TITANIUM alloys

Titanium Metals Corporation

TIMET®

Typical Mechanical properties of *Timetal*® Alloys

	0.2% proof stress MPa Limite élastique à 0.2% MPa 0.2% Streckgrenze MPa	Tensile strength MPa Résistance à la traction MPa Zugfestigkeit MPa	Elongation % Allongement % Bruchdehnung %	Tensile modulus GPa Module d'élasticité GPa Elastizitätsmodul GPa	Fatigue limit % of TS Limite de fatigue % de RT Dauerschwingfestigkeit	Bend radius on 2mm sheet Rayon de pliage sur toles de 2mm Biegeradius bei	Density g/cm³ Densité g/cm³ Dichte g/cm³	Beta Transus ±10C Beta Transus ±10C Beta Transus ±10C
***TIMETAL* 35A**	220	345	35	105-120	50	2t	4.51	890
***TIMETAL* 50A**	345	485	28	105-120	50	2.5t	4.51	915
***TIMETAL* 65A**	450	585	25	105-120	50	2.5t	4.51	920
***TIMETAL* 75A**	560	680	23	105-120	50	3.0t	4.51	950
***TIMETAL* 100A**	430	540	16	105-120	50	–	4.51	960
***TIMETAL* Code 12**	460	600	22	105-120	50	2.5t	4.51	890
***TIMETAL* 230**								
Annealed	510	620	25	105-120	60-65	2.5t	4.56	895
STA	600	760	20	105-120		–		
***TIMETAL* 62S**								
Annealed Sheet/plate and Billet/Bar	960	1000	16	128	60	4.5t	4.44	1024
***TIMETAL* 6-4**								
Sheet	980	1035	12	105-120	55-60	5t	4.42	995
Rod	885	985	15	105-120				
Fastener Stock	1075	1205	14					
***TIMETAL* 3-2.5**	550	650	15	105-120	50	2.5t	4.51	
***TIMETAL* 367**	800*	900*	10*	105-120	55-60	–	4.52	1015
***TIMETAL* 10-2-3**								
Aged Billet/Bar	1170	1260	10	107	75		4.65	800
Aged Billet/Bar	1070	1170	12	108	75			
Aged Billet/Bar	970	1040	15	103	75			
***TIMETAL* 550**								
ST	930	1080	12	110-120	50-60	–	4.60	975
STA	1070	1200	14					
***TIMETAL* 551**								
<25mm	1210	1450	10	110-120	40-50	–	4.60	1050
25-100mm	1200	1310	10					
***TIMETAL* 6-6-2**								
Annealed	1005	1090	10	115	45		4.53	945
STA	1105	1205	8					
***TIMETAL* 15-3**								
Annealed Strip/Sheet	780	825	16	70		2t	4.78	760
Aged(482C)	1210	1300	9	107				
Aged(538C)	1050	1160	11	103	65			
***TIMETAL* 21S**								
Annealed Strip/Sheet	880	915	15	83		2.5t	4.94	800
Aged(538C)	1210	1310	8	102				
Aged(593C)	1035	1100	10	100				
Overaged	860	930	14	99				
***TIMETAL* 6-2-4-2**								
R.T.	895	1000	12	115	50	4.5t	4.54	996
80C	590	700	15					
***TIMETAL* 17**								
Aged Billet/Bar	1100	1180	10	109	75		4.65	800
***TIMETAL* 6-2-4-6**								
R.T.	1100	1200	12	115	50		4.64	940
425C	725	930	15					
***TIMETAL* 679**								
Quenched and aged	970*	1110*	8*	105-110	55-60	–	4.84	950
***TIMETAL* 685**								
R.T.	900	1030	10	~125	50	–	4.45	1020
520C	525	670	12			–	–	–
***TIMETAL* 8-1-1**								
Annealed Sheet	930	1020	13	125	45	4.5t	4.36	1040
***TIMETAL* 829**								
R.T.	860	980	10	~120	50	–	4.51	1015
540C	500	630	13			–	–	–
***TIMETAL* 834**								
R.T.	930	1050	11	~120	50	6t	4.55	1045
***TIMETAL* 1100**								
R.T.	910	1000	8	120	50	6t	4.50	1015
600C	480	620	11					

*Minimum Value, Not Typical

Industry Specifications

	UK Aerospace Grande-Bretagne Aéronautique Großbrittanien Luft-und Raumfahrt	France France Frankreich	Germany Aerospace Allemagne Aéronautique Deutschland Luft-und Raumfahrt	Germany Engineering Allemagne Mécanique Deutschland Maschinenbau	USA Aerospace USA Aéronautique USA Luft-und Raumfahrt	USA Engineering USA Mécanique USA Maschinenbau
***TIMETAL* 35A**	BS TA. 1	T-35	3.7024	3.7025		ASTM Gr. 1
***TIMETAL* 50A**	BS TA. 2, 3, 4, 5	T-40	3.7034	3.7035	AMS 4902, 4941	ASTM Gr. 2
***TIMETAL* 65A**	DTD 5023, 5273	T-50	3.7055		AMS 4900	ASTM Gr. 3
***TIMETAL* 75A**	BS TA. 6	T-60	3.7064	3.7065	AMS 4901	ASTM Gr. 4
***TIMETAL* 100A**	BS TA. 7, 8, 9	T-60	3.7064	3.7065	AMS 4921	
***TIMETAL* Code 12**						ASTM Gr. 12
***TIMETAL* 230**	BS TA. 21, 22, 23	T-U2	3.7124			
***TIMETAL* 62S**						ASTM (Pending)
***TIMETAL* 6-4**	BS TA. 10, 11, 12, 13, 28, 56 DTD 5363	T-A6V	3.7164	3.7165	AMS 4911, 4928 4932, 4935, 4954 4965, 4967	ASTM Gr. 5
***TIMETAL* 3-2.5**						ASTM Gr. 9
***TIMETAL* 367**						
***TIMETAL* 10-2-3**					AMS 4984 AMS 4986 AMS 4987	
***TIMETAL* 550**	BS TA. 45, 46, 47 48, 49, 50, 51, 57	T-A4DE	3.7184			
***TIMETAL* 551**	BS TA. 38, 39, 40 41, 42					
***TIMETAL* 6-6-2**						
***TIMETAL* 15-3**					AMS 4914A	
***TIMETAL* 21S**					AMS G92AP	ASTM Gr. 21
***TIMETAL* 6-2-4-2**					AMS 4919	
***TIMETAL* 17**						
***TIMETAL* 6-2-4-6**						
***TIMETAL* 679**					AMS 4974	
***TIMETAL* 685**	BS TA. 43, 44	T-A6ZD	3.7154			
***TIMETAL* 8-1-1**		T-A8DV			AMS 4915, 4916	
***TIMETAL* 829**						
***TIMETAL* 834**			T-A6EZr4Nb			
***TIMETAL* 1100**						

Product Forms Available from Timet

	Rod Rond Stäbe	Bar Barre Stangen	Billet Bilette Vormaterial	Wire Fil Draht	Plate Plaque Platten	Sheet Tôle Blech	Strip Feuillard Blech auf Band	Tube Tube Rohr	Extrusions Extrusion Profile	Castings Pièces Coulées Gussteile
***TIMETAL* 35A**	■	■	■	■	■	■	■	■	■	■
***TIMETAL* 50A**	■	■	■	■	■	■	■	■	■	■
***TIMETAL* 65A**	■	■	■	■	■	■	■	■	■	■
***TIMETAL* 75A**					■	■	■			
***TIMETAL* 100A**	■	■	■	■					■	
***TIMETAL* Code 12**	■	■	■	■	■	■	■	■	■	
***TIMETAL* 230**	■	■	■	■	■	■			■	
***TIMETAL* 62S**	■	■	■	■	■	■				
***TIMETAL* 6-4**	■	■	■	■	■	■			■	■
***TIMETAL* 3-2.5**	■	■	■	■	■	■	■	■	■	
***TIMETAL* 367**	■	■	■						■	
***TIMETAL* 10-2-3**										
***TIMETAL* 550**	■	■	■		■	■			■	
***TIMETAL* 551**	■	■	■						■	
***TIMETAL* 6-6-2**		■	■							
***TIMETAL* 15-3**		■	■	■	■	■	■	■	■	■
***TIMETAL* 21S**		■	■	■	■	■	■	■		
***TIMETAL* 6-2-4-2**		■	■		■	■			■	■
***TIMETAL* 17**		■	■							
***TIMETAL* 6-2-4-6**		■	■							
***TIMETAL* 679**	■	■	■						■	
***TIMETAL* 685**	■	■	■						■	
***TIMETAL* 8-1-1**	■	■	■		■	■	■			
***TIMETAL* 829**	■	■	■						■	
***TIMETAL* 834**	■	■	■		■	■			■	■
***TIMETAL* 1100**		■	■			■				

CONVERSION KEY:

1 mm = 0.039 in
1 MPa = 0.145 ksi
1 GPa = 0.145 Msi
g/cm³ = 0.0361 lbs/in³
°F = 1.8°C +32

Timet metallurgists have developed a series of propRietary alloys which are widely used

	COMMERCIALLY PURE (CP) GRADES OF TITANIUM
TIMETAL **35A-100A**	The mechanical properties of CP titanium are influenced by small additions of oxygen and iron. By careful control of these additions, the various grades of commercially pure titanium are produced to give properties suited to different applications. *TIMETAL* 35A contains the lowest oxygen and iron levels, producing the most formable grade of material. *TIMETAL* 50A, 65A, 75A, and 100A have progressively higher oxygen contents and correspondingly higher strength levels. Palladium stabilized grades of these materials are also available for enhanced corrosion resistance.
TIMETAL **Code 12**	Highly weldable, near-alpha alloy, exhibiting improved strength and temperature capability over CP combined with superior crevice corrosion resistance and excellent resistance under oxidizing to mildly reducing conditions especially chlorides.
	MEDIUM AND HIGH STRENGTH ALLOYS
TIMETAL **230** (Ti-2.5% Cu)	This binary, age hardening alloy combines the easy formability and weldability of commercially pure titanium with improved mechanical properties, particularly at temperatures up to 350°C.
TIMETAL **62S** (Ti-6% Al-2% Fe-0.1% Si)	Properties and processing characteristics equivalent to or better than *TIMETAL* 6-4, but with significantly higher stiffness (elastic modulus). Due to the use of iron as the beta stabilizer, the alloy has lower formulation costs than *TIMETAL* 6-4. The combination of reasonable cost and excellent mechanical properties make *TIMETAL* 62S a practical substitute for many engineering materials.
TIMETAL **6-4** (Ti-6% Al-4% V)	A versatile medium strength alloy, the "workhorse" *TIMETAL* 6-4 exhibits good tensile properties at room temperature, creep resistance up to 325°C and excellent fatigue strength. It is often used in less critical applications up to 400°C. *TIMETAL* 6-4 is the alloy most commonly used in wrought and cast forms.
TIMETAL **3-2.5** (TI-3% Al-2.5% V)	Cold formable and weldable, this alloy is used primarily for honeycomb foil and hydraulic tubing applications. Industrial applications such as pressure vessels and piping also utilize this alloy. Available with Pd stabilization to enhance corrosion resistance.
TIMETAL **367** (Ti-6% Al-7% Nb)	*TIMETAL* 367 is a dedicated, medium strength, titanium alloy for surgical implants.
TIMETAL **10-2-3** (Ti-10% V-2% Fe-3% Al)	A readily forgeable alloy that offers excellent combinations of strength, ductility, fracture toughness and high cycle fatigue strength. Typically used for critical aircraft structures, such as landing gear.
TIMETAL **550** (Ti-4% Al-4% Mo-2% Sn-0.5% Si)	*TIMETAL* 550, like *TIMETAL* 6-4, is readily forgeable and is generally used in a heat treated condition. It has superior room and elevated temperature tensile strength and fatigue strength compared to *TIMETAL* 6-4, and is creep resistant up to 400°C.
TIMETAL **551** (Ti-4% Al-4% Mo-4% Sn-0.5% Si)	*TIMETAL* 551 has high strength and is creep resistant up to 400°C. It has a similar composition to *TIMETAL* 550, apart from an increase in tin content, which gives increased strength at room and elevated temperatures.
TIMETAL **6-6-2** (Ti-6% Al-6% V-2% Sn-0.5% Fe-0.5% Cu)	*TIMETAL* 6-6-2 offers improved strength properties and greater depth hardenability compared with *TIMETAL* 6-4.
TIMETAL **15-3** (Ti-15% V-3% Cr-3% Sn-3% Al)	Cold formable and weldable, this strip alloy is primarily used for aircraft ducting, pressure vessels and other fabricated sheet metal structures up to 300°C.
TIMETAL **21S** (Ti-15% Mo-3% Nb-3% Al-0.2% Si)	Offers the good cold formability and weldability of a beta strip alloy, but with greatly improved oxidation resistance and creep strength. Aerospace applications include engine exhaust plug and nozzle assemblies.

TITANIUM
MEMBER

HQ-10/97-BG106-4M
Printed in the USA

Titanium Alloys

	HIGH TEMPERATURE ALLOYS
***TIMETAL* 6-2-4-2** (Ti-6% Al-2% Sn-4% Zr-2% Mo-0.08% Si)	*TIMETAL* 6-2-4-2 has good tensile creep and fatigue properties up to 540°C. It is the most commonly used high temperature alloy in jet engine compressors and airframe structures.
***TIMETAL* 17** (Ti-5% Al-2% Sn-4% Mo-2% Zr-4% Cr)	High strength, deep hardenable forging alloy primarily for jet engines. Allows heat treatment to a variety of strength levels in sections up to 6 inches. Offers good ductility and toughness, as well as good low cycle and high cycle fatigue properties.
***TIMETAL* 6-2-4-6** (Ti-6% Al-2% Sn-4% Zr-6% Mo)	*TIMETAL* 6-2-4-6 is a stronger derivative of *TIMETAL* 6-2-4-2 offering higher strength, depth hardenability and elevated temperature properties up to 450°C
***TIMETAL* 679** (Ti-11% Sn-5% Zr-2.25% Al-1% Mo-0.2% Si)	*TIMETAL* 679 has excellent tensile strength and is creep resistant up to 450°C.
***TIMETAL* 685** (Ti-6% Al-5% Zr-0.5% Mo-0.25% Si)	*TIMETAL* 685 possesses excellent tensile strength and creep resistance up to 520°C. It is weldable and has good forging characteristics.
***TIMETAL* 8-1-1** (Ti-8% Al-1% Mo-1% V)	Designed for creep resistance up to 450°C, used primarily in engine applications such as forged compressor blades and disks. This alloy has a relatively high tensile modulus to density ratio compared to most commercial titanium alloys.
***TIMETAL* 829** (Ti-5.6% Al-3.5% Sn-3% Zr-1% Nb-0.25% Mo-0.3% Si)	*TIMETAL* 829 combines creep resistance up to 540°C with good oxidation resistance. It is weldable and like *TIMETAL* 685, *TIMETAL* 829 has good forgeability.
***TIMETAL* 834** (Ti-5.8% Al-4% Sn-3.5% Zr-0.7% Nb-0.5% Mo-0.35% Si-0.06% C)	*TIMETAL* 834 is a near alpha titanium alloy offering increased tensile strength and creep resistance up to 600°C together with improved fatigue strength when compared with established creep resistant alloys such as *TIMETAL* 6-2-4-2, *TIMETAL* 829 and *TIMETAL* 685. Like these alloys, it is weldable and has good forgeability.
***TIMETAL* 1100** (Ti-6% Al-2.7% Sn-4% Zr-0.4% Mo-0.45% Si)	A near alpha, high temperature creep resistant alloy developed for elevated temperature use in the range of 600°C that offers the highest combination of strength, creep resistance, fracture toughness and fatigue crack growth resistance.
	DEVELOPMENTAL ALLOYS
***TIMETAL* 21SR_x**	A development from the alloy *TIMETAL* 21S with the aluminum additions removed and targeted at biomedical applications.
***TIMETAL* LCB**	A metastable beta alloy produced in bar or rod form and targeted at titanium spring and other high strength requirement applications.
TIMETAL 5111	A near alpha alloy with excellent weldability, seawater stress corrosion cracking resistance and high dynamic toughness.

For technical information on these developmental alloys, or technical advice on any *TIMETAL* alloy, please call the following numbers:
Henderson, NV, USA (702) 566-4403 Witton, UK (0)121-356-1155 x308

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