Refractory Metals & Alloys

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Molybdenum

Description: Molybdenum's unique properties give rise to processes and applications in electronics, aerospace, nuclear and metal working industries which would not be possible with many of the more common metals and alloys. Some of the more interesting properties of Molybdenum relate to high temperature applications, such as high melting points, excellent high temperature strength, and good thermal and electrical conductivity, low coefficient of expansion and low vapor pressure at elevated temperature.

Applications: In missile industry: nose cones, high temperature structural parts _ nozzles, leading edges of control surfaces, support vanes, re-entry cones, heat radiation shields. In electronics: cathodes, magnetron end hats, x-ray tube components. In high temperature applications: furnace windings, structural furnace members, and containers for components exposed to high temperatures.

TZM Molybdenum

Description: Molybdenum TZM is an alloy of 0.50% Titanium, 0.08% Zirconium and 0.02% Carbon with the balance Molybdenum. TZM alloy is manufactured by either P/M or Arc Cast technologies and is of great utility due to its high strength/high temperature applications, especially above 2000˚F.

TZM has a higher recrystallization temperature, higher strength, hardness and good ductility at room and elevated temperatures than unalloyed molybdenum. In addition, TZM exhibits good thermal conductivity, low vapor pressure, good corrosion resistance and is machinable.

Applications: Structural furnace components; die inserts for casting aluminum; hot stamping tooling; rocket nozzles; glass to metal seals; electrodes.

Tantalum

Description: Tantalum is famous for its resistance to corrosion by acids; in fact, below 150˚C, tantalum is almost completely immune to corrosion by aqua regia. Due to its resistance to attack by body fluids, tantalum provides an excellent material for medical devices. Another major use of tantalum is for electronic components and due to its absorption properties, it is an excellent getter of residual gasses in evacuation tubes.

Applications: Capacitors; surgical implants and instruments; ink jet nozzles.

Niobium aka Columbium

Description: Niobium, also termed Columbium, is a shiny grey metal that takes on a bluish tinge when exposed to air at room temperature. Due to its low capture cross section for thermal neutrons, niobium has application in the nuclear industry. Niobium can be electrically heated and anodized to a wide variety of colors that makes it very attractive in the jewelry industry. Niobium is added to iron or nickel to produce alloys in the aerospace, medical and electronics industries.

Applications: Jet engines, rocket nozzles, semi-conductor equipment, reaction vessels, jewelry.

Tungsten

Description: Many practical applications of Tungsten are based on its high melting point and low vapor pressure. Tungsten not only has the highest melting point, but the lowest vapor pressure of all metals, hence Tungsten is an excellent material for high-vacuum technology and related applications at the highest temperatures. The low thermal expansion combined with its high melting point and great dimensional stability at high temperatures makes Tungsten a highly suitable material for glass seals. Electrical resistance characteristics of Tungsten make it ideal in high temperature furnace construction. Tungsten's high density gives it a high capacity to absorb radioactive radiation.

Applications: High temperature furnaces, arc lamps, welding electrodes, glass to metal seals, vacuum deposition, medical apparatus, lamp components, and lamp filaments.

Rhenium

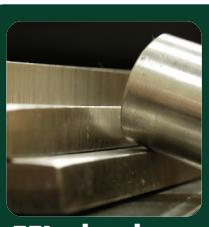
Description: Among the highest density element and melting point, rhenium does not have a ductile to brittle transition temperature and does not form carbides. High resistivity, combined with low vapor pressure, it is an ideal material for filament applications. Excellent resistance to corrosion, resists acid attack and the mechanical effects of electrical erosion. Rhenium has a beneficial effect as an alloying addition with other refractory metals as it greatly enhances the ductility and tensile strength of these alloys.

Applications: Mass spectrometer filaments; grid heaters; cathode cups; thermocouples; nuclear reactors; semiconductors.

Tungsten Alloys

Description: Tungsten alloys, which contain elements such as nickel, copper and iron, produce a host of alloys which have engineering properties similar to steel, are relatively easy to machine, and can be plated or painted to enhance their corrosion protection. These alloys are approximately 50% denser than lead resulting in a higher concentration of mass in a limited area.

Applications: Tungsten alloys have found wide acceptance in applications such as radiation shielding, boring bars, and counterweights in aircraft and racing cars.



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EFI also has a large inventory of Special Purpose Materials, Metals and Alloys for Soft Magnetic, Controlled Expansion and other Applications.

For customers outside of North America, contact
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THE MATERIALS YOU NEED, WHEN YOU NEED THEM

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Physical Properties	UNIT	Molybdenum	TZM Molybdenum	Tantalum	Niobium	Tungsten	Rhenium
Density	lb/cu in	0.37	0.37	0.60	0.31	0.70	0.77
	gm/cm³	10.30	10.22	16.60	8.57	19.27	21.20
Melting Point	°F	4760	4753	5425	4380	6170	5767
	°C	2625	2623	2996	2415	3410	3180
Electrical Resistivity	micro-ohm-cm	5.17	6.85	12.40	13.10	5.50	13.50
Thermal Conductivity	cal/cm²/cm°C/sec	0.35	0.30	0.13	-	0.48	0.39
Specific Heat	Cal/gm/°C	0.061	0.073	0.036	0.065	0.032	0.033
Recrystalization Temp.	°C	1100	1400	-	800	-	-
Coefficient of	in/in/°F x 10⁻⁶	4.9	4.9	6.5	7.1	4.3	6.32
Linear Thermal Expansion	m/m/°K x 10⁻⁶	4.8	4.8	6.3	7.3	4.6	6.8
Mechanical Properties							
Tensile Strength	KSI (Mpa)-RT	150 (1035)	110 (750)	50 (345)	40 (275)	250 (1725)	200 (1380)
	KSI (Mpa)-500°C	75 (515)	-	35 (240)	30 (205)	150 (1035)	135 (930)
	KSI (Mpa)-1000°C	25 (175)	-	15 (100)	10 (70)	75 (515)	70 (480)
Elongation	% (in.) 1.0"	12	15	20	30	-	2
Typical Hardness	DPH (vickers) RC	230	220	200	130	300	-
Modulus of Elasticity	ksi	45,000	48,000	27,000	15,250	58,000	67,150
	Gpa	310	320	185	105	400	483
Chemistry							
minimum %		99.95 Mo	99.20 Mo 0.08 - 0.12 Zn 0.40 - 0.50 Ti	98.99 Ta	99.60 Nb	99.95 W	99.97 Re
Specifications							
	ASTM	B386 type 361 B387 type 361	B386 type 364 B387 type 364	B365 -	B392 B393	- -	- -
	AMS	7800	7817	7849	7850	7898/7899	

TUNGSTEN ALLOY GRADES

EFI GRADE	ASTM B 777-07 GRADE	NOMINAL % TUNGSTEN	NOMINAL DENSITY GM/CC	MINIMUM ULTIMATE TENSILE STRENGTH KSI (MPa)	MINIMUM ELONGATION %	MODULUS OF ELASTICITY (KSI)
EF17	1	90	17.00	110 (758)	5	45,000
EF 17N*	1	90	17.00	94 (648)	2	45,000
EF175	2	92.5	17.50	110 (758)	5	48,000
EF175N*	2	92.5	17.50	94 (648)	2	48,000
EF18	3	95	18.00	107 (738)	3	50,000
EF18N*	3	95	18.00	94 (648)	2	50,000
EF185	4	97	18.50	100 (689)	2	52,000

** N - Non-Magnetic Compositions Note: Typical Hardness for all grades is RC 32 MAX*

FORMS AVAILABLE

	Molybdenum	TZM Molybdenum	Tantalum	Niobium	Tungsten	Tungsten Alloys*	Rhenium
Rod/Wire**	0.001" - 4.0"	0.020" - 2.0"	0.001" - 2.0"	0.001" - 4.0"	0.035" - 2.0"	0.060" & up	0.100" - 4.0"
Sheet	0.005" - 0.187"	0.005" - 0.187"	0.005" - 0.187"	0.010" - 0.125"	0.005" - 0.187"	to order	0.001" - 0.30"
Foil/Strip/Coil	0.001" - 0.030"	-	0.010" - 0.062"	0.010" - 0.070"	-	to order	0.001" - 0.005"
Plate	0.1875" - 1.0"	0.1875" - 0.50"	0.1875" 0.50"	0.187" - 1.0"	0.1875" - 1.0"	to order	0.150" - 0.30"

If you do not see the size or form you required listed above please call us. New stock sizes and forms are added often.
**Tungsten Alloys also available as crankshaft weights, boring bars, and other shapes. **Wire cut to length to your tolerance, concentricity and straightness.*