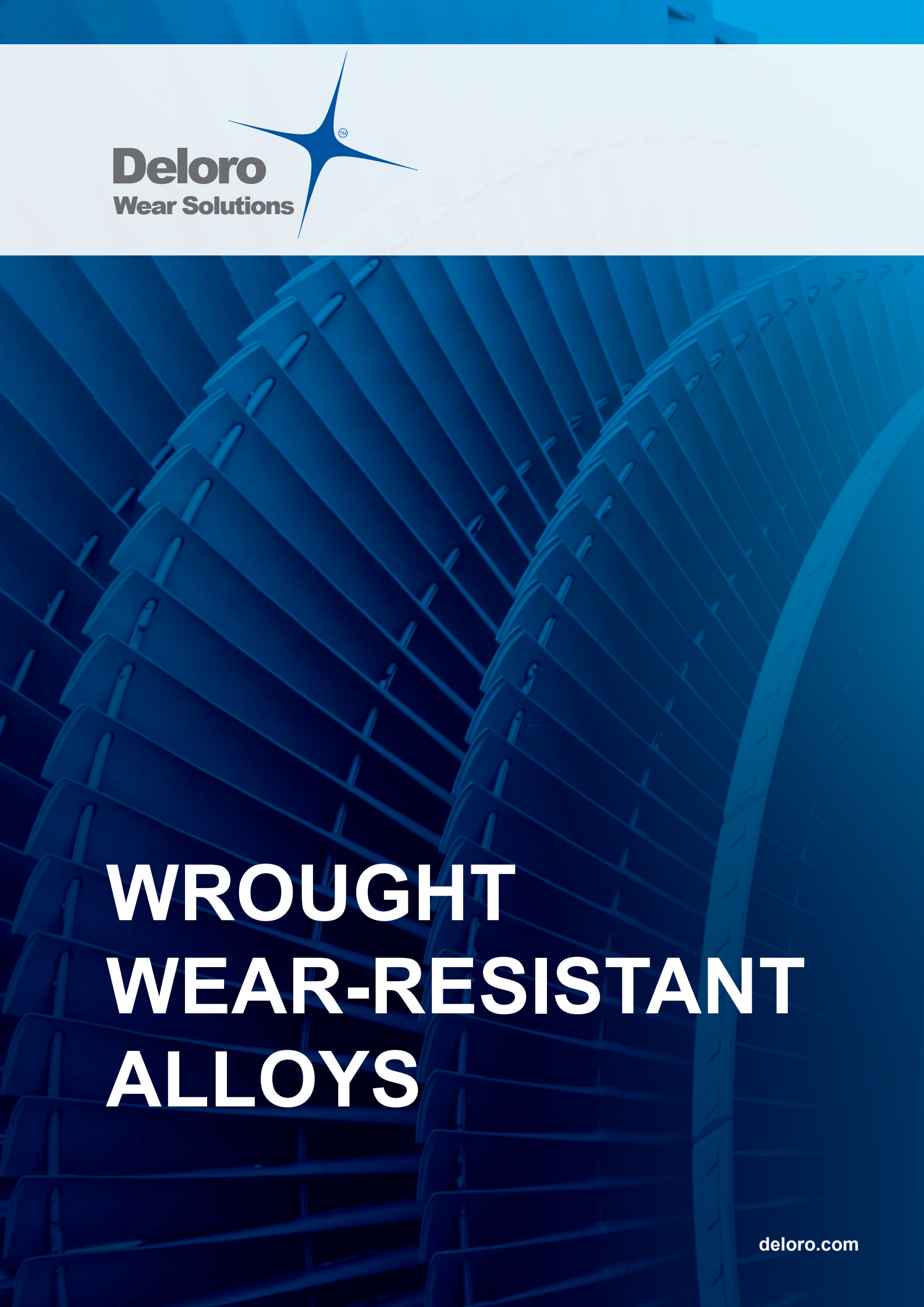
Deloro
Wear Solutions



WROUGHT WEAR-RESISTANT ALLOYS

deloro.com

DELORO WEAR SOLUTIONS GMBH

Deloro Wear Solutions is a global world-class provider and manufacturer of innovative metallic wear solutions. We put at your disposal our metallurgical and process technology expertise to enhance performance of your critical components or processes exposed to any combination of mechanical, corrosive or heat related wear. Your productivity is our mission!

Solid cobalt-, nickel- and iron- based alloy castings, coatings, as well as overlay materials, combat wear in aggressive environments in our customers' operations in multiple industries.

TABLE OF CONTENTS

STELLITE™ 6B AND 6K

Stellite™ alloys are available in many different grades (chemical compositions) and several different processes or methods of manufacture. These different processes include casting, powder metal, hardfaced deposit and wrought. For wrought grades Stellite™ 6B and Stellite™ 6K, the wrought or hot forging method of production leads to improvements of the resulting material in regards to:

- Mechanical Properties
- Toughness
- Wear Resistance
- Corrosion Resistance

Stellite™ 6B

When it comes to tough, wear-resistant materials with "guaranteed" mechanical properties, Stellite™ 6B is in a class by itself. Unlike many other materials that sacrifice toughness for wear resistance, Stellite™ 6B offers both. The key is the extensive hot working processing of the material which transforms a brittle, wear-resistant ingot into tough, wear-resistant Stellite™ 6B. With its excellent wear characteristics, hot hardness, good corrosion resistance and superior mechanical properties, Stellite™ 6B has been the material-of-choice for the most demanding wear applications.

Whether your application involves high-impact pulp agitators, critical directional drilling tools, or aerospace components, Stellite™ 6B can offer superior wear resistance and the mechanical properties needed to withstand the toughest of applications. Stellite™ 6B meets the requirements of Aerospace Material Specification AMS 5894. All Stellite™ 6B products are accompanied by full material certifications and are DFARS compliant.

When it comes to your equipment, don't settle for anything less; use genuine Stellite™ 6B.

Stellite™ 6B is stocked in standard mill forms of flat stock ranging from 0,79 - 25,4 mm thick and round bar ranging from 7,9 - 152,4 mm diameter. Special sizing is available on request. Ask about our finish machined Stellite™ 6B components capability.

Stellite™ 6K

Stellite™ 6K has similar properties to Stellite™ 6B, but is slightly harder and less ductile. Stellite™ 6K is excellent for cutting or scraping applications, such as knives or scraper blades. Stellite™ 6K is a custom-rolled material and can be produced to a gauge and sheet size uniquely suited to your application.

Stellite™ 6K is available in flat stock ranging from 1,14 - 9,53 mm thick. Ask about our finish machined Stellite™ 6K components capability.

Resist Seizing and Galling

Stellite™ 6B is resistant to the effects of seizing or galling. In many cases, its low coefficient of friction allows sliding contact with other metals without damage by metal pick-up. Stellite™ 6B has been used in equipment where no lubricants were used because of the nature of the product being handled. Sleeves made of Stellite™ 6B move smoothly, with minimum resistance, even when operating in contact with other metal parts. They have been useful in inaccessible areas where efficient lubrication is impossible. Sleeves and bushings have resisted seizing even when lubricants were diluted by gasoline, cleaning fluids and other liquids that wash out an oil film. They have operated at peak efficiency even when lubricants decomposed under heat or were destroyed by abrasive particles.

Resist Erosive Wear

Parts made of Stellite™ 6B have a long service life, even under constant erosive conditions. This material has outstanding resistance to cavitation-erosion. The wrought structure results in improved abrasion wear resistance comparable to much harder cast materials. Stellite™ 6B used for steam turbine erosion shields has protected the blades of turbines for over 30 years of continuous service.

Excellent Hot Hardness

Stellite™ 6B retains high hardness, even at red heat. Once cooled back to room temperature, it recovers its full original hardness.

Good Impact and Thermal Shock Resistance

Stellite™ 6B combines wear and corrosion resistance with good impact strength and resistance to thermal shock. The toughness of the wrought alloy depicted by its charpy impact energy goes up almost four fold compared to the cast version.

Resist Heat and Oxidation

High temperatures have little effect on the hardness, toughness and dimensional stability of these alloys. They are highly resistant to atmospheric oxidation at ordinary temperatures and have good resistance to oxidation at elevated temperatures.

Corrosion Resistance

In addition to wear resistance, Stellite™ 6B has good resistance to a variety of corrosive media. This combination of properties makes Stellite™ 6B particularly useful in such applications such as food-handling machinery, chemical equipment and others where both wear and corrosion resistance are necessary.

Heat Treatment

Wrought forms of Stellite™ 6B and Stellite™ 6K are supplied in the solution heat-treated condition, unless otherwise specified. The standard heat treatment is at 1.200°C followed by air cooling.

AVAILABLE FORMS

Stellite™ 6B and Stellite™ 6K are available in sheets, plates and fabricated shapes. Stellite™ 6B is also available as round bar stock. Deloro Wear Solutions has the capability to provide components made of these materials to your exact specifications. For more information, contact us about our in-house machine shop capabilities.

Available Forms

Product	Stellite™ 6B	Stellite™ 6K
Round Bar	Ø 7,9 - 152,4 mm diameter	Not available in Bar Stock
Flatstock	Thickness = 0,79 - 25,4 mm Sheet Size = up to 914,4 x 2.438,4 mm	Thickness = 1 ,14 - 9,53 mm Sheet Size = custom rolled sizes
Fully Machined Components	—	—

PROPERTIES OF STELLITE™ 6B AND 6K

Certified Mechanical Properties

Covers Stellite™ 6B in the form of sheet and plate up to 25,4 mm thick and round bar up to 88,9 mm diameter.

Minimum Properties of Wrought Stellite™ 6B

Property	Value
Tensile Strength	896 MPa MIN
Yield Strength at 0,2% offset	483 MPa MIN
Elongation in 4D	5% MIN
Reduction in Area	7% MIN
Hardness	33 - 43 HRC

Properties Data

The properties listed in this booklet are typical or average values based on laboratory tests conducted by the manufacturer. They are indicative only of the results obtained in such tests and should not be considered as guaranteed maximums or minimums. Materials must be tested under actual service conditions to determine their suitability for a particular purpose. All data represent the average of four tests or less, unless otherwise noted.

Chemical Composition, Percent

Product	Co	Ni	Si	Fe	Mn	Cr	Mo	W	C
Stellite™ 6B	Bal.	3,00*	2,00*	3,00*	2,00*	28,00 - 32,00	1,50*	3,50 - 5,50	0,90 - 1,40
Stellite™ 6K	Bal.	3,00*	2,00*	3,00*	2,00*	28,00 - 32,00	1,50*	3,50 - 5,50	1,40 - 1,90

* Maximum

Average Physical Properties

Physical properties	Temp., (°C)	Metric units Stellite™ 6B	Metric units Stellite™ 6K
Hardness Limits Typical	22	33 - 43 RC 36 - 40 RC	40 - 42* RC 43 - 47 RC
		Kg/m^3	
Density	22	8.387	8.387
Melting Range	—	1.265 - 1.354 °C	
		microhm-m	
Electrical Resistivity	22	0.91	—
		watt-cm / sq. cm-°C	
Thermal Conductivity	22	0.147	—
		x 10 - 6/m/m.K	
Mean Coefficient of Thermal Expansion	0 - 100	13,9	13,8
	0 - 200	14,1	13,8
	0 - 300	14,5	13,8
	0 - 400	14,7	13,8
	0 - 500	15,0	13,8
	0 - 600	15,3	14,0
	0 - 700	15,8	14,2
	0 - 800	16,3	14,5
	0 - 900	16,9	14,9
	0 - 1.000	17,4	15,5
Electrical Conductivity Compared to Copper, percent	22	1,90	—
Specific Heat (calculated)	Room	J/kg•K 423	Room —
Magnetic Permeability at 200 Oersteds (15.900 A/m)	22	< 1,2	< 1,2
Reflecting Power, percent	—	57 - 70	—

* Minimum depending on gauge

Average Hot Hardness

Product	Test Temp. (°C)	Brinell hardness at temperature, mutual identation method
Stellite™ 6B	538	226
	649	203
	760	167
	871	102

Average Compressive Strength

Product	Form	Test Temp.	Average compressive strength (MPa)
Stellite™ 6B	12,7 mm, Plate [1]	Room	2.392
Stellite™ 6K	Sheet [1]	Room	2.241

Average Modulus of Rupture

Product	Form	Test Temp.	Average Modulus of Rupture (MPa)
Stellite™ 6B	Sheet [1]	Room	2.360

Average Modulus of Elasticity

Product	Form	Test Temp.	Average Modulus of Elasticity (MPa)
Stellite™ 6B	Sheet [1]	Room	210.000
Stellite™ 6B	15,9 mm, Bar	Room	214.000

Average Izod Impact Strength (un-notched)

Product	Form	Test Temp.	Average Izod Impact Strength (un-notched) (J)
Stellite™ 6B	12,7 mm, Plate [1]	Room	84

Average Charpy Impact Strength

Product	Test Temp. (°C)	Type of Test	Average Charpy Impact Strength (J)	
			Longitudinal	Transverse
Stellite™ 6B 12,7 mm, Plate [1]	Room	Un-notched	98	88
		notched	8	—
	538	Un-notched	110	—
		notched	20	—
	677	Un-notched	157	—
		notched	20	—
	816	Un-notched	171	—
		notched	20	—

[1] Solution heat-freated at 1232 °C, air cooled.

Average Room Temperature Data - Stellite™ 6B

Form	Condition	Ultimate Tensile Strength (MPa)	Yield Strength at 0,2% Offset (MPa)	Elongation in 2 in. 50,8 mm (%)	Hardness Rockwell C
Sheet 1,0 mm, thick	Solution Heat-treated [1]	1.000*	621*	12*	36*
Sheet 1,7 mm, thick	Solution Heat-treated [1]	971*	598*	11*	36*
Sheet 3,2 mm, thick	Solution Heat-treated [1]	998*	619*	11*	37*
Sheet 4,8 mm, thick	Solution Heat-treated [1]	996*	616*	10*	37*

[1] Solution heat-freated at 1.232 °C, air cooled.
* Average of 27 - 31 tests.

Average Tensile Data [1]

Product	Form	Test Temp. (°C)	Ultimate Tensile Strength (MPa)	Yield Strength at 0,2% Offset (MPa)	Elongation in 50,8 mm (%)
Stellite™ 6B	Sheet 1,6 mm	Room	1.007	632	11
		816	509	313	17
		871	385	270	18
		982	225	137	36
		1.093	134	75	44
		1.149	92	53	22
	Plate 12,7 mm	Room	1.020	607	7
		538	917	403	9
		677	793	418	9
	Bar 15,9 mm	Room	1.063	638	17*
		316	1.019	514	30*
		538	890	464	28*
		816	520	321	28
		871	402	261	34*
Stellite™ 6K	Sheet 1,6 mm	Room	1.217	708	4
		649	1.007	—	8
		816	484	307	17
		982	235	133	28
		1.093	120	59	53

[1] Solution heat-freated at 1232 °C, air cooled.
* Elongation percent in 25,4 mm.

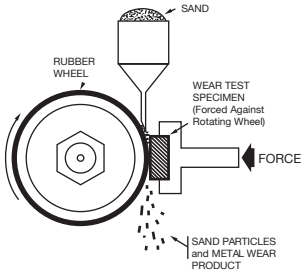
Average Cavitation-Erosion Data

Alloy	Test Duration (hrs)	Weight Loss (mg)
Stellite™ 6B	100	42,3
Type 304 Stainless Steel	7	39,9

Average Abrasive Wear Data

Alloy	Condition	Volume Loss (mm^3)	Hardness, Rockwell	Wear Coefficient [1]
Stellite™ 6B	Mill annealed	8,2	C-38	$0{,}471 \times 10^{-3}$
Stellite™ 6K	Mill annealed	13,3	C-46	$0{,}946 \times 10^{-3}$
Stellite™ 25	Mill annealed 1hr. at 871 °C	53,0	C-24	$2{,}00 \times 10^{-3}$
1090 Steel	water quenched + 4 min. at 482 °C	37,2	C-55	$8{,}00 \times 10^{-3}$
Type 316 Stainless Steel	As received sheet	81,4	B-86	$2{,}00 \times 10^{-3}$
Type 304 Stainless Steel	As received sheet	102,1	B-92	$3{,}00 \times 10^{-3}$

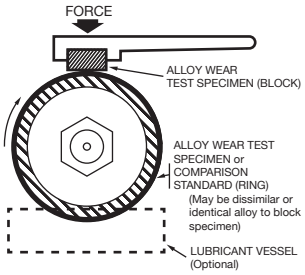
Abrasive Wear Test Unit
(Dry Sand)



Average Adhesive Wear Data*

Alloy	Condition	Ring Alloy	Volume Loss (mm^3)	Wear Coefficient [1]
Stellite™ 6B	Mill annealed	4620 Steel	0,293	$3{,}70 \times 10^{-5}$
Stellite™ 6K	Mill annealed	4620 Steel	0,561	$8{,}73 \times 10^{-5}$
Stellite™ 25	Mill annealed 1hr. at 871 °C	4620 Steel	0,285	$2{,}50 \times 10^{-5}$
1090 Steel	water quenched + 4 min. at 482 °C	4620 Steel	0,293	$6{,}00 \times 10^{-5}$

Adhesive Wear Test Unit
(Metal to Metal)



Coefficient represents tangent of angle of repose. Tests made on dry surface having better than 120 grit finishes.
All values based on averages and are to be used comparatively and not as absolute values.

* Average of two or more tests against a case–hardened SAE 4620 steel ring (Rockwell C–63).

[1] The wear coefficient (K) was calculated using the equation $V = \frac{KPL}{3h}$
where: V = Wear volume (mm3)
P = Load (kg)
L = Sliding distance (mm)
h = Diamond pyramid hardness

A combination of a low wear coefficient and a high hardness is desirable for good wear resistance.

Average Coefficients Of Static Friction For Some Common Materials

Material Against	Stellite™ 6B	Cast Iron	Bronze	Aluminium	Lead
Stellite™ 6B	0,119	0,123	0,125	0,138	0,119
Cast Iron	0,123	0,199	0,245	0,213	0,225
Bronze	0,125	0,245	0,231	0,257	0,249
Aluminium	0,138	0,213	0,257	0,213	0,328
Lead	0,119	0,225	0,249	0,328	0,290

Average Corrosion Data - Stellite™ 6B*

Form	Concentration, Percent by Weight	Test Temp. (°C)	Average Penetration Rate per Year** (mm)
Acetic Acid	10	Boiling	0,002
Acetic Acid	30	Boiling	0,001
Acetic Acid	50	Boiling	<0,001
Acetic Acid	70	Boiling	<0,002
Acetic Acid	99	Boiling	<0,001
Chromic Acid	10	66	2,41
Formic Acid	10	Boiling	0,51
Formic Acid	30	Boiling	0,66
Formic Acid	50	Boiling	1,19
Formic Acid	70	Boiling	1,27
Formic Acid	88	Boiling	0,58
Hydrochloric Acid	2	Room	<0,003
Hydrochloric Acid	5	Room	1,60
Hydrochloric Acid	10	Room	2,74
Hydrochloric Acid	20	Room	2,36
Hydrochloric Acid	2	66	<0,003
Hydrochloric Acid	5	66	>25,4
Hydrochloric Acid	10	66	>25,4
Hydrochloric Acid	20	66	>25,4
Nitric Acid	10	Boiling	<0,004
Nitric Acid	30	Boiling	0,15
Nitric Acid	50	Boiling	>25,4
Nitric Acid	70	Boiling	>25,4
Phosphoric Acid	10	Boiling	Nil
Phosphoric Acid	30	Boiling	0,05

Form	Concentration, Percent by Weight	Test Temp. (°C)	Average Penetration Rate per Year** (mm)
Phosphoric Acid	50	Boiling	0,48
Phosphoric Acid	70	Boiling	0,58
Phosphoric Acid	85	Boiling	15,5
Sodium Hydroxide	30	Boiling	0,33
Sulfuric Acid	10	Room	<0,001
Sulfuric Acid	30	Room	Nil
Sulfuric Acid	50	Room	0,01
Sulfuric Acid	77	Room	0,02
Sulfuric Acid	10	66	<0,001
Sulfuric Acid	30	66	<0,003
Sulfuric Acid	50	66	>25,4
Sulfuric Acid	77	66	4,5
Sulfuric Acid	2	Boiling	0,79
Sulfuric Acid	5	Boiling	2,31
Sulfuric Acid	10	Boiling	3,99
Sulfuric Acid	20	Boiling	9,14
Sulfuric Acid	50	Boiling	>25,4
Sulfuric Acid	30	Boiling	>25,4
Sulfuric Acid	77	Boiling	>25,4
Ferric Chloride (10 days without crevice)	10	Room	0,33***
Ferric Chloride (10 days with crevice)	10	Room	0,23***
Ferric Chloride + Sodium Chloride (10 days)	5 10	Room	0,46***
Potassium Permanganate + Sodium Chloride (120 hrs)	2 2	90	0,20

* Determined in laboratory tests. It is recommended that samples be tested under actual plant conditions.
** Corrosion rates for all duplicate samples based on an average of 4–24 hour test periods.
*** Samples pitted during test.

Average Stress Rupture and Creep Data

Product	Test Temp. °C	Stress (MPa)	Initial Elongation (%)	Life (hrs.)	Time in Hours for Total Elongation (%) of			Elongation at Rupture (%)
					0,5	1,0	2,0	
Stellite™ 6B 1,6 mm, Sheet[2]	538	414	0,70	192,8[1]	—	—	—	0,8
	649	345	0,45	361,4	0,5	113,8	—	3,0
	760	241	0,35	59,3	0,4	3,8	16,3	5,1
	816	172	0,35	70,6	0,2	4,3	19,9	4,7
	871	131	0,10	57,9	0,5	2,2	11,1	4,3
	927	83	0,19	104,0	1,8	20,9	89,9	2,6
	982	55	0,05	113,4	5,1	22,7	57,6	5,5
	1.093	14	0,004	116,7	4,4	—	—	13,3

[1] Test discontinued before rupture.
[2] Specimens were solution heat–treated at 1.232ºC and air cooled prior to testing.

FUSION WELDING

Stellite™ 6B and Stellite™ 6K can be welded by gas tungsten-arc (TIG) with an argon flow of 0,708 m^3/h, gas metal-arc (MIG), shielded metal-arc (coated electrode) and oxy-acetylene in this order of preference. The oxy- acetylene method should be used with discretion and care in that Stellite™ will “boil” during welding, which may cause porosity. Use a 3x reducing flame to minimize oxidation, penetration and inter-alloying.

Stellite™ 6B and Stellite™ 6K should be preheated and maintained at approx 350°C to prevent cracking during welding and then still air cooled. Fixturing, which would chill the weld rapidly, should not be used. Standard weld joints are recommended. INCONEL® 82, 92 or 625 filler metals are recommended for joining Stellite™ 6B to softer materials such as carbon steel or stainless steel, while the harder cobalt-base filler metals such as Stellite™ 6 and Stellite™ 21 are recommended for joining Stellite™ 6B to itself, especially if wear resistance is required in the weld areas. In the latter case, INCONEL® 82, 92 or 625 may be used for root passes and then be overlayed with the harder materials.
Gas shielding of the root side of the gas tungsten-arc weldments is not mandatory, but is recommended in order to improve weld penetration.

Adequate ventilation is required to control exposure to airborne dust, fumes and particulate when machining, grinding or welding Stellite™ alloys. MSDS sheets are available.

BRAZING

Stellite™ 6B and Stellite™ 6K are readily joined to other materials by brazing. All forms of surface dirt such as paint, ink, oil, chemical residues, etc., must be removed from the mating parts by etching, solvent scrubbing, degreasing or other means. In addition, fluxing will be required during torch brazing operations when using silver brazing filler metal to help clean the joint and allow the filler metal to flow more freely over the mating surfaces. Brush joining areas generously with brazing flux prior to heating. When torch or induction brazing, as soon as the brazing filler metal melts, the source of heat should be removed and the parts positioned. The assembly should then be pressed together to squeeze out the excess flux and still air cooled. The parts should not be quenched.

Other brazing filler metals (i.e., gold, palladium, or nickel-based alloys) are satisfactory for joining Stellite™ 6B and Stellite™ 6K. Brazing filler metal selection depends on the service conditions expected. A close fit of the mating surfaces is recommended. The finished joints will have greater strength if the filler metal is very thin, generally 0,03–0,13mm thick.

Brazing with high-temperature filler materials is generally performed in a furnace. Induction and resistance heating with salt-bath and metal-bath dip brazing have limited application. Vacuum furnaces held at less than one micron pressure or controlled atmosphere furnaces, having adequate moisture control at brazing temperatures (less than 15°C dew point), produce the most satisfactory results. Controlled atmospheres such as hydrogen or cracked ammonia are suitable for brazing Stellite™ 6B and Stellite™ 6K base materials.

Deloro
Coatings

Offering high-quality coating services utilizing a wide range of cobalt, nickel and iron-based alloys as well as tungsten carbide

Deloro
Microfusione

Leading manufacturing services provider for highly-demanding air- and vacuum-cast super alloy investment castings

Deloro
Wear Solutions

Offering bespoke components, coating services, consumables and equipment

Deloro Wear Solutions GmbH
Zur Bergpflege 51 - 53
56070Koblenz | Germany
Phone: +49 26180 88 0
Fax: +49 261 80 88 35
E-mail: wearsolutions@deloro.com
deloro.com