

Ti Grade 2

Mahesh Enterprises is India's one of the leading Fasteners manufacturers & Suppliers in Grade 2 Titanium. It is called Work Horse of the commercially pure titanium industry, to its varied usability and wide availability. It shares many of the same qualities as Grade 1 titanium, but it is slightly stronger. Both are equally corrosion resistant. This grade possesses good weldability, strength, ductility and formability. This makes Grade 2 titanium bar and sheet are the prime choice for many fields of applications:

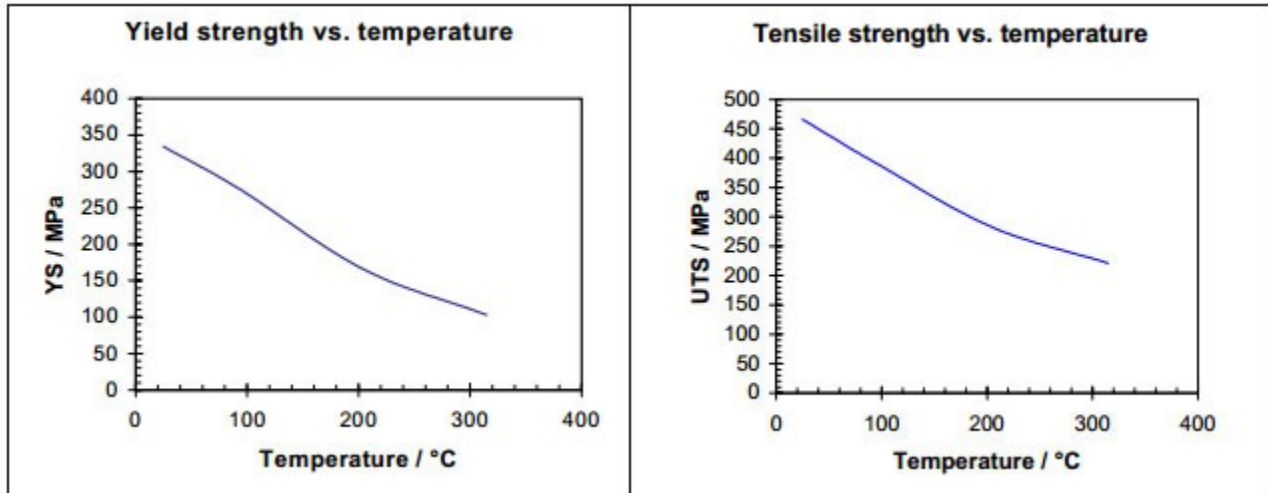
- Architecture
- Power generation
- Medical industry
- Hydro-carbon processing
- Marine industry
- Exhaust pipe shrouds
- Airframe skin
- Desalination
- Chemical processing
- Chlorate manufacturing

Chemical composition:-

O	N	C	H	Fe	Al	V	Ni	Mo	Other	Residuals
0.25	0.05	0.08	0.015	0.30						0.4

Grade 2 is the most widely used titanium alloy in all product forms for industrial service, offering an excellent balance of moderate strength and reasonable ductility. Highly corrosion resistant in highly oxidizing and mildly reducing environments, including chlorides.

Mechanical properties at room temperature	Minimum values	Typical values
Yield Strength	275 MPa	350-450 MPa
Ultimate Strength	345 MPa	485 MPa
Elongation in 50 mm, A5	20 %	28 %
Reduction in Area	30 %	55 %
Hardness		160-200 HV
Modulus of elasticity		103 GPa
Charpy V-Notch Impact		240-82 J



Fatigue properties at room temperature (Stress to cause failure in 10⁷ Cycles) Rotating bend

Smooth K_t=1 230 MPa
 Notch K_t=3 155 MPa

Physical properties

Melting point, ± 15 °C	1660 °C
Density	4.51 g/cm ³
Beta transus, ± 15 °C	910 °C
Thermal expansion, 20 - 100 °C	8.6 *10 ⁻⁶ K ⁻¹
Thermal expansion, 0 - 300 °C	9.7 *10 ⁻⁶ K ⁻¹
Thermal conductivity, room temperature	20.8 W/mK ⁻⁶ K ⁻¹
Thermal conductivity, 400 °C	15 W/mK
Specific heat, room temperature	0.52 J/gK
Specific heat, 400°C	0.60 J/gK
Electrical resistivity, room temperature	56 μW*cm
Poisson's ratio	0.34-0.40

Heat treating		Temperature	Time
Annealing	air-cooled	650-760 °C	6 min - 2 hours
Stress relieving	air-cooled	480-595 °C	15 min - 4 hours

Weldability – excellent

Grade 2 has very good weldability. Being substantially single phase material, the microstructure of the alpha phase is not affected greatly by thermal treatments or welding temperatures. Therefore, the mechanical properties of a correctly welded joint are equal to, or exceed those of the parent metal and show good ductility.

Available mill products

Bar, billet, ingot, extrusions, plate, sheet, strip, tubing, wire, pipe, forging, casting

Typical Applications

For corrosion resistant in the chemical and offshore industries, in aircraft construction where a certain strength level and ease of formability is desired. Also used in heat exchangers, hypochlorite systems, fire water systems, ballast water systems, risers, fittings, flanges, fasteners, forgings, pumps, valves.

Industry specifications - ASTM Grade 2, AMS 4902, JIS Grade 2, TIB, RMI 40, ST-50

Sheet and plate	Bars and billets	Tube	Forging	Casting
ASTM B265 Gr2, MIL-T-9046 CP-3, AMS 4900	ASTM B348 Gr2	ASTM B337 Gr2, ASTM B338 Gr2	ASTM B381 Gr2	ASTM B367 Gr2, ASTM F467 Gr2, ASTM F468 Gr2

Ti Grade 3

Mahesh Enterprises is India's one of the leading Fasteners manufacturers & Suppliers in Ti Grade 3. This grade is least used of the commercially pure titanium grades, but that does not make it any less valuable. Grade 3 is stronger than Grades 1 and 2, similar in ductility and only slightly less formable - but it possesses higher mechanicals than its predecessors. Grade 3 is used in applications requiring moderate strength and major corrosion resistance. These include

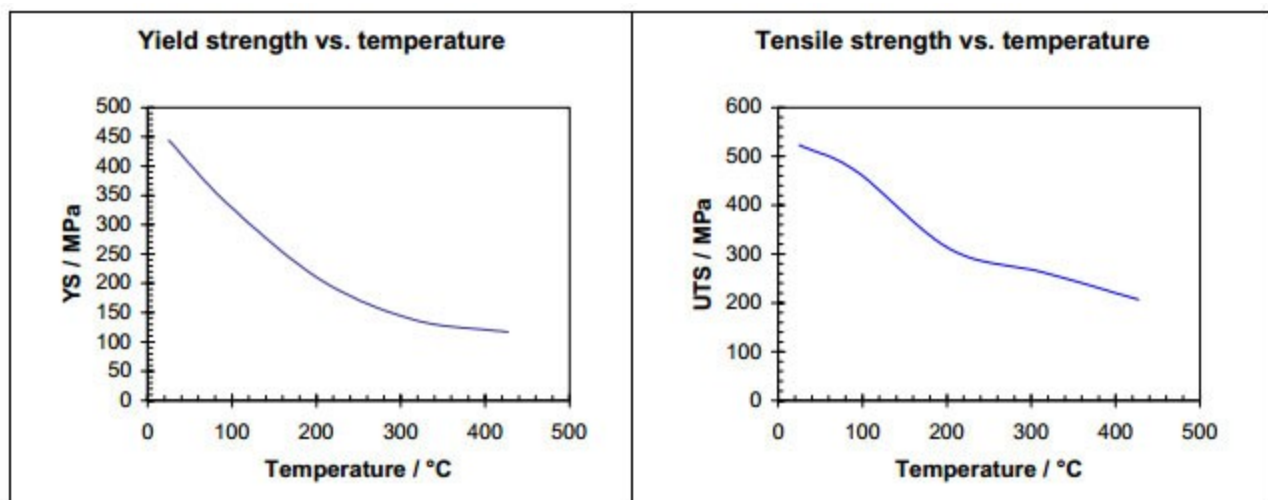
- Aerospace structures
- Chemical processing
- Medical industry
- Marine industry

Chemical composition:-

O	N	C	H	Fe	Al	V	Ni	Mo	Other	Residuals
0.35	0.05	0.08	0.015	0.30						0.4

Unalloyed titanium offering optimum ductility and cold formability with useful strength, high impact toughness, and excellent weldability. Highly corrosion resistant in oxidizing and mildly reducing environments, including chlorides.

Mechanical properties at room temperature	Minimum values	Typical values
Yield Strength	380 MPa	460 MPa
Ultimate Strength	450 MPa	595 MPa
Elongation in 50 mm, A5	18 %	25 %
Reduction in Area	30 %	%
Hardness		180-220 HV
Modulus of elasticity		103 GPa
Charpy V-Notch Impact		24-48 J



Fatigue properties at room temperature (Stress to cause failure in 10⁷ Cycles) Rotating

bend	
Rotating bend	Direct stress limit
Smooth Kt=1 380 MPa	Smooth Kt=1 280 MPa
Notch Kt=3 165 MPa	Notch Kt=3 123 MPa

Physical properties	
Melting point, ± 15 °C	1680 °C
Density	4.51 g/cm ³
Beta transus, ± 15 °C	920 °C
Thermal expansion, 20 - 100 °C	$8.6 \cdot 10^{-6}$ K ⁻¹
Thermal expansion, 0 - 300 °C	$9.2 \cdot 10^{-6}$ K ⁻¹
Thermal conductivity, room temperature	17 W/mK ⁻⁶ K ⁻¹
Thermal conductivity, 400 °C	16 W/mK
Specific heat, room temperature	0.54 J/gK
Specific heat, 400°C	0.60 J/gK
Electrical resistivity, room temperature	56 μ W*cm
Poisson's ratio	0.34-0.40

Heat treating	Temperature	Time
Annealing	air-cooled 650-760 °C	6 min - 2 hours
Stress relieving	air-cooled 480-595 °C	15 min - 4 hours

Weldability – excellent

Grade 3 has very good weldability. Being substantially single phase material, the microstructure of the alpha phase is not affected greatly by thermal treatments or welding temperatures. Therefore, the mechanical properties of a correctly welded joint are equal to, or exceed those of the parent metal and show good ductility.

Available mill products

Bar, billet, ingot, extrusions, plate, sheet, strip, tubing, wire, pipe, forging, casting

Typical Applications

Equivalent to Grade 1 and 2, and eminently suitable where high strength is needed

Industry specifications - ASTM Grade 3, AMS 4900, JIS Grade 3, TIC, RMI 55, ST-70

Sheet and plate	Bars and billets	Tube	Forging	Casting
ASTM B265 Gr3, MIL-T-9046 CP-2, AMS 4900	ASTM B348 Gr3	ASTM B337 Gr3, ASTM B338 Gr2	ASTM B381 Gr3	ASTM B367 Gr3, ASTM F467 Gr3 ASTM F468 Gr3, DIN 3.7055

Ti Grade 4

Mahesh Enterprises is India's one of the leading Fasteners manufacturers & Suppliers in Grade 4. It is known for the strongest of the four grades of commercially pure titanium. It is also known for its excellent corrosion resistance, good formability and weldability. Though it is normally used in the following industrial applications, Grade 4 has recently found a niche as a medical grade titanium. It is needed in applications in which high strength is required:

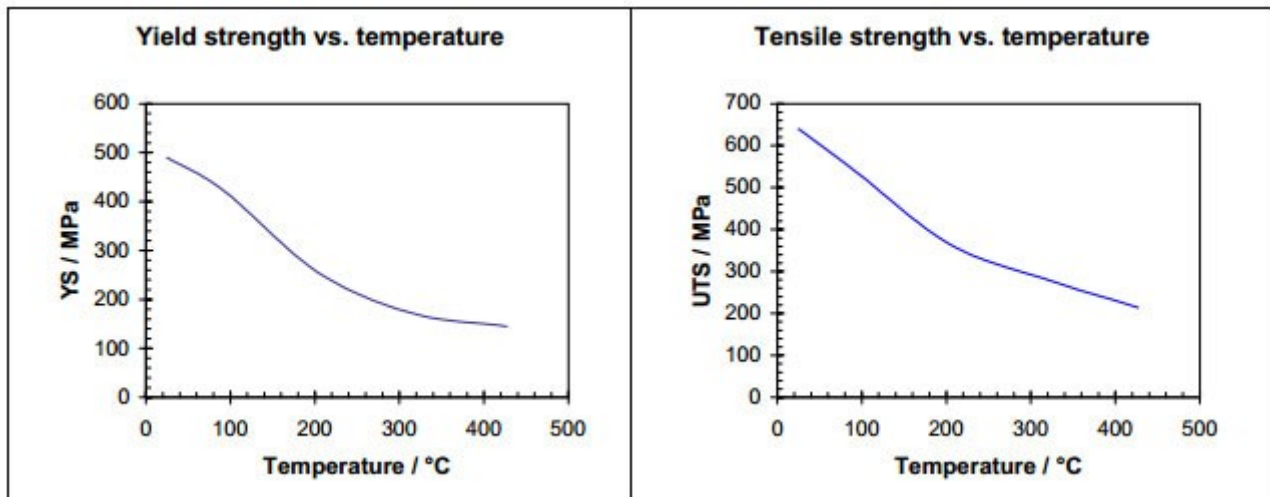
- Airframe components
- Cryogenic vessels
- Heat exchangers
- CPI equipment
- Condenser tubing
- Surgical hardware
- Pickling baskets

Chemical composition:-

O	N	C	H	Fe	Al	V	Ni	Mo	Other	Residuals
0.40	0.05	0.08	0.015	0.50						0.4

Unalloyed titanium offering reasonable high strength with good weldability. Good corrosion resistance in neutral to oxidizing environments, including chlorides.

Mechanical properties at room temperature	Minimum values	Typical values
Yield Strength	485 MPa	560 MPa
Ultimate Strength	550 MPa	685 MPa
Elongation in 50 mm, A5	15 %	23 %
Reduction in Area	30 %	%
Hardness		250 HV
Modulus of elasticity		104 GPa
Charpy V-Notch Impact		13-27 J



Fatigue properties at room temperature (Stress to cause failure in 10⁷ Cycles) Rotating bend

Direct stress limit

Smooth Kt=1 375 MPa

Physical properties

Melting point, ± 15 °C	1660 °C
Density	4.54 g/cm ³
Beta transus, ± 15 °C	950 °C
Thermal expansion, 20 - 100 °C	8.6 *10 ⁻⁶ K ⁻¹
Thermal expansion, 0 - 300 °C	9.2 *10 ⁻⁶ K ⁻¹

Thermal conductivity, room temperature	17.3 W/mK ⁻⁶ K ⁻¹
Thermal conductivity, 400 °C	W/mK
Specific heat, room temperature	0.54 J/gK
Specific heat, 400°C	0.40 J/gK
Electrical resistivity, room temperature	60 μW*cm
Poisson's ratio	0.34-0.40

Heat treating		Temperature	Time
Annealing	air-cooled	650-760 °C	6 min - 2 hours
Stress relieving	air-cooled	480-595 °C	6 min - hours

Weldability – excellent

Grade 4 has very good weldability. Being substantially single-phase material, the microstructure of the alpha phase is not affected greatly by thermal treatments or welding temperatures. Therefore, the mechanical properties of a correctly welded joint are equal to, or exceed those of the parent metal and show good ductility.

Available mill products

Bar, billet, ingot, extrusions, plate, sheet, strip, tubing, wire, pipe, forging, casting

Typical Applications

For corrosion resistance in the chemical and marine industries and for aircraft construction.

Industry specifications - ASTM Grade 4, JIS Grade 4, TID, RMI 70

Sheet and plate	Bars and billets	Forging	Bar, forging and circular forging	Bar, billet and forging blank
AMS 4901, MIL-T-9046 CP- 1	ASTM B348 Gr4	ASTM B381 Gr4	AMS 4921	ASTM F467 Gr4, ASTM F468 Gr4 DIN 3.7065 BSTA 6,7,8,9

Ti Grade 5

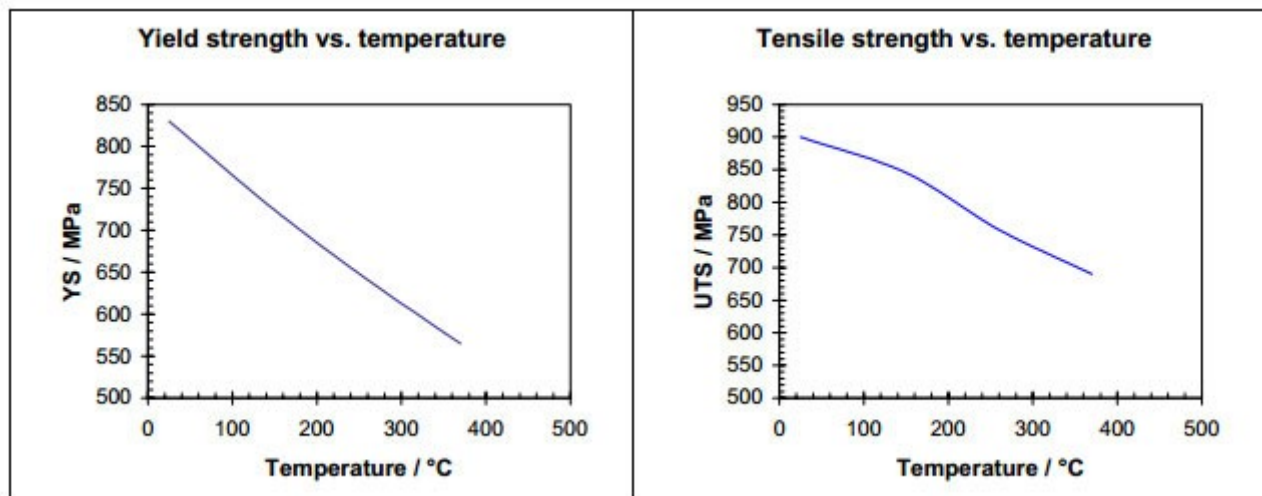
Mahesh Enterprises is India's one of the leading Fasteners manufacturers & Suppliers in Ti Grade 5.

Chemical composition:-

O	N	C	H	Fe	Al	V	Ni	Mo	Other	Residuals
0.20	0.05	0.08	0.015	0.40	5.5-6.75	3.5-4.5				0.4

This is the most widely used titanium alloy. It has very high strength but relatively low ductility. The main application of this alloy is in aircraft and spacecraft. Offshore use is growing. The alloy is weldable and can be precipitation hardened.

Mechanical properties at room temperature	Minimum values	Typical values
Yield Strength	825 MPa	910 MPa
Ultimate Strength	895 MPa	1000 MPa
Elongation in 50 mm, A5	10 %	18 %
Reduction in Area	20 %	%
Hardness		330-390 HV
Modulus of elasticity		114 GPa
Charpy V-Notch Impact		20-27 J



Fatigue properties at room temperature (Stress to cause failure in 10⁷ Cycles) Rotating bend

Smooth Kt=1 430-520 MPa
 Notch Kt=3 MPa

Direct stress limit

Smooth Kt=1 376 MPa
 Notch Kt=3 270 MPa

Physical properties

Melting point, ± 15 °C	1650 °C
Density	4.43 g/cm ³
Beta transus, ± 15 °C	995 °C
Thermal expansion, 20 - 100 °C	9.0 *10 ⁻⁶ K ⁻¹
Thermal expansion, 0 - 300 °C	9.5 *10 ⁻⁶ K ⁻¹
Thermal conductivity, room temperature	6.6 W/mK ⁻⁶ K ⁻¹
Thermal conductivity, 400 °C	13 W/mK
Specific heat, room temperature	0.57 J/gK
Specific heat, 400°C	0.65 J/gK
Electrical resistivity, room temperature	171 μW*cm
Poisson's ratio	0.30-0.33

Heat treating	Temperature	Time
Solution treating temperature	950-970°C	1 hours
Ageing temperature	480-595 °C	4-8 hours
Annealing	710-790 °C	1-4 hours
Stress relieving	480-650 °C	1-4 hours

Weldability – excellent

Since the two-phase microstructure of alpha-beta titanium alloys responds to thermal treatment, the temperatures encountered during the welding cycle can affect the material being welded.

Available mill products

Bar, billet, extrusions, plate, sheet, strip, wire

Typical Applications

Compressor blades, discs and rings for jet engines, aircraft components, pressure vessels, rocket engine cases, offshore pressure vessels.

Industry specifications - ASTM Grade5, ST-AI40, AMS4911D, MIL-T-9047G

Sheet and plate	Bars and billets	Bars, billets and forging (+circular forging)	Extruded products	Castings
ASTM B265 Gr5, AMS 4911	ASTM B348 Gr5	AMS 4928, AMS 4965, AMS 4967	AMS 4935	ASTM B367 Gr5

Ti Grade 7

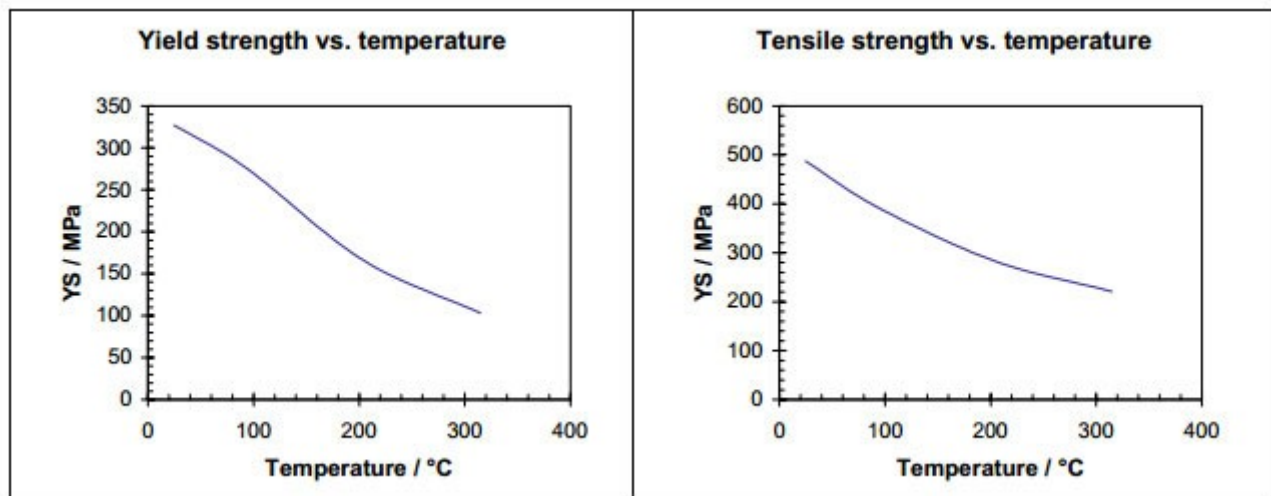
Mahesh Enterprises is India's one of the leading Fasteners manufacturers & Suppliers in Grade 7. It is mechanically and physically equivalent to Grade 2, except with the addition of the interstitial element palladium, making it an alloy. Grade 7 possesses excellent weld ability and formability, and is the most corrosion resistance of all titanium alloys. In fact, it is most resistant to corrosion in reducing acids. Grade 7 is used in chemical processes and production equipment components.

Chemical composition:-

O	N	C	H	Fe	Al	V	Ni	Mo	Pd	Residuals
0.25	0.05	0.08	0.015	0.30					0.12- 0.25	0.40

Most corrosion-resistant titanium alloy offering outstanding resistance to general and localized crevice corrosion in a wide range of oxidizing and reducing acid environments including chlorides, with a good balance of moderate strength, reasonable ductility and excellent weldability. Physical and mechanical properties equivalent to Grade 2.

Mechanical properties at room temperature	Minimum values	Typical values
Yield Strength	275 MPa	350 MPa
Ultimate Strength	345 MPa	485 MPa
Elongation in 50 mm, A5	20 %	28 %
Reduction in Area	30 %	%
Hardness		150 HV
Modulus of elasticity		103 GPa
Charpy V-Notch Impact		40-82 J



Physical properties

Melting point, ± 15 °C	1660 °C
Density	4.51 g/cm ³

Beta transus, ± 15 °C	915 °C
Thermal expansion, 20 - 100 °C	8.6 *10 ⁻⁶ K ⁻¹
Thermal expansion, 0 - 300 °C	9.2 *10 ⁻⁶ K ⁻¹
Thermal conductivity, room temperature	20.8 W/mK ⁻⁶ K ⁻¹
Thermal conductivity, 400 °C	16 W/mK
Specific heat, room temperature	0.52 J/gK
Specific heat, 400°C	0.60 J/gK
Electrical resistivity, room temperature	56 μW*cm
Poisson's ratio	

Heat treating		Temperature	Time
Annealing	air-cooled	650-760 °C	6 min - 2 hours
Stress relieving	air-cooled	480-595 °C	15 min - 4 hours

Weldability – excellent

Grade 7 has very good weldability. Being substantially single phase material, the microstructure of the alpha phase is not affected greatly by thermal treatments or welding temperatures. Therefore, the mechanical properties of a correctly welded joint are equal to, or exceed those of the parent metal and show good ductility.

Available mill products

Bar, billet, ingot, extrusions, plate, sheet, strip, tubing, wire, pipe, forging, casting

Typical Applications

Good corrosion resistance for chemical processing industry applications in which the liquid medium is mildly reducing or varies between oxidizing and reducing. Palladium improves resistance to crevice corrosion. Grade 7 has good formability.

Industry specifications - ASTM Grade7, RMI 0.2 % Pd, TIMETAL 50A Pd, ST-50Pd

Sheet and plate	Bars and billets	Forging	Casting	Tube
ASTM B265 Gr7	ASTM B348 Gr7	ASTM B381 Gr7	ASTM B367 Gr7	ASTM B337 Gr7, ASTM B338 Gr7