Metal Material Properties Table 1

※Published data is for reference only

Material / Data / Unit				Metals with high melting point					Alloys				
				Tungsten	Molybdenum	Tantalum	Niobium	Titan	Alloy (W-Cu)	Alloy (Mo-Cu)	Heavy alloy Heavy metal (W-)	Sealing alloy (Kovar)	Sealing alloy (Kovar)
Material symbol				W	Mo	Ta	Nb	Ti	W-Cu	Mo-Cu	W:90%	FeNiCo (sintered)	FeNiCo (HIP)
Component amount [%]				99.9%～99.99%	99.9%～99.99%	99.9%	99.99%	99.8%～99.98%	W:89% Cu:11%	Mo:65% Cu:35%	W:90%	Ni:29% Co:17% Fe:53.5% Mn:0.3% Si:0.2%	Ni:29% Co:17% Fe:53.5% Mn:0.3% Si:0.2%
	Density		[g/cm^3]	19.3	10.2	16.6	8.47	4.54	17.00	9.70	17.0	8.0	8.35
Machining properties	Hardness	Vickers hardness Hv1	[GPa]	4.20	2.60	0.69～1.20	0.50～0.80	1.10(1 type-HR) 1.60(2 type-HR) 2.00(3 type-HR) 2.20(4 type-HR)	3.00	1.70 ※rolled sheet	< 3.20(Hv_{10}) 26(HRC)	1.60	1.50
	Tensile strength	20℃	[MPa]			207	124	270～410(1 type-RT)	> 480	> 280	590	540	540
		600℃	[MPa]			200(100℃)	340～510(2 type-RT)				690 (Compressive		
		800℃	[MPa]			175(200℃)	480～620(3 type-RT)				2.0 impact value		
		1000℃	[MPa]			160(250℃)	550～750(4 type-RT)						
	Yield strength		[MPa]			138	85	>145(1 type-RT) >315(2 type-RT) >345(3 type-RT) >485(4 type-RT)			510	270	270
	Dilation		[%]			20	25	>21(1type-RT) >15(2 type-RT) >14(3 type-RT) >485(4 type-RT)			0.4	35	35
	Flexural rigidity		[GPa]	1900							1.4		
	Young's modulus		[GPa]	403	327	185	103	106	330	220	280	159	159
	Poisson's ratio		-		0.32	0.35	0.38	0.34					
Thermal properties	Max. use temp.	Depending on atmosphere	[℃]	3000	1900	700 and more							
	Recrystallization temperature		[℃]	1150～1350	900～1200	900～1400							
	Melting point		[℃]	3387	2623	3017	2468	1668				1450	1450
	Boiling point		[℃]	5527	4827								
	Linear expansion coefficient	RT	[*10^{-6}/℃]		5.10								
		RT～100℃	[*10^{-6}/℃]	4.5	5.2		7.1	8.4	6.1	8.6	6.0	5.2(200℃) 5.1(300℃)	5.2(200℃) 5.1(300℃)
		RT～500℃	[*10^{-6}/℃]	4.6	5.7	3.6			6.4(300℃)	9.2(300℃)	6.2(300℃)	4.9(400℃) 5.3(450℃)	4.9(400℃) 5.3(450℃)
		RT～1000℃	[*10^{-6}/℃]	4.6	5.75				6.7(450℃)	9.6(450℃)	6.2(450℃)	6.2(500℃)	6.2(500℃)
		RT～1500℃	[*10^{-6}/℃]	5.4(2000℃) 6.6(3000℃)	6.51						6.0		
	Thermal conductivity	20℃	[W/(m·K)]	168	142			17	180	210	90	17	17
		100℃	[W/(m·K)]	159	138	56	52		176	205			
		500℃	[W/(m·K)]	122	122								
		1000℃	[W/(m·K)]	111	105								
		1500℃	[W/(m·K)]	92.98(2000℃)	84								
	Specific heat		[J/(kg·K)]	140(20℃) 140(500℃)	260(20℃) 280(500℃)	78	272	520	160	320		460	460
Electrical characteristics	Electric conductivity		[%I.A.C.S]						> 25	> 47	15		
	Volume resistivity	20℃	[μΩ·cm]	5.5(20℃) 18.0(500℃)	5.7(20℃) 17.6(500℃)	14.7	14.5	47.0	5.3	3.5	12.0	49	49
Magnetic characteristics	Permeability		[Km]								< 1.05		
	Susceptibility		[Xm]								0.00022		
Chemical reactivity	Liquid	hydrochloric acid	Loss	Slightly melts in 100℃ diluted or concentrated hydrochloric acid	Slowly melts in heated diluted hydrochloric acid								
		hydrochloric acid	Loss	no reaction									
		sulfuric acid	Loss	Slightly melts in heated diluted sulfuric acid Melts in concentrated sulfuric acid	Promptly melts in around 200℃concentrated sulfuric acid								
		sulfuric acid	Loss	No reaction in diluted sulfuric acid Melts slightly in concentrated sulfuric acid	Slightly melts in diluted sulfuric acid Slowly melts in 110℃ concentrated sulfuric acid								
		nitric acid	Loss	Slightly melts	Easily melts								
		caustic soda (sodium hydroxide)	Loss		Almost not affected in solution Rapid reaction for molten salt								
		caustic soda (sodium hydroxide)	Loss	Slightly melts in solution Rapid reaction for molten salt	Almost not affected in solution Rapid reaction for molten salt								
	Gas	air or oxygen	Loss	Slightly oxidizes (discoloration) in around 400℃ starts to oxidize	Starts to oxidize in room temperature								
		air or oxygen	Loss	In above 700℃ tungsten trioxide forms and suddenly oxidizes	In above 500℃ molybdenum trioxide forms and suddenly oxidizes								
		vapor	Loss	Promptly oxidizes in red heat state	Starts to oxidize in around 700℃								
		nitrogen	Loss	In about 2300℃ and above forms a nitride	In 600℃ and above embrittles In 1500℃ and above forms a nitride								
		carbon monoxide	Loss	In around 850℃ and above embrittles In about 1000℃ forms a	From about 1000℃ forms a carbide								
		carbon dioxide	Loss	From about 1200℃ forms an oxide	From about 1200℃ forms an oxide								
		hydrogen	Loss	no reaction	no reaction								
		hydrofluoric acid	Loss	Forms a fluoride in room temperature	Slightly melts in room temperature								
		chlorine	Loss	From 250℃ to 300℃ forms a chloride	In 250℃ forms a chloride								
		bromine	Loss	Forms a bromide in red heat state									
		iodine	Loss	Forms an iodide in red heat state	Even in red heat state does not react with iodine								
		ammonia	Loss	Does not react in room temperature	Slightly reacts in room temperature								
		hydrogen sulfide	Loss	Surface reaction occurs while in red heat state	In about 1200℃ forms a sulfide								
	Solid body	sulfur	Loss	Slightly reacts in room temperature	In 600℃ and above forms a sulfide								
		carbon, graphite	Loss	From around 800℃ starts to absorb and embrittles From 1400℃ forms tungsten carbide	In 900℃ starts to embrittle From 1300℃ forms molybdenum trioxide								
Features & applications				High thermal conductivity	High melting point High intensity Electric conductivity Thermal conductivity				Thermal expansion coefficient is variable	Easy to roll or presswork		For sealing hard glass Electronic components	For sealing hard glass Electronic components
Remarks													