PROPERTIES OF TITANIUM GRADES

		Commercially Pure	*Commercially Pure*	*Commercially Pure*	*Commercially Pure*	*Commercially Pure*	*Commercially Pure*	*Alpha Alloy*	*Alpha-Beta Alloy*	*Alpha-Beta Alloy*	*Alpha-Beta Alloy*
Designation		**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**	**Grade 7**	**Grade 12**	**Ti--5Al-2.5 Sn**	**Grade 5**	**Ti-3Al-2.5V**	**Ti-6Al-2Sn-4Zr-2Mo**
Chemical Composition (percent)	(Max. values unless range is shown)	0.08C; 0.20Fe; 0.03 N; 0.18O; 0.015H (sheet) 0.0125H (bar) 0.0100H (billet)	0.10C; 0.30Fe; 0.03N; 0.25O; 0.015H (sheet) 0.40O; 0.015H (sheet) 0.0125H (bar) 0.0100H (billet)	0.10C; 0.30Fe; 0.05N; 0.35O; 0.015H (sheet) 0.0125H (bar) 0.0100H (billet)	0.10C; 0.50Fe; 0.05N; 0.0125H (bar) 0.0100 H (billet)	0.10C; 0.30Fe; 0.03N; 0.12/ 0.25Pd; 0.25O; 0.15H(sheet) 0.0125H; (bar)	0.08C; 0.03N; 0.30Fe; 0.015H; 0.25O; 0.2/0.4Mo; 0.6/0.9 Ni	.08C; .50Fe; .05N; .20O_2 4.0/6.0Al; 2.0/3.0Sn H_2.0200(forging, bar, sheet)	.08C;0.25Fe; .05N; 0.20O; 5.50/6.75Al; 3.5/4.5V; 0.0150H(sheet);0.0125H(bar) 0.100H(billet)	0.05C; 0.02N; 0.30Fe; 0.12O; 2.5/3.5Al: 2.0/3.0V 0.0150H(sheet); 0.0125H(bar)	.10C; .25Fe; 0.5N; .15O_2 5.5/6.5Al; 1.8/2.2Sn; 3.6/4.4Zr; 1.8/2.2Mo 0.6-.1Si; 0.125H_2 (bar); 150H_2 (forging)
Mill Annealed Tensile Properties		**Guaranteed Min. R.T.**	**Guaranteed. Min. R.T.**	**Guaranteed. Min. R.T.**	**Guaranteed Min. R.T.**	**Guaranteed Min. R.T.**	**Guaranteed Min. R.T.**	**Guaranteed Min. R.T.**	**Guaranteed Min. R.T.**	**Guaranteed Min. R.T.**	**Guaranteed Min. R.T.**
										Min. Ann. C.W.S.R.*	
Ultimate Strength (psi)		35.000	50.000	65.000	80.000	50.000	70.000	120.000	130.000	90.000 125.000	130.000
Yield Strength (psi) 0.2% offset		25.000	40.000	55.000	70.000	40.000	50.000	115.000	120.000	75.000 105.000	120.000
Elongation in 2"(%) Sheet>0.025 thick		24	20	18	15	20	18	10	10	15 10	10
Reduction in Area (%) Bar		30	30	30	25	25	25	25	25		25
										**C.W.S.R.:Cold Worked Stress Relieved. Tubing only.*	
Mechanical Properties (Typical)				800°F	800°F			800°F 1000°F	600°F 800°F	600°F 800°F	1000°F
Stress to Rupture	Stress (psi)			20.000	17.000						
in Time Shown	Time (hrs.)			100	450			62.000 20.000	98.000 60.000	50.000	50.000
								1.000 1.000	1.000 1.000	100	50hrs.
Stress and Time to	Stress (psi)				8.000						
Produce Elongation	Time (hrs.)				150			48.000 5.000	70.000 32.000	58.000	12.000
Shown (creep)	Creep (%)				.15			100 100	1.000 1.000	1.000	1.000
								0.1 0.1	0.1 0.1	0.1	0.1
Charpy V-Notch Impact (ft.-lbs.) @ Rm. Temp.			25-40	20-40				10-15	10.14		
Bend Radius	Under 0.070" thick	1.5 x Thickness	2.0 x Thickness	2.0 x Thickness	2.5 x Thickness	2.0 x Thickness	2.0 x Thickness	4.0 x Thickness	4.5 x Thickness		4.5 x Thickness
	0.070" and Over	2.0 xThickness	2.5 x Thickness	2.5 x Thickness	3.0 x Thickness	2.5 x Thickness	2.5 x Thickness	4.5 x Thickness	5.0 x Thickness		5.0 x Thickness
Welded Bend Radius		1.5-2.0 x Thickness	2.0-3.0 x Thickness	2.0-3.0 x Thickness	3.0-5.0 x Thickness	2.0-3.0 x Thickness		5.6 x Thickness	6.0-10.0 x Thickness		5.0 x Thickness
Hardness		Rb70	Rb80	Rb90	Rb100	Rb80		Rc36	Rc36		
Physical Properties											
Beta Transus (F± 25)		1630	1675	1690	1740	1675	1634	1900	1830	1715	1820
Coefficient of	32-212	4.8	4.8	4.8	4.8	4.8		5.2	5.0	5.3	4.3
Thermal Expansion	32-600	5.1	5.1	5.1	5.1	5.1	5.3	5.3	5.3	5.5	4.5
(10^6 in./in./Fahrenheit)	32-1000	5.4	5.4	5.4	5.4	5.4		5.3	5.6	5.5	4.5
	32-1200	5.6	5.6	5.6	5.6	5.6		5.4	5.9		
	32-1500	5.6	5.6	5.6	5.6	5.6		5.6	6.1		
Density (lbs./cu.in.)		0.163	0.163	0.163	0.163	0.163	0.163	0.162	0.160	0.162	0.164
Melting Point, Approx. (Fahrenheit)			3040	3020	3020 3020	3020	3020	2910	3200	3100	3100
Electrical Resistivity @ R.T (Microhms cm)		56	56	56	60	56	52	157	171	126	171
Modulus of Elasticity - Tension (10^6 psi)		14.9	14.9	15.0	15.1	14.9	15.0	16.0	16.5	15.0	16.5
Modulus of Elasticity - Torsion (10^6 psi)		6.5	6.5	6.5	6.5	6.5	6.2	7.0	6.1		
Thermal Conductivity (Btu/hr./sq.ft./F/Ft.)		9.0 @ Rm. Temp.	9.5 @ Rm. Temp.	9.5 @ Rm. Temp.	9.8 @ Rm. Temp.	9.5 @ Rm. Temp.	11.0 @ Rm. Temp.	4.5@ Rm. Temp.	3.9 @ Rm. Temp.		
Specific Heat (Btu/Lb./F) @ Rm. Temp.		0.124	0.124	0.125	0.129	0.124	0.13	0.125	0.135		
Weldability		GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	FAIR	GOOD	FAIR
Annealing	Full	1300/30 Min.-2 Hrs.; AC	1300/30 Min.-2 Hrs.; AC	1300/30 Min.-2 Hrs.; AC	1300/30 Min.-2 Hrs.; AC	1300/30 Min. -2Hrs.; AC	1300/30 Min. -2Hrs.; AC	1325-1550/5 Min.-4Hrs.;AC	1300-1450/15Min.-2Hrs.; AC	1200-1400/1 Hr.; AC	Duplex-sheet 1650/30 Min.
Temp. (Fahrenheit)	Stress Relief	1000-1100/30 Min.; AC	1000-1100/30 Min.; AC	1000-1100/30 Min.; AC	1000-1100/30 Min.; AC	1000-1100/30 Min.;Air Cool	1000-1100/30 Min.; Air Cool	1000-1200/15 Min.-1Hr.; AC	900-1200/1-4Hrs.; Air Cool	1000-1200/1 Hr.; Air Cool	900-1200 1-4 Hrs.; AC
Forging	Blocking	1600-1700	1600-1700	1600-1700	1650-1700	1600-1700	1600-1700	1850-1950	1750-1800	1600-1650	1900-1950
Temp. (Fahrenheit)	Finishing	1500-1600	1500-1600	1500-1600	1500-1600	1500-1600	1500-1600	1800-1850	1650-1750	1550-1600	1750-1800
Typical Applications		For corrosion resistance in the chemical and marine industries, and where maximum ease of formability is desired.	For corrosion resistance in the chemical and marine industries, and where maximum ease of formability is desired.	For corrosion resistance in the chemical and marine industries.	For corrosion resistance in the chemical and marine industries.	For corrosion resistance in the chemical industry where media is midly reducing or between oxidizing and reducing.	For corrosion resistance in the chemical industry where media is midly reducing or varies between oxidizing and reducing.	Air frame and jet engine applications requiring good weldability stability and strength at elevated temperatures required.	Jet engine components; air frame forgings; sheet; plate; air frame components.	Air frames and jet engines; hydraulic and fuel lines.	For use where optimum strength and high strength at elevated varies temperatures required.
Industry Specifications		ASTM B265 Gr1 ASTM B348 Gr1 ASTM B337 Gr1 ASTM B338 Gr1 ASTM B381 Gr1 ASTM F67 Gr1 ASTM F467 Gr1 ASTM F468 Gr1	AMS 4902 ASTM B265 Gr2 ASTM B337 Gr2 ASTM B338 Gr2 ASTM B348 Gr2 ASTM B367 Gr2 ASTM B381 Gr2 ASTM F67 Gr2 ASTM F467 Gr2 ASTM F468 Gr2	AMS 4900 ASTM B265 Gr3 ASTM B337 Gr3 ASTM B338 Gr3 ASTM B348 Gr3 ASTM B367 Gr3 ASTM B381 Gr3 ASTM F67 Gr3	AMS 4901; 4921 ASTM B348 Gr4 ASTM B381 Gr4 ASTM F67 Gr4 ASTM F467 GR4 ASTM F468 Gr4	ASTM B265 GR7 ASTM B337 Gr7 ASTM B338 Gr7 ASTM B348 Gr7 ASTM B367 Gr7 ASTM B381 Gr7 ASTM F467 Gr7 ASTM F468 Gr7	ASTM B265 GR12 ASTM B348 Gr12 ASTM B337 Gr12 ASTM B338 Gr12 ASTM B381 Gr12 ASTM F467 Gr12 ASTM F468 Gr12	AMS 4910; 4926; 4966 ASTM B367 Gr6	AMS 4911; 4928; 4930; 4931; 4935; 4965;4967;4985;4991 ASTM B265 Gr5 ASTM B348 Gr5 ASTM B367 Gr5 ASTM B381 Gr5 ASTM F467 Gr5 ASTM F468 Gr5	AMS 4943; 4944; 4945 ASTM B337 Gr9 ASTM B338 Gr9 ASTM B381 Gr9	AMS 4919; 4975; 4976

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PROPERTIES OF TITANIUM GRADES

		Alpha-Beta Alloy	*Alpha-Beta Alloy*	*Alpha-Beta Alloy*	*Beta Alloy*		*Beta Alloy*	*Beta Alloy*	*Beta Alloy*
Designation		**Ti-6Al-2Sn-4Zr-6Mo**	**Ti-8Al-1Mo-1V**	**Ti-6Al-6V-2Sn**	**Ti-3Al-8V-6Cr-4Zr-4Mo**		**Ti-10V-2Fe-3Al**	**Ti-13V-11Cr-3Al**	**Ti-15V-3Cr-3Sn-3Al**
Chemical Composition (percent)	(Max. values unless range is shown)	.10C;.15Fe;.04N;.15O;5.5/6.5Al;1.8/2.2Sn;3.6/4.4Zr;5.5/6.5Mo;.0125H(bar)	.08C;.30Fe;.05N;.12O;7.35/8.35Al;.75/1.25Mo;.75/1.25V;H_2.0125(bar).0150(forging)	.05C;.04N;.20O;5.0/6.0Al;5.0/6.0V;1.5/2.5Sn;.35/1.0Fe;.35/1.0Cu;.0150H_2(bar, sheet, plate)	.05C;.03N;.14O;3.0/4.0Al;7.5/8.5V;5.5/6.5Cr;3.5/4.5Zr;3.5/4.5Mo	(Max. values unless range is shown)	.05C;.05N;.17O_2;.35Fe;2.6/3.4Al;9.0/11.0V;0.0015H_2	.05C;.05N;.17O_2;.35 Fe;12.5/14.5V;10/12Cr;2.5/3.5Al;H_2.250 (bar,billet)	.05C;.03N;.13);.30Fe 14/16V;2.5/3.5Cr;2.5/3.5Sn;2.5/3.5Al;0.150H_2
Mill Annealed Tensile Properties		**Guaranteed R.T. Min. Prop. (S.T.A.)**			**Guaranteed R.T. Min. (S.T.A.)**		**Guaranteed** R.T. Min. Prop. (S.T.A.)	**Guaranteed** R.T. Min. Prop. (S.T.A.)	**Guaranteed** R.T. Min. (S.T.A.)
		1100ºF 8 Hrs. Air Cool			850-1000ºF 8 Hrs. Min. AC		900-950ºF Age	900ºF (2-60 Hr))	1000ºF 8 Hrs. Air Cool
Ultimate Strength (psi)		170,000	130,000	150,000	180,000		170,000	170,000	145,000
Yield Strength (psi) 0.2% offset			160,000	120,000	140,000 170,000		160,000	160,000	140-170,000
Elongation in 2" (5) Sheet>0.025 thick		10		10	6		6	4	7
Reduction in Area (%) Bar		20		20					
Mechanical Properties (Typical)		800ºF 1000ºF	600ºF 800ºF	600ºF			600ºF		
Stress to Rupture	Stress (psi)	110,000				Stress (psi)	140,000		
	Time (hrs.)	100				Time (hrs.)	100		
Stress and Time to Produce Elongation Shown (creep)	Stress (psi)	70,000	82,000 60,000	100,000		Stress (psi)	100,000		
	Time (hrs.)	100	100 100	150		Time (hrs.)	100		
	Creep (%)	0.2	0.2 0.2	0.2		Creep (%)	0.2		
Charpy V-Notch Impact (ft.-lbs.) @Rm. Temp.			15-25	10-14					
Bend radius	Under 0.070" thick		4.0 x Thickness	4.0 x Thickness	3.0 (S/t only)	Under 0.070" thick		3.0 (S/n only)	4 (S/t only)
	0.070" and Over		4.5 x Thickness	4.5 x Thickness	3.5 (S/t only)	0.070" and Over		3.5 (S/n only)	5 (S/t only)
Welded Bend Radius			6-10 x Thickness						
Hardness			R_c36	R_c38					
Physical Properties									
Beta Transus (F ±25)		1720	1900	1735	1460		1460	1325	1400
Coefficient Expansion of Thermal Expansion (10^{-6}in./in./F)	32-21	4.8	4.7	5.0	4.9	32-21	4.9		
	32-600	5.7	5.0	5.2	5.2	32-600	5.2	5.4 (400ºF)	5.4 (400ºF)
	32-1000	5.8	5.6	5.3	5.4	32-1000	5.4	5.9	
	32-1200		5.7						
	32-1500								
Density (lbs./cu.in.)		0.169	0.158	0.164	0.174		0.174	0.175	0.172
Melting Point, Approx. (F)				3100	3000		3000		
Electrical Resistivity (@ R.T. (Microhms cm)			199	157				140/150	
Modulus of Elasticity-Tension (10^6 psi)		16.0	18.5	16.5	15.0		15.0	15.0	13.5/16.5
Modulus of Elasticity- Torsion (10^6 psi)			6.7		6.0		6.0	6.2	
Thermal Conductivity (Btu/hr./sq.ft./F?ft.)		4.1 @ Rm. Temp.		4.2 @ Rm. Temp				4.0 @ Rm. Temp.	
Specific Heat (Btu/l.b./F) @ Rm. Temp.				0.155					
Weldability		LIMITED	FAIR	LIMITED	FAIR		FAIR	GOOD	GOOD
Annealing	Full			1330-1550/2 Hrs. AC or FC	1500/30 Min.-Air Cool	Full	To 1/2 in. thick 1500/30 Min.	1450-15 Min. Air Cool	1450 (Sol Anneal)
	Stress Relief		1100-1200 1 Hr. Air Cool	1100/2 Hrs. Air Cool		Stress Relief		900/4 Hrs. (STA Cond.)	
Forging	Blocking	1600-1650	1850-1950	1650-1750	1600-1700	Blocking	1600-1700	1950-2150	1800-2000
	Finishing	1550-1650	1750-1850	1550-1650	1600-1700	Finishing	1600-1700		1500-1700
Typical Applications		Jet engine components requiring high tensile strength and intermediate creep strength.	Jet engine components requiring good creep strength, high strength at elevated temperatures.	Rocket engine case air frame applications including forgings, fasteners.	Air frame high strength fasteners, rivets, torsion bars, springs, pipe for oil industry and geothermal applications.		High strength air frame components.	High strength air frame components including wire springs.	High strength aircraft and aerospace components.
Industry Specifications		AMS 4981	AMS 4915, 4916, 4972, 4973	AMS 4918, 4936, 4971, 4978, 4979	AMS 4957, 4958		AMS 4983; 4984; 4986; 4987	AMS 4917; 4959	AMS 4914

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