


Typical Properties of Materials

	Tungsten	Molybdenum	Tantalum		Alumina	Mullite
General				General		
Atomic Number	74	42	73	Crystal Size [microns], based on Thin-Section	6	10
Atomic Weight	183.86	95.95	180.95	Water Absorption [%], based on ASTM-373	0	0
Atomic Volume	9.53	9.41	10.9	Gas Permeability	0	0
Lattice Type	Body Centered Cube	Body Centered Cube	Body Centered Cube			
Lattice Constant at 20°C [Å]	3.1585	3.1468	3.3026			
Isotope (Natural)	180, 182, 183, 184, 186	92, 94, 95, 96, 97, 98, 100	181			
Mass				Mass		
Density at 20°C [gm/cc]	19.3	10.2	16.6	Density [gm/cc], based on ASTM-C20	3.92	2.80
Density at 20°C [lb/cu.in.]	0.697	0.368	0.600			
Thermal Properties				Thermal Properties		
Melting Point °C	3410	2610	2996	Thermal Conductivity, 20 °C [Wm/degrees K], based on ASTM-C408	30	3.5
Boiling Point °C	5530	4830	5430	Coefficient of Thermal Expansion, 25-1000 °C [1 x 10-6/degrees C] based on ASTM-C372	8.2	5.3
Linear Coefficient of Expansion per °C	4.3E-06	4.9E-06	6.5E-06	Specific Heat, 100 °C [J/kg*K] based on ASTM-E1269	880	950
Thermal Coefficient at 20°C [cal/cm2.cm°C/sec]	0.40	0.35	0.130	Maximum Use Temperature [°C], based on No-Load Conditions	1750	1700
Specific Heat at 10°C [cal&g/°C]	0.032	0.061	0.036	Thermal Shock Resistance, (delta)Tc [°C] *	200	300
Working Temperature	1700°C down	1600°C down	Room	*Thermal shock resistance -- Test are run by quenching samples into water from various elevated temperatures. The change in temperature where a sharp decrease in flexural strength is observed is listed as (delta)Tc.		
Recrystallization Temperature	1300°C - 1500°C	900°C - 1200°C	1050°C - 1500°C			
Stress Relieving Temperature	1200°C	800°C	900°C			
Mechanical Properties				Mechanical Properties		
Tensile Strength at Room Temperature [psi]	100,000 - 500,000	120,000 - 200,000	35,000 - 70,000	Flexural Strength (MOR), 20 °C	375(54)	170(25)
Tensile Strength, 500°C [psi]	75,000 - 200,000	35,000 - 65,000	25,000 - 45,000	Elastic Modulus, 20 °C [GPa], based on ASTM-F417	370 (54)	150(22)
Tensile Strength, 1000°C [psi]	50,000 - 75,000	20,000 - 30,000	13,000 - 17,000	Poisson's Ratio, 20 °C, based on ASTM-C848	0.22	--
Young's Modulus of elasticity [lb/sq. in.]:				Compressive Strength [MPa], based on ASTM-C773	2500 (363)	550(80)
at Room Temperature	59 x 10E06	46 x 10E06	27 x 10E06	Hardness [GPa(kg/mm ²)], based on KNOOP 1000 gm	14.1 (1440)	7.4(750)
at 500°C	55 x 10E06	41 x 10E06	25 x 10E06	Hardness [GPa(kg/mm2)], based on Rockwell 45 N	83	70
at 1000°C	50 x 10E06	39 x 10E06	22 x 10E06	Tensile Strength, 25 °C [MPa], based on ACMA Test #4	248 (36)	--
Poisson's Ratio	0.284	0.321	0.35	Fracture Toughness K(Ic) [Mpa m ^{1/2}], based on Notched Beam	4-5	2
Spectral Emissivity				Electrical Properties		
(Wave Length approx. 0.65µ)	0.45 (900°C)	0.37 (1000°C)	0.46 (900°C)	Dielectric Stength [ac-kV/mm (acV/mil)], based on ASTM-D116	8.7 (220)	9.8(248)
				Dielectric Constant, 1MHz, 25 °C, based on ASTM-D150	9.8	6
Total Emissivity				Dielectric Loss (tan delta), 1MHz, 25 °C, based on ASTM-D2520	0.0001	0.002
at 1500°C	0.23	0.19	0.21	Volume Resistivity [ohm-cm], based on ASTM-D1829:		
at 2000°C	0.28	0.24	0.26	at 25°C	>10 ¹⁴	>10 ¹⁴
Nuclear - Cross Section				at 500°C	2 x 10 ¹⁰	5 x 10 ¹²
Thermal Neutrons [Barns/atom]	19.2	2.4	21.3	at 1000°C	2 x 10 ⁷	3 x 10 ⁵
Metallography				 <p align="center">Thermo Shield Since 1978 Refractory Fasteners & Materials</p>		
Etchant	Hot H2O2 6% Solution	Alk. K3FE(CN) Solution	HF - NH ₄ F Solution			
Polishing	Emery to 000 levigated alumina to finish					