

TIMETAL® 6-4, 6-4 ELI & 6-4-.1Ru

MEDIUM TO HIGH STRENGTH GENERAL-PURPOSE ALLOYS

TIMETAL 6-4 is a general-purpose alpha-beta alloy in widespread use. It contains a favorable balance of properties with moderately high tensile strength, good fatigue strength, with intermediate fracture toughness. Reasonable properties are retained up to about 350°C (660°F). Most properties are affected by the microstructure, which is determined by the thermo-mechanical history. This alloy is hardenable in sections up to 1.0" thick and is weldable by various methods provided the joint area is clean before welding. In most of the welding methods, an inert gas or vacuum environment is required during welding. TIMETAL 6-4 alloy is highly resistant to general corrosion in sea water. This alloy is offered in several variants. The ELI (ASTM Grade 23) variant is available for fracture critical applications. The 0.1Ru ELI variant (ASTM Grade 29) of this alloy is available for enhanced corrosion resistance. TIMETAL 6-4 alloy and its variants has been used in air-frames, jet engine & rocket components, pressure vessels, fasteners, prosthetic implants, geothermal-well casings, automotive components and sports equipment. This alloy is available in most common product forms including billet, bar, wire, plate, and sheet.

TABLE 1

CHEMICAL COMPOSITION

ELEMENT	WEIGHT %					
	TIMETAL 6-4 ASTM Grade 5 Mil T-9047		TIMETAL 6-4 ELI ASTM Grade 23 AMS 4981		TIMETAL 6-4-.1Ru ASTM Grade 29	
	Min.	Max.	Min.	Max.	Min.	Max.
Aluminum	5.5	6.75	5.5	6.5	5.5	6.5
Vanadium	3.5	4.5	3.5	4.5	3.5	4.5
Nitrogen	—	0.05	—	0.03	—	0.03
Carbon	—	0.08	—	0.08	—	0.08
Oxygen	—	0.20	—	0.13	—	0.13
Iron	—	0.40	—	0.25	—	0.25
Hydrogen	—	0.015	—	0.0125	—	0.015
Ruthenium	—	—	—	—	0.08	0.14
Resid. Elements, ea.	—	0.1	—	0.1	—	0.1
Resid. Elements, tot.	—	0.4	—	0.4	—	0.4

FIGURE 1

ELEVATED TEMPERATURE TENSILE PROPERTIES

TYPICAL TENSILE STRENGTHS VS TEMPERATURE

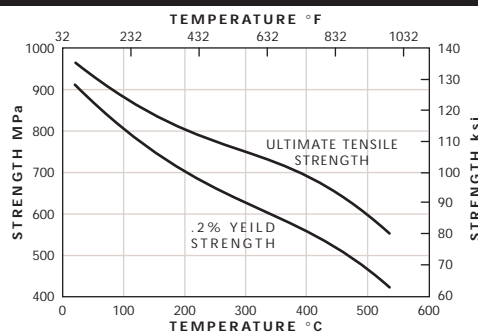


TABLE 2

PHYSICAL PROPERTIES

Property	T (°F)	T (°C)	Value	Value (SI)
Density	72	22	0.160 lb in ⁻³	4.42 g cm ⁻³
Beta Transus	1825±25	996±14		
Melting (liquidus) Point	3000-3020±25	1650-1660±14		
Thermal Conductivity	68	20	3.8 Btu hr ⁻¹ ft ⁻¹ °F ⁻¹	6.6 W m ⁻¹ K ⁻¹
Mil Annealed	600	315	6.1 Btu hr ⁻¹ ft ⁻¹ °F ⁻¹	10.6 W m ⁻¹ K ⁻¹
	1200	650	10.1 Btu hr ⁻¹ ft ⁻¹ °F ⁻¹	17.5 W m ⁻¹ K ⁻¹
Specific Heat	68	20	0.140 Btu lb ⁻¹ °F ⁻¹	0.586 J kg ⁻¹ K ⁻¹
	800	425	0.140 Btu lb ⁻¹ °F ⁻¹	0.586 J kg ⁻¹ K ⁻¹
	1600	870	0.140 Btu lb ⁻¹ °F ⁻¹	0.586 J kg ⁻¹ K ⁻¹
Electrical Resistivity	32	0	66 μΩ·in	1.68 μΩ·m
	600	315	73 μΩ·in	1.86 μΩ·m
	1200	650	74 μΩ·in	1.89 μΩ·m
Magnetic Permeability			1.00005 at 20 oersteds	
Mean Coefficient of Thermal Expansion	32-212	0-100	5.0 x 10 ⁻⁶ in in ⁻¹ °F ⁻¹	9.0 x 10 ⁻⁶ m m ⁻¹ °C ⁻¹
	70-800	20-425	5.2 x 10 ⁻⁶ in in ⁻¹ °F ⁻¹	9.4 x 10 ⁻⁶ m m ⁻¹ °C ⁻¹
	70-1200	20-650	5.4 x 10 ⁻⁶ in in ⁻¹ °F ⁻¹	9.7 x 10 ⁻⁶ m m ⁻¹ °C ⁻¹
Young's Modulus (Dependent on texture and heat treatment)	68	20	15.5-17.7 Msi	107-122 GPa
	450	230	13.8-16.2 Msi	95-111 GPa
Shear Modulus	68	20	5.9-6.5 Msi	41-45 GPa
Poisson's Ratio	68	20	.31	.31



TABLE 3

MINIMUM TENSILE PROPERTIES OF TIMETAL 6-4

Product (in)	Condition	Specification	Dir.	Temperature °F (°C)	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation %	Reduction in Area %
0.025-1.000 Sheet & Plate	Annealed ^a	ASTM B265	L & LT	68 (20)	130 (895)	120 (828)	10 ^b	—
≤3.00 RD or Thk.	Annealed	ASTM B348	L	68 (20)	130 (895)	120 (828)	10	25
≤4.00 RD or Thk.	Annealed	Mil-T-9047G ^c	All	68 (20)	130 (896)	120 (827)	10	25
>4.00-6.00	Annealed	Mil-T-9047G ^c	All	68 (20)	130 (896)	120 (827)	10	20
<0.500	STD ^d	Mil-T-9047G		68 (20)	165 (1137)	155 (1068)	10	20
>0.500-1.000	STD ^d	Mil-T-9047G		68 (20)	160 (1103)	150 (1034)	10	20
>1.000-1.500	STD ^d	Mil-T-9047G		68 (20)	155 (1068)	145 (999)	10	20
>1.500-2.000	rd., sq., hex	Mil-T-9047G		68 (20)	150 (1034)	140 (965)	10	20
>2.000-3.000	rd., sq., hex	Mil-T-9047G		68 (20)	140 (965)	130 (896)	10	20

MINIMUM TENSILE PROPERTIES OF TIMETAL 6-4 ELI

0.025-1.000 Sheet & Plate	ST	ASTM B265	L & LT	68 (20)	120 (828)	110 (759)	10	—
≤3.00 RD or Thk.	Annealed	ASTM B348	L	68 (20)	120 (828)	110 (759)	10	25
≤1.75 RD or Thk.	Annealed ^a	ASTM F136	L	68 (20)	125 (860)	115 (795)	10	25 ^e
1.75-2.50	Annealed ^a	ASTM F136	L & LT	68 (20)	120 (825)	110 (760)	8	20
2.50-4.00	Annealed ^a	ASTM F136	L, LT & ST	68 (20)	120 (825)	110 (760)	8	15

^a 1300°F/1hr/AC or slower. ^b For materials less than .025 thick, the elongation must be negotiated with the manufacturer. ^c Partial list of tensile requirements from the specification. ^d Solution Treat and Age (1650-1775°F)/2-120 min/WQ + 900-1275°F/2-8hr/AC ^e Only for 0.187-<1.75" thick material

FIGURE 2

FATIGUE PROPERTIES

Ti 6Al-4V AXIAL FATIGUE OF UN-NOTCHED STA PLATE

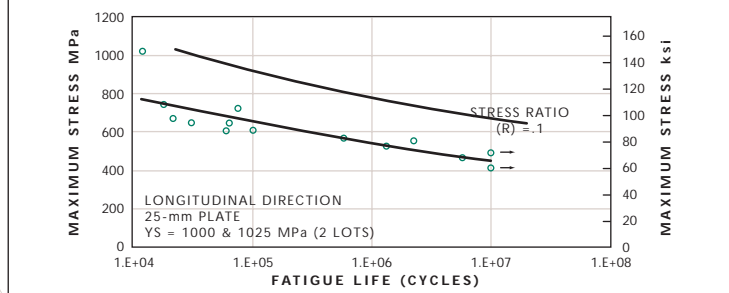
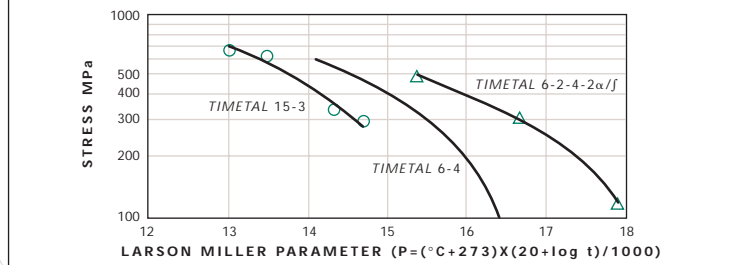


FIGURE 3

CREEP COMPARISON

0.2% CREEP COMPARISON BETWEEN TIMETAL 6-4, TIMETAL® 6-2-4-6 AND TIMETAL® 15-3



The data and other information contained herein are derived from a variety of sources which TIMET believes are reliable. Because it is not possible to anticipate specific uses and operating conditions, TIMET urges you to consult with our technical service personnel on your particular applications.

References

- (1) Timet Booklet, "Properties and Processing Ti-6Al-4V", 1986.
- (2) Boyer, Rodney; Welsch, Gerhard; Collings, E.W., "Ti-6Al-4V", Materials Properties Handbook: Titanium Alloys, pp 483-636, 1994.
- (3) ASTM B265-95a, Titanium and Titanium Alloy Strip, Sheet, and Plate
- (4) ASTM B348-95a, Titanium and Titanium Alloy Bars and Billets
- (5) Mil-T-9047G, Military Specification Titanium and Titanium Alloy Bars (Rolled or Forged) and Reforging Stock, Aircraft Quality
- (6) ASTM F136-96, Wrought Titanium-6 Aluminum-4 Vanadium ELI (Extra Low Interstitial) Alloy (R56401) for Surgical Implant Applications

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