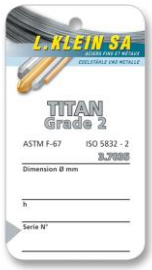


TITAN Grade 2

3.7035 - EN Ti 2 / ASTM B348 and F 67 – CP Titanium Grade 2
For the medicine, micro-engineering, watch making etc.

Features and Particularities

The Titanium Grade 2 is a CP (Commercially Pure) titanium. It is vacuum melted and remelted. The contents of in interstitials elements C, O, N and H are closely limited and controlled. The Fe content is limited in correlation with the O content, this to improve the cold working without jeopardizing the ductility. Its corrosion resistance is very good, more particularly in Cl containing mediums. It is the corrosion resistance of reference, benchmark, for all titanium or other materials for implants. Titanium Grade 2 is totally biocompatible in the human body. Its anodic oxidation is easy and allows to create a very broad spectrum of interference colors, offering also a better the wear resistance. Grade 2 exhibits also a good oxidation resistance.

Uses

Titan Grade 2 is very well indicated for implants, medical, surgical and dental applications, as well as for precision micro-engineering and watch making components for movements as and the watch exterior not requiring high mechanical properties. It has a good corrosion resistance Cl containing mediums and for marine applications. Its high corrosion resistance indicates it for applications in the chemical industry. Its particular anodic oxidation capability makes it the material of choice for decorative non-allergenic jewelry, and applications requiring an improved wear resistance.

Standards

Material number	3.7035
EN & DIN	Ti 2
ISO	5832-2
AFNOR	T40
ASTM	B 348, F 67
UNS	R 50400

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

C	Fe	O	N	H	Ti
max.	max.	max.	max.	max.	balance
0.08	0.30	0.25	0.03	0.0125	

Dimensions and Executions

- Bars: 3m (2m), cold drawn, ground and polished, rugosity: Ra ≤ 0.5 µm
  Tolerance: ISO h6 (h7); Closer tolerances on request
  > 1.0 mm: pointed and chamfered
  SWISSLINE: Ø > 6.0 mm
  Crack test DIN/EN 10277-1, Tab. 1
  Ø < 2.00 mm: class 1 Ø ≥ 2.00 mm: clase 3
- Wires: rings

Others executions on request

Availability

Dimensions courantes en stock, see: Delivery program

Mechanical properties

According to ISO and/or ASTM:

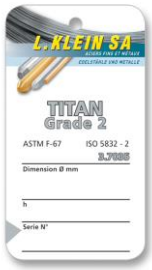
Strength UTS/Rm:	500 -700 MPa	
Yield strength Rp$_{0.2}$:	320 MPa	
Elongation A:	ø < 5.0 mm:	≥14%
	ø ≥ 5.0 mm:	≥12%

Machining

Cutting speed:	Vc ≈ 20-40 m/min
Feed:	0.08-0.15 mm/tour
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.

L. Klein AG • Längfeldweg 110 • CH-2504 Biel/Bienne
Telefon 0041 (0)32 341 73 73 • Telefax 0041 (0)32 341 97 20 • www.kleinmetals.swiss • info@kleinmetals.swiss



TITAN Grade 2

3.7035 - EN Ti 2 / ASTM B348 and F 67 – CP Titanium Grade 2
For the medicine, micro-engineering, watch making etc.

Grain size

According to ASTM E112: ≥5

Cold working capacity

- Cold: UTS/Rm ≤ 760 - 965* MPa
  $YS_{0.2}/Rp_{0.2}$: ≤ 450 - 620* MPa
  *Indicative values only
- UTS/Rm and $YS_{0.2}/Rp_{0.2}$ are function of the amount and type of cold working.
- High strengths are achievable by cold working up to 95% total reduction. It can be achieved by repeated cold deformations up to approximately 50% followed by 500-540°C/1h stress relieving anneals.

Annealing

- 600°C/0.5-1h

Stress relieving

- ≤ 500°C/1h
- Stress relieving treatment can also be applied between the rough and fine or finishing machining operations. This to reduce or eliminate the possible internal stresses build in during heavy or rough machining that may lead to distortions.

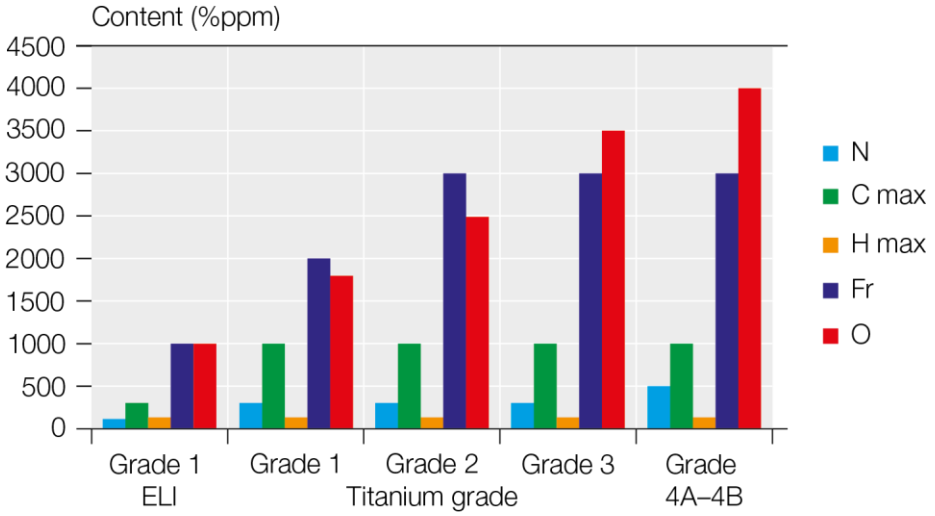
Final stabilization anneal

- 420-440°C/1h

Comparison between the non allied titanium Grades

The choice of the adequate Grade of CP titanium is essentially a decision based on the composition and the mechanical properties.
The Figures 1 and 2 show this aspect of the best choice of CP titanium Grade for the aimed use.

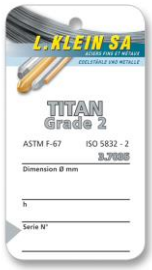
Figure 1 Composition of the 4 non allied Titanium grades



O, Fe et C are the three elements which could be regarded as alloying element per se and the elements allowing the control of the achievable mechanical properties. The others chemical element of the composition are controlled impurities.

Negative role of hydrogen

Hydrogen diffuses easily and readily in titanium and titanium alloys. It renders them brittle. The pick up and presence of hydrogen must be avoided by any means. The sources of the H contamination are the protective atmospheres, and the chemical and electrochemical reactions producing hydrogen.



TITAN Grade 2

3.7035 - EN Ti 2 / ASTM B348 and F 67 – CP Titanium Grade 2
For the medicine, micro-engineering, watch making etc.

Figure 2 Achievable mechanical properties of the Titanium 1-4 grades

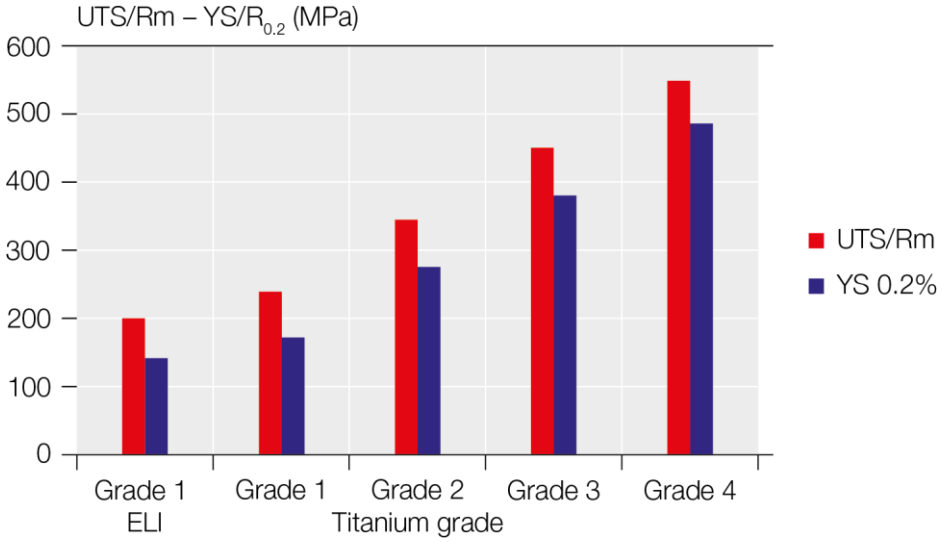


Figure 2 shows the indicative mechanical properties that can be reached by the Titanium CP Grade in the annealed condition.

Pickling

Titan Grade 2 can be pickled with a solution of:
– 10 parts of HCl Hydrochloric acid and
– 1 part of HF Fluor hydric acid.
The proper setting of the dissolution allows controlling the intensity of the pickling with the surface condition to obtain or satisfy.
- Pickling permits to obtain chemically clean surfaces not retaining residual contaminations due to the processing.

Passivation

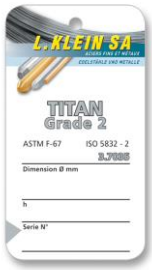
Titanium reacts spontaneously in the presence of oxygen to form a protective passive oxide layer. The thickness of this layer is in the low nanometer range. It provides and warrants the excellent corrosion resistance and biocompatibility of Titan Grade 2.
- Electro polishing of Titan Grade 2 permits to reinforce the passive oxide layer. But its main role is to clean the surface of any residual contaminations that cannot be as efficiently removed by pickling only.

Corrosion resistance

Titan Grade 2 as an excellent corrosion resistance, the highest of all titanium and titanium alloys. It is notably the benchmark reference the reference to be matched or to compared to by all materials for medical applications

Biocompatibility

The biocompatibility of Titan Grade 2 in the human body is excellent and superior to any other materials. It is not allergenic and is the benchmark, or reference to match, or to be compared to by all materials for medical applications, notably implants.



TITAN Grade 2

3.7035 - EN Ti 2 / ASTM B348 and F 67 – CP Titanium Grade 2
For the medicine, micro-engineering, watch making etc.

Figure 3
Anodic oxidation

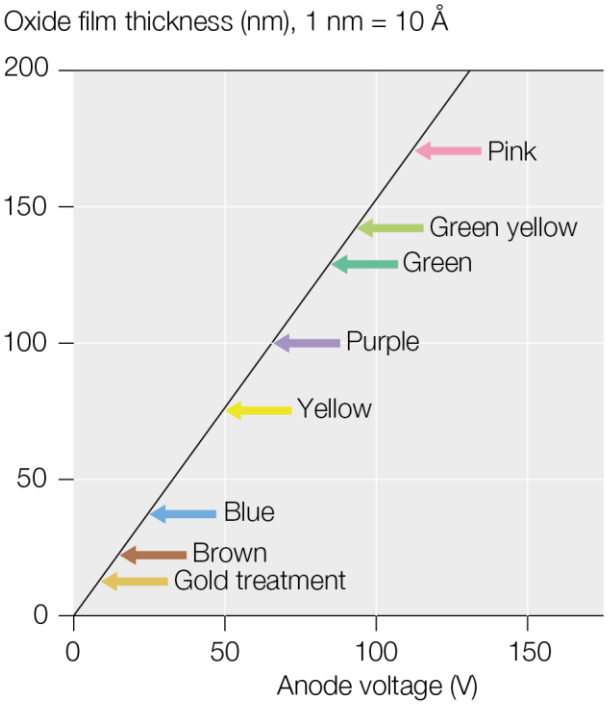


Table 1
Relation between the observed color and the thickness of the oxide layer

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 2 can easily be anodic oxidized in oxidant acid baths, such the phosphoric acid (H_3PO_4) or sulfuric acid (H_2SO_4). As shown by Figure3, 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 colors observed are pure interference colors.

Color spectrum

Table 1 shows that each oxide layer or TiO_2 oxide film thickness has a particular color. The color spectrum is produced by the interference of the incident light by the oxide layer that reflects and refracts it. These colors are not a coloration of the surface, but pure interference colors. They are virtual colors.

Reinforced Biocompatibility

The biocompatibility of Titan Grade 2, and titanium based implants in general, is bound to the capability of titanium to passivize itself spontaneously in presence of oxygen to form a TiO_2 oxide layer. The thickness of this protective passivized film is in the low nanometer range. The excellent biocompatibility of Titan Grade 2 per se, is still reinforced by a thicker anodic oxidation film.

Corrosion resistance

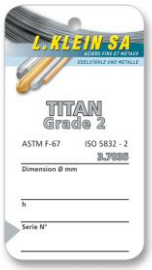
A colored anodic oxide layer does not affect the excellent corrosion resistance of Titan grade 2.

Wear resistance

The anodic oxide layer produced by an anodic oxidation improves the wear resistance of the surface. This favorable behavior can be used to improve the fretting properties of Titan Grade 2 during its forming and cold working processing.

Exploitation of the Color spectrum

The virtual colors of an anodic oxidation can be used for decorative purposes as in jewelry, or for the identification of products made of Titan Grade 2.



TITAN Grade 2

3.7035 - EN Ti 2 / ASTM B348 and F 67 – CP Titanium Grade 2
For the medicine, micro-engineering, watch making etc.

Physical properties

Properties	Unit	Temperature (°C)				
		20	200	300	400	500
Density	g cm^{-3}	4.51				
Young modulus E	GPa	105-110	92	85	78	72
Compression modulus	GPa	110				
Shear modulus	GPa	45				
Poisson coefficient	-	0.31-0.37				
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	20–400°C	20–500°C
	10^{-6}	8.6	8.9	9.5	9.6	9.7
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	$J.g^{-1}.K^{-1}$	0.523				
Emissivity (1-10)	-	0.3				
Visible light						
Reflex ion coefficient	-	0.56				
Melting range	°C	1665-1677				
Allotropic trans us α/ß	°C	913				
α structure cubic centered	°C	≥913				
ß structure hexagonal	°C	≤913				
Magnetic relative						
Relative magnetic						
permeability (µr) at	955 $H.m^{-1}$	1.00005-1.0001				

Disclaimer: The information and data of this informative “Data sheet“ are indicative only. They are not use instructions. The users must define and endorse them in each case.