Ti-6Al-2Sn-4Zr-6Mo

TIMETAL® 6-2-4-6

HIGH-STRENGTH INTERMEDIATE TEMPERATURE ALLOY

TIMETAL 6-2-4-6 is an alpha-beta alloy capable of being heat tr eated to higher strengths in greater section sizes than *TIMETAL*® 6-4 alloy. The properties of this alloy are influenced by its thermo-mechanical history. Enhanced strength, ductility, and low-cycle fatigue properties are contained in alpha-beta forged material. Beta-forged material contains the best combination of good low-cycle fatigue and fatigue-crack gr owth resistance. *TIMETAL* 6-2-4-6 alloy is similar in forgeability and crack sensitivity to *TIMETAL* 6-4. This alloy is used in intermediate compr essor stages of turbine engines for disks and blades, seals, and for airframe parts.

TABLE 1

CHEMICAL COMPOSITION

ELEMENT	WEIGHT %			
	Mil T-9047		*AMS 4981*	
	Min.	*Max.*	*Min.*	*Max.*
Aluminum	5.5	6.5	5.50	6.50
Tin	1.75	2.25	1.75	2.25
Zirconium	3.6	4.4	3.50	4.50
Molybdenum	5.5	6.5	5.50	6.50
Iron	—	0.15	—	0.15
Oxygen	—	0.15	—	0.15
Carbon	—	0.04	—	0.04
Nitrogen	—	0.04	—	0.04
Hydrogen	—	0.125	—	0.125
Residual Elements, each	—	0.1	—	0.10
Residual Elements, total	—	0.4	—	0.40

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TABLE 2

PHYSICAL PROPERTIES

Property	*T (°F)*	*T (°C)*	*Value*	*Value SI*
Density	72	22	0.168 lb in^{-3}	4.64 g cm^{-3}
Beta Transus	1715	935		
Melting (liquidus) Point	2900-3050	1595-1675		
Thermal 68-78 Conductivity		20-25	4.40 Btu hr^{-1} ft^{-1} $°F^{-1}$	7.61 W m^{-1} K^{-1}
Specific Heat			0.120 Btu lb^{-1} $°F^{-1}$	502 J kg^{-1} K^{-1}
Electrical 68-78 Resistivity		20-25	75-80.7 μΩ•in	190-205 μΩ•m
Magnetic Nonmagnetic Permeability				
Mean Coefficient of Thermal Expansion	68-212	20-100	5.0 x 10^{-6} in in^{-1} °F	9.0 x 10^{-6} m m^{-1} $°C^{-1}$
Young's Modulus (Dependent on texture and heat treatment)	68 600 800	20 315 425	10-16.5 Msi 15.5 Msi 14.5 Msi	70-114 GPa 107 GPa 100 GPa

TABLE 3

MINIMUM TENSILE PROPERTIES

Material RD or Thk. (in)	*Condition*	*Specification*	*Temperature °F (°C)*	*UTS ksi (MPa)*	*0.2% YS ksi (MPa)*	*Elongation %*	*Reduction in Area %*
≤2.00	DA[c]	Mil T-9047G	68 (20)	160 (1103)	150 (1034)	10	25
2.00-4.00				150 (1034)	140 (965)	8 [6]	20 [15]
≤2.50	STA[d]	Mil T-9047G	68 (20)	170 (1172)	160 (1103)	10	20
>2.50-3.00				165 (1138)	155 (1068)	8 [6]	15 [12]
>3.00-4.00				160 (1103)	150 (1034)	8 [6]	15 [12]

[a] Unless otherwise noted, properties apply in any grain direction. [b] [] values apply to ST for ≥ 3.0 in. material. [c] Duplex Anneal Cycle at 870-900°C (1600-1650°F)/1h/AC + 540-593°C (1000-1100°F)/8h/AC [d] Solution Treated and Aged at 870-925°C (1600-1700°F)/2-90 min/WQ or AC + 480-675°C (1050-1250°F)/4-8hr

TABLE 4

TYPICAL VARIATIONS IN TENSILE PROPERTIES WITH HEAT TREAT CONDITION

% Primary α	*Condition*	*Temperature °F (°C)*	*UTS ksi (MPa)*	*0.2% YS ksi (MPa)*	*Elongation %*	*Reduction in Area %*
10-20	STA[a]	68 (20)	176 (1214)	162 (1118)	13	37
10-20	STOA[b]	68 (20)	160 (1100)	150 (1035)	6	12
40-50	STA[a]		180 (1242)	167 (1152)	14	42
40-50	STOA[b]		166 (1145)	155 (1070)	14	41
β forged	STA[c]		174 (1201)	152 (1049)	6.5	13

[a] Solution Treated and Aged at 885°C(1630°F)/1h/AC + 595°C(1100°F)/8h/AC [b] Solution Treated and Aged at 885°C(1630°F)/1h/AC + 705°C(1300°F)/1h/AC
[c] Solution Treated and Aged at 985°C(1810°F)/1h/AC + 595°C(1100°F)/1h/AC

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TABLE 5

FATIGUE AND TENSILE DATA

Condition	Tensile Yield Strength ksi (MPa)	Ultimate Tensile Strength ksi (MPa)	Elongation %	Reduction in Area %	Fatigue Strength at 10^7 Cycles Smooth ksi (MPa)	Fatigue Strength at 10^7 Cycles Notched ksi (MPa)
10% equiaxed α + annealed[a]	148 (1020)	161 (1109)	15	37	90 (620)	42 (289)
10% equiaxed α + STA[b]	162 (1116)	176 (1213)	13	37	90 (620)	36 (248)
50% equiaxed α + annealed	154 (1061)	164 (1130)	13	34	90 (620)	41 (282)
50% equiaxed α + STA	167 (1151)	180 (1240)	14	42	98 (675)	40 (276)
50% equiaxed α + STOA[c]	155 (1068)	166 (1144)	14	41	90 (620)	38 (262)
50% elongated α + STA	159 (1096)	175 (1206)	10	23	109 (751)	40 (276)
20% elongated α + STA	161 (1109)	175 (1206)	11	26	90 (620)	41 (282)
β forged + STA	152 (1047)	174 (1199)	7	13	98 (675)	38 (262)

[a] Annealed = 705°C (1300°F)/1h/AC. [b] STA = 885°C (1630°F)/1h/AC + 595°C (1100°F)/8hr/AC.
[c] ???? [d] STOA = 885°C (1630°F)/1h/AC + 705°C (1300°F)/1hr/AC.

FIGURE 1

ELEVATED TEMPERATURE TENSILE PROPERTIES

TENSILE STRENGTH OF TRIPLEX ANNEALED* SHEET

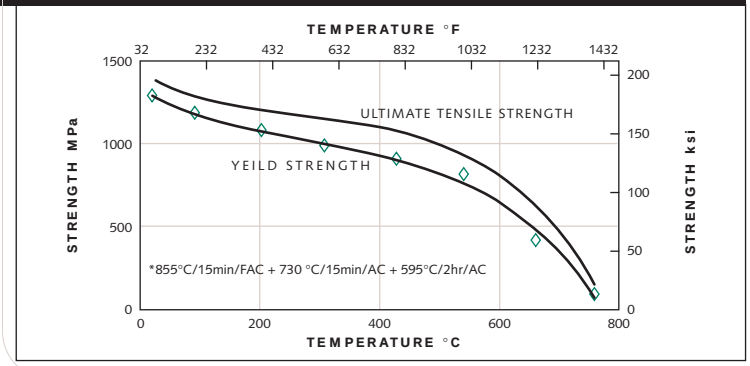
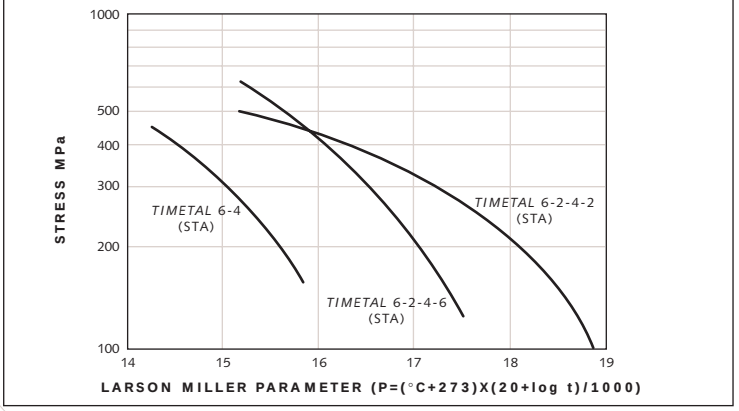


FIGURE 2

CREEP COMPARISON

0.2% CREEP COMPARISON BETWEEN *TIMETAL* 6-2-4-6 AND *TIMETAL®* 6-4



References

(1) Boyer, Rodney; Welsch, Gerhard; Collings, E.W. , "Ti-6Al-2Sn-4Zr—6Mo", Materials Properties Handbook: Titanium Alloys, pp 465 -481(1994).
(2) Mil-T-9047G, "Military Specification Titanium and Titanium Alloy Bars (Rolled or Forged) and Reforging Stock, Aircraft Quality".
(3) AMS 4981C, "Titanium Alloy Bars, Wire, and Forgings 6.0Al-2.0Sn-4.0Zr-6.0Mo Solution and Precipitation Heat Treated" (1990).

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.

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