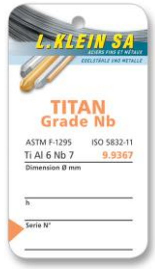

TITAN Grade Nb TiAl6Nb7

9.9367 – Titan Grade Nb / EN TiAl6Nb7 / ASTM F 1295
Titanium alloy for implants and prostheses for joint replacements

Features and Peculiarities

The TITAN Grade Nb is the titanium alloy TiAl6Nb7, where, compared to Grade 23, Nb substitutes V. Each of its constitutive element is individually biocompatible and allergy free. The contents of the interstitials elements and of Fe are kept low. It is VAR Vacuum Arc melted and remelted. Its very clean microstructure exhibits a very good corrosion resistance, better than this of Grade 23. TITAN Grade Nb is totally biocompatible and fulfills the ROHS requirements. It can easily be anodic oxidized to generate a broad range of fine nuanced interference colors. The resulting TiO_2 mixed oxides oxide layer possesses a satisfactory wear-fretting resistance as well.

Uses

The TITAN Grade N TiAl6Nb7 is most suitable for implants and prostheses for joint replacement. It can also be used for many other purposes in the medical, surgical and dental fields. In non-medical fields, it is used in micro-mechanical engineering and for components of watch movements as well as for the watch exterior. Its good corrosion resistance in chloride containing mediums indicates it for its uses in the chemical industry. TITAN Grade N has an excellent biocompatibility and is also totally allergy free. Its anodic oxidation reinforces these features further, besides allowing the creation of a broad color spectrum for jewelry and wear resistant oxide layers,

Standards

Material Number:	9.93767
EN	TiAl6Nb7
ISO	5832-11
ASTM	F 1295
UNS	R 56760

Chemical composition ($\%_{wt.}$)

C	Al	Nb	Fe	Ta	O	N	H	Ti
max.	5.50.	6.50	max.	max.	max.	max.	max.	balance
0.08	6.50	7.50	0.25	0.50	0.05	0.009	0.50	

Dimensions and Executions

- Bars: 3m (2m), cold drawn, ground polished, roughness: Ra ≤ 0.8 µm
  Tolerance: ISO h6 (h7), other tolerances on request
  ø > 2.0 mm: pointed and chamfered
  Straightness: < 0.4 mm/m
  Craking test: DIN/EN 10277-1, Tab. 1
  ø < 2.00 mm: class 1
  ø ≥ 2.00 mm: class 3
  SWISSLINE: ø > 6.0 mm

Other executions on request

Availability

Dimensions courantes en stock, see: Delivery program

Mechanical Properties

According to ISO and/or ASTM:

Strength UTS/Rm:	≥ 900 MPa
Yield strength $YS_{0.2}/R_{0.2}$:	≥ 795 MPa
Elongation A:	≥ 10%

Machining

Cutting speed:	Vc ≈ 20-40 m/min
Feed:	0.08-0.15 mm/U
Rake angle:	-100/120°
Lubricant-coolant:	individual choice

- The optimal cutting conditions depend on the machine tool, the cutting tools, the chip dimensions, the lubricant-cooling fluid, as well as the tolerances and surface the roughness to be achieved.

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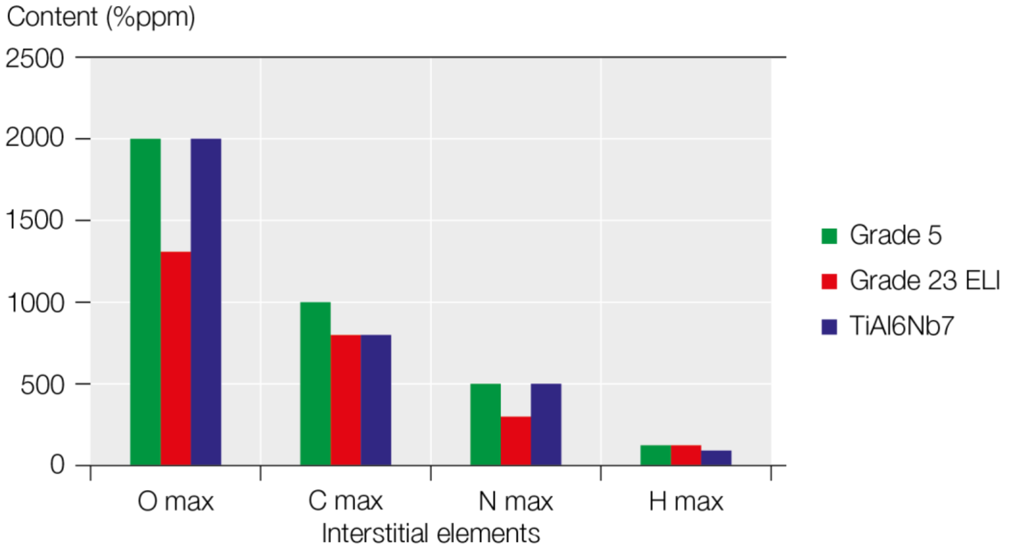
Figure 1
Comparison
Interstitial elements



Interstitial contents

In addition to the constitutive metallic elements Ti, Al and Nb, die interstitial elements C, O, N and H play an important role. Figure 1 shows the tolerated maximal contents of the interstitials elements of Titan Grade Nb in comparison to Grade 5 and 23. These content restrictions are necessary to improve the impact resistance, toughness, and the deformation capability and capacity, as well as machining.

Figure 2
Comparison
Mechanical
Properties

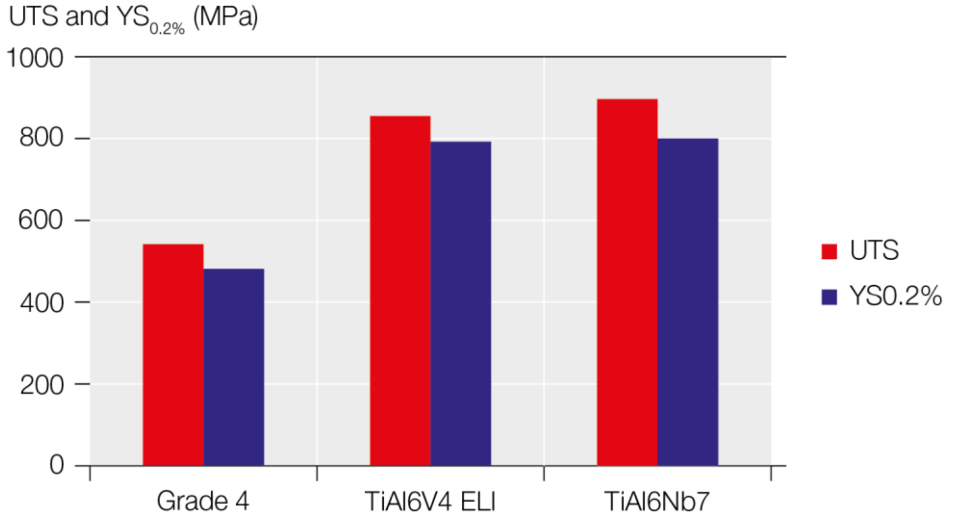


Figure 2 shows the typical mechanical properties of the Titanium based materials for implants. This Figure also shows the ductility improvement of TITAN Grade Nb compared to TITAN Grade 23. This improvement being illustrated by the more favorable ratio $YS_{0.2}/R_{02}/Rm$ of the TITAN Grade Nb compared to TITAN Grade 23 TiAl6V4 ELI.

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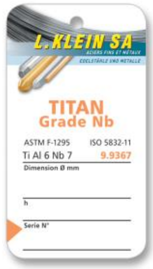

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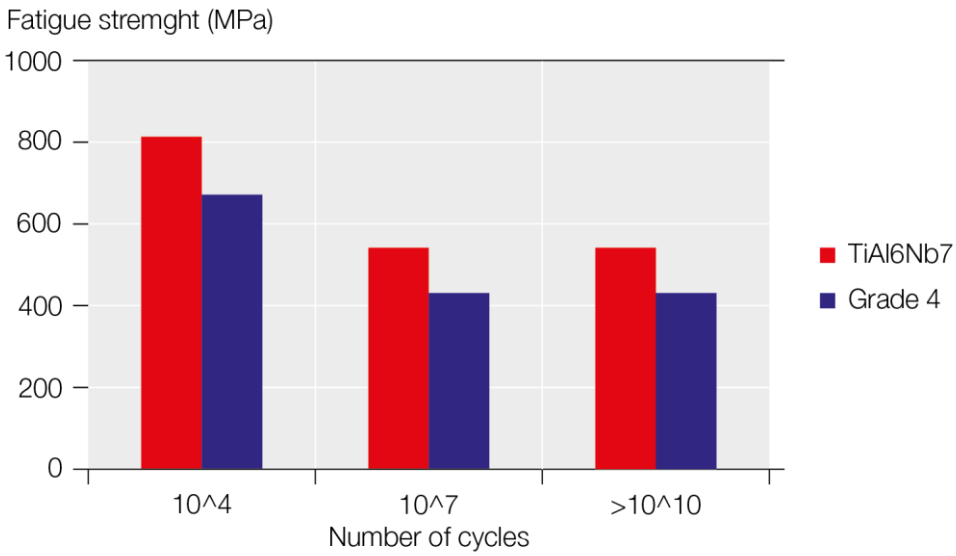
Figure 3 Comparison Rotating bending fatigue



The fatigue resistance of TITAN GRADE Nb is very important. It is decisive in the choice of the correct material for implants and prostheses for joint replacement. Similar criteria apply in material selection in micro-mechanical engineering as well.

Forming	Warm:	Rough forging:	950-980°C
		Finish forging:	900-970°C
	Cold:	feasible, but quite difficult	
Thermal treatments	Annealing:	705-730°C/1-4h/slow cooling to 565°C/air	
	Hardening:	950-955°C/up to 5h/ slow cooling to 565°C/air	
	Stress relieving:	480-650°C/up to 4h/air	
	Subzero treatment:	-196°C (liquid N_2)	

Negative role of H_2

Hydrogen diffuses easily and readily in titanium and embrittles it. Contamination with H_2 must be systematically avoided by any means.
Hydrogen sources are often the protective atmospheres and the chemical reactions liberating hydrogen.

Corrosion resistance

TITAN Grade Nb (Ti6Al7Nb) has, next to titanium grade 2 and 4, the best corrosion resistance of all Ti-alloys. The alloying elements Al and Nb make it stronger.

Biocompatibility

TITAN Grade Nb (Ti6Al7Nb) exhibits a very good biocompatibility in the human body and in contact with it. It is totally non-allergenic.

Anodic Oxidation

TITAN Grade Nb (Ti6Al7Nb) forms spontaneously in the presence of oxygen in the atmospheres or solutions. It reacts to form a passive oxide film or layer <1-2 nm thick of passive oxide layer of TiO_2-mixtoxyd (with Ti, Al and Nb metallic components). This protective layer is totally biocompatible and non allergenic in the human body or in contact with it. The anodic oxidation process further increase the thickness of this mixed oxide layer.

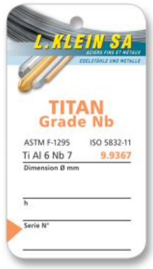


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Figure 4
Anodic Oxydation

Oxide film thickness (nm), 1 nm = 10 Å

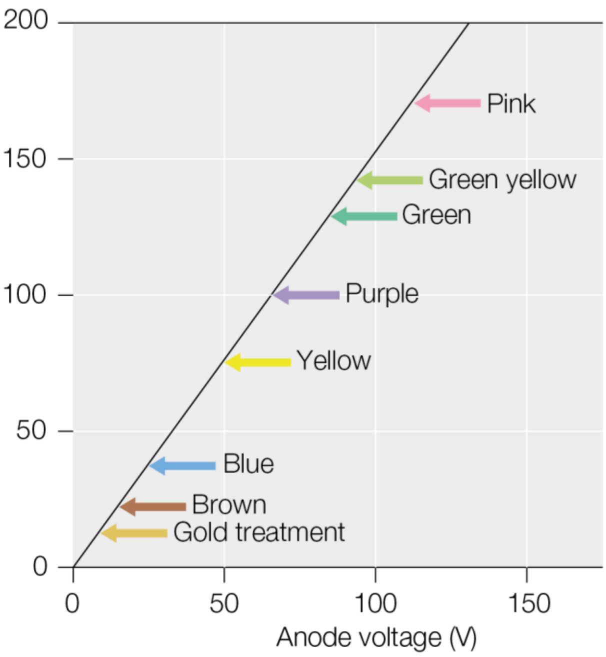

Table 1
Relation between the oxide color and the thickness of the oxide layer

0	46.0	92.0	137.9
3.1	49.0	95.0	141.0
6.1	52.1	98.1	144.1
9.2	55.2	101.1	147.1
12.3	58.2	104.2	150.2
15.3	61.3	107.3	153.3
18.4	64.4	110.3	156.3
21.5	67.4	113.4	159.4
24.5	70.5	116.5	162.5
27.6	73.6	119.5	165.5
30.7	76.6	122.6	168.6
33.7	79.7	125.7	171.6
36.8	82.8	128.7	174.7
39.8	85.8	131.8	
42.9	88.9	134.9	

TITAN Grade Nb can easily be anodic oxidized in oxidizing acid baths, like phosphoric acid (H_3PO_4) or sulfuric acid (H_2SO_4). As shown by Figure 3, a large spectrum of interference colors can be produced in function of the concentration of the selected oxidant acid, i.e. 4M H3PO4, the temperature and the applied voltage. No additive or coloration pigment is necessary. The observed colors are pure interference colors.

Color spectrum

The interference colors arise by the reflexion and refraction of the incident visible light on the surface of the metal. As Table 1 shows, anodic oxidation can produce a broad spectrum of nuanced colors by adjusting the thickness of the oxide layer.

Reinforced Biocompatibility

The good biocompatibility of TITAN Grade Nb (Ti6Al7Nb) is due to its capacity and capability to spontaneously passivize in the presence of oxygen to form a TiO_2 mixed oxides layer. This layer as shown in Table 1 is very thin < 1-2 nm. Thicker layers as produced by anodic oxidation, reinforce the biocompatibility and corrosion resistance.

Corrosion resistance

The corrosion resistance of TITAN Grade Nb (Ti6Al7Nb) is excellent. It can still be reinforced by the formation of a thicker TiO_2 mixed oxides layer by an anodic oxidation.

Resistance to fretting

The thicker mixed oxide layers produced by anodic oxidation can still improve the gliding properties. These oxide layers can be exploited to improve the gliding properties, the wear and fretting resistances. These improvements can be exploited to enhance the gliding properties during forming operations of TITAN Grade Nb (Ti6Al7Nb).

Exploitation of the color spectrum

The broad color spectrum produced by the anodic oxidation is absolute allergy free can be used in ornamentation and jewelry industries (Table shows 58 distinct colors), and for fast recognition or identification purposes, as for example in the medical field.

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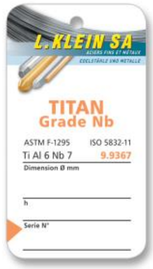

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Physical properties

Properties	Unit	Temperature (°C)				
		20	200	300	400	500
Density	g cm^{-3}	4.52				
Young modulus E	GPa	105				
Compression modulus	GPa	101				
Shear modulus	GPa	41				
Poisson Coefficient	-	0.34				
Thermal conductibility	$W.m^{-1}.K^{-1}$	6.7		6.8		7.1
Electrical resistance	$\Omega.mm^2.m^{-1}$	0.55	0.58	0.595	0.605	0.615
Thermal expansion	$W.m^{-1}.K^{-1}$	20–100°C	20–200°C	20–300°C	20–500°C	20–815°C
	10^{-6}	8.6	9.2	9.5	10	11
Thermal conductivity	$W.m^{-1}.K^{-1}$	17	15	15	15	15
Magnetic susceptibility	10^{-6}	3.4	3.5	3.6	3.9	4.0
Specific heat	$J.kg^{-1}.K^{-1}$	560				
Emissivity (1-10) Visible light	-	0.3				
Coefficient of reflexion	-	0.56				
Melting point	°C	1650				
Latent heat of fusion	kJ/kg	360-370				
Transus allotropique	°C	1010±15				
Magnetic permeability	µr	1.00005				

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