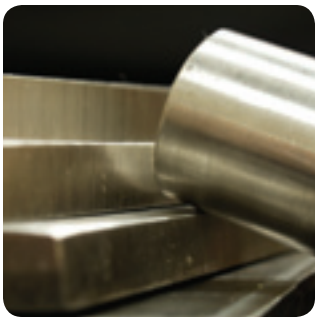
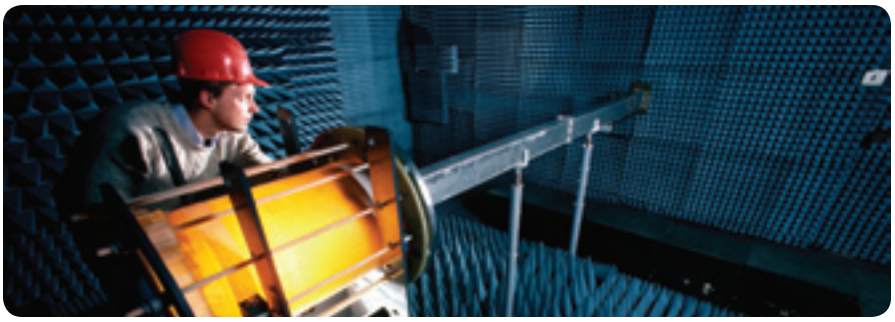
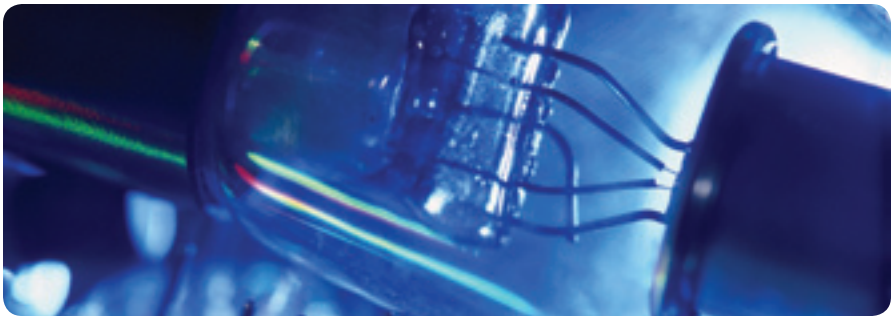
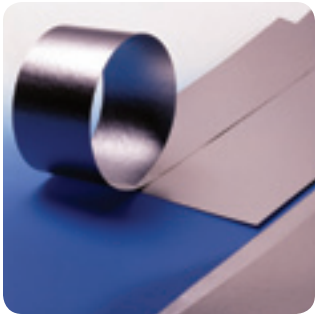
ED FAGAN INC.
Special Purpose Alloys

Controlled Expansion Alloys, Electrical/Electronic Nickel, Soft Magnetic Alloys, and Refractory Metals and Alloys from Stock…









THE MATERIALS YOU NEED, WHEN YOU NEED THEM

If you need specialty metals or special purpose alloys for Aerospace/Aviation, Defense, Electronics, Ceramic, Heat Treating, Magnetic, Medical, Lighting, Optical, Telecommunications, or other high-technology, industrial applications, call Ed Fagan Inc.

EFI has supplied specialty metals, alloys, and hard-to-locate materials to these markets since 1965. We have a large, comprehensive inventory of Controlled Expansion Alloys, Electrical/Electronic Grade Nickel; as well as Soft Magnetic Alloys, and Refractory Metals and Alloys. We stock the highest quality materials available in forms such as: Bar, Rod, Sheet, Plate, Strip, Wire, and Foil... from the highest quality mills such as ThyssenKrupp VDM, Carpenter Technology and Plansee. And, we stock these materials in many gauges, widths/lengths, and conditions for immediate delivery.

Our specialty is solving the inventory management problems of our customers. When you need a standard stock material quickly, we can have it shipped within 24 hours. And, all materials can be certified with shipment. If your material requirement is too small to be of interest to the large producers, we'll use our buying power and expertise to source it for you. When you have a technical problem relating to an application using Controlled Expansion Alloys, Soft Magnetic Alloys, Refractory Metals and Alloys, or any other high-tech material, please call us; our inhouse experts can help you solve your problems. If you have an unusual requirement, for instance alloy, size or grade, our sales people are very knowledgeable and can assist you. If you have a special purpose material that you can't find, if we don't stock it, we'll use our Material-Locator service and try to find it for you.

We also offer Consignment Programs and Custom Stocking Programs to help you cut down your administrative burden, and streamline your manufacturing process. So call us now at 800-348-6268 to place an order or to speak with a materials expert. Or visit our website today, and use our "Request a Quote" link to find out how Ed Fagan Inc. can supply you with the materials you need, when you need them.

JUST IN TIME DELIVERY:
All standard stock items can be **shipped within 24 hours** – and are often **shipped the same day.**
NO ORDER TOO SMALL!

CONTROLLED EXPANSION ALLOYS

ALLOY ASTM F-15

Description: ASTM F-15 Alloy is a controlled expansion alloy consisting of 29% Nickel, 17% Cobalt, and balance Iron. It is produced to ensure good properties for machining and deep drawing as well as porosity free product. Its expansion characteristics match both borosilicate (Pyrex) glasses and alumina ceramics. It is one of the most popular of the controlled expansion alloys for hermetic sealing.

Applications: power tubes, microwave tubes, transistors, diodes, and hybrid packages.

AKA: Kovar[1], Pernifer 2918[2] , Dilvar P1[3] , Rodar[1], NILO K[4]

INVAR[3]

Description: A low expansion alloy, consisting of 36% Nickel, balance Iron. This alloy exhibits extremely low expansion around ambient temperatures and is often used where minimum expansion is required.

Applications: optoelectronics, optical and laser benches, electronics, and scientific instruments.

AKA: Invar 36[1], Pernifer 36[2], NILO 36[4], Invar Steel

ALLOY 52

Description: A controlled expansion alloy, consisting of 51% Nickel, balance Iron; used in a wide variety of electronic applications, especially for glass seals.

Application: Glass to metal seals for electronic tubes, automotive and industrial lamps, and specialty hermetic devices.

AKA: Pernifer 50[2], NILO 50[4], Glass Seal 52[1]

ALLOY 48

Description: A controlled expansion alloy, consisting of 48% Nickel, balance Iron; used in a variety of electronic applications, especially for glass and ceramic seals.

Application: Glass to metal seals for variety of electronic tubes and hermetic devices.

AKA: Pernifer 48[2], NILO 48[4], Glass Seal 48[1]

Footnotes

1. Trademark Carpenter Technology Corp., Reading PA
2. Trademark ThyseenKrupp-VDM, Germany
3. Trademark Imphy Alloys, France
4. Trademark Special Metals Corporation, USA

ALLOY 46

Description: A controlled expansion alloy, consisting of 46% Nickel, balance Iron; used in a variety of electronic applications, especially for glass and ceramic seals.

Application: Glass to metal seals for electronic tubes and hermetic devices.

AKA: Pernifer 46[2], NILO 46, Glass Seal 46[1]

ALLOY 42

Description: A controlled expansion alloy, consisting of 42% Nickel, balance Iron; used in a wide variety of electronic application, lead frames, especially for glass and ceramic seals.

Application: Glass to metal seals for a wide variety of electronic tubes, hermetic packages, and automotive and industrial lamps.

AKA: Pernifer 42[2], NILO 42[4], Glass Seal 42[1]

ALLOY 42-6

Description: A controlled expansion alloy, consisting of 42% Nickel, 6% Chromium, balance Iron; used in a wide variety of electronic applications, especially for glass seals

Application: Glass to metal seals for a variety of electronic tubes and CRT tubes.

AKA: Glass Seal 42-6[1]

CONTROLLED EXPANSION ALLOYS

Physical Properties	Kovar	Alloy 52	Alloy 48	Alloy 46	Alloy 42	Alloy 42-6	Invar 36
DENSITY							
lb/cu in	0.302	0.300	0.298	0.295	0.293	0.293	0.291
SPECIFIC GRAVITY	8.36	8.30	8.25	8.17	8.12	8.12	8.05
CURIE TEMP							
°F	815	986	880	860	716	560	535
°C	435	530	471	460	380	293	279
MELTING POINT							
°F	2640	2600	2600	2600	2600	2600	2600
°C	1449	1427	1427	1427	1427	1427	1427
ELECTRICAL RESISTIVITY							
micro-ohm-cm	49	44	49	47	68	97	84
ohm-cir mil/ft	294	258	290	277	400	570	495
THERMAL CONDUCTIVITY							
W/cm °C	0.17	0.14	0.13	0.11	0.11	0.13	0.10
BTU-in/sq. ft-hr-°F	120.0	97.0	90.0	79.2	74.5	87.0	72.6
SPECIFIC HEAT							
Cal/g-°C	0.11	0.12	0.12	0.12	0.12	0.12	0.123
BTU/lbm-°F	0.11	0.12	0.12	0.12	0.12	0.12	0.123
THERMAL EXPANSION							
ppm/°F (75°F to 842°F)	2.9	5.5	5.0	4.4	3.9	5.9	4.9
ppm/°C (25°C to 450°C)	5.3	9.9	9.0	7.9	7.0	10.6	8.9
Mechanical Properties							
TENSILE STRENGTH							
ksi	75	80	79	80	82	80	75
MPa	518	552	545	552	566	552	518
YIELD STRENGTH							
ksi	40	40	36	35	34	40	40
MPa	276	276	248	242	235	276	276
ELONGATION							
% in 2 in.	30	35	30	30	30	30	34
TYPICAL HARDNESS Ann.							
Rockwell	HRB 80	HRB 80	HRB 80	HRB 80	HRB 80	HRB 80	HRB 80
MODULUS OF ELASTICITY							
Mpsi	30	23	23	23	21.5	23	20.5
kMPa	207	159	159	159	148	159	141
Chemistry							
maximum % unless noted							
Iron	Bal	Bal	Bal	Bal	Bal	Bal	Bal
Nominal Nickel	29	50.5	48	46	41	42	36
Nominal Cobalt	17	-	-	-	-	-	0.5
Carbon	0.02	0.05	0.05	0.05	0.05	0.07	0.05
Silicon	0.20	0.30	0.30	0.30	0.30	-	0.40
Sulfur	-	0.025	0.025	0.025	0.025	0.025	0.015
Chromium	0.20	0.025	0.025	0.025	0.025	5.60	0.25
Titanium							
Magnesium							
Specifications							
ASTM	F-15 / F-1466	F-30	F-30	F-30	F-30	F-31	F-1684
MIL	I-23011 Cl 1	I-23011 Cl 2	I-23011 Cl 3	I-23011 Cl 4	I-23011 Cl 5	I-23011 Cl 6	I-23011 Cl 7
AMS	I-23011 Cl 1	I-23011 Cl 2	I-23011 Cl 3	I-23011 Cl 4	I-23011 Cl 5	I-23011 Cl 6	I-23011 Cl 7

CONTROLLED EXPANSION ALLOYS

FORMS AVAILABLE

	Kovar	*Alloy 52*	*Alloy 48*	*Alloy 46*	*Alloy 42*	*Invar 36*
Rod	0.040″ - 6.0″	0.040″ - 0.250″	*	*	*	0.125″ - 6.0″
Sheet	0.010″ - 0.125″	*	*	*	0.020″ - 0.125″	0.020″ - 0.125″
Plate	0.150″ - 2.0″	*	*	*	*	0.187″ - 4.0″
Strip	0.004″ - 0.070″	0.010″ - 0.030″	*	*	*	*
Coil	0.004″ - 0.070″	0.004″ - 0.031″	*	*	0.005″ - 0.062″	*
Photo-Etch	0.004″ - 0.020″	*	*	*	*	*

**Though not a standard stock item, we may be able to supply you with the exact size, shape & quantities you require. Please call.*

LINEAR COEFFICIENT OF THERMAL EXPANSION *(ppm per °C)*

Deg. °C	**Class 1** *Kovar*	**Class 2** *Alloy 52*	**Class 3** *Alloy 48*	**Class 4** *Alloy 46*	**Class 5** *Alloy 42*	**Class 6** *Alloy 42-6*	**Class 7** *Invar 36*
30-100	—	10.5	9.4	8.2	4.8	—	0.8-1.6
30-150	—	10.5	9.4	8.1	4.6	—	—
30-200	5.5	10.4	9.4	7.9	4.5	—	1.3-2.1
30-250	—	10.4	9.3	7.8	4.5	—	—
30-300	5.1	10.2	8.8	7.5	4.0-4.7	8.2	4.92
30-325	—	—	—	—	4.7	—	—
30-350	—	10.2	9.0	7.1-7.8	5.0	8.5-9.2	6.2-7.0
30-375	—	—	—	7.5	5.5	—	—
30-400	4.6-5.2	10.1	8.2-9.2	7.5	6.0	10.0	7.8
30-425	—	—	8.9	7.6	—	9.7-10.4	—
30-450	5.1-5.5	9.6-10.1	9.0	7.9	6.7-7.4	10.6	8.5-9.2
30-475	—	10.1	9.3	—	—	—	—
30-500	6.2	10.0	9.4	8.2-8.9	8.0	11.2	9.7
30-525	—	10.4	—	—	—	—	—
30-550	—	10.2-10.7	9.6-10.3	9.3	8.8	11.7	—
30-600	7.9	10.8	10.4	9.8	9.5	12.2	11.4
30-700	9.3	11.7	11.3	10.7	10.5	13.0	12.7
30-800	10.4	12.5	12.1	11.6	11.4	13.7	13.5
30-900	11.5	13.3	13.0	12.5	12.3	14.6	13.9
30-1000	—	14.2	13.9	13.4	13.2	15.4	—

ELECTRICAL/ELECTRONIC NICKEL

Physical Properties	Nickel 200	Nickel 201	Nickel 205	Nickel 233	Nickel 270
DENSITY					
lb/cu in	0.321	0.321	0.321	0.321	0.321
SPECIFIC GRAVITY	8.89	8.89	8.89	8.89	8.89
CURIE TEMP					
°F	680	680	680	680	680
°C	360	360	360	360	360
MELTING POINT					
°F	2624	2624	2624	2624	2624
°C	1440	1440	1440	1440	1440
ELECTRICAL RESISTIVITY					
micro-ohm-cm	8.5	8.5	9.5	7.7	7.5
ohm-cir mil/ft	51	51	57	46	45
THERMAL CONDUCTIVITY					
W/cm °C	0.79	0.79	0.75	0.81	0.86
BTU-in/sq. ft-hr-°F	550	550	520	565	600
SPECIFIC HEAT					
Cal/g-°C	0.108	0.108	0.108	0.108	0.108
BTU/lbm-°F	0.108	0.108	0.108	0.108	0.108
THERMAL EXPANSION					
ppm/°F (75°F to 842°F)	7.2 (212°F)	7.2 (212°F)	7.2 (212°F)	7.2 (212°F)	7.2 (212°F)
ppm/°C (25°C to 450°C)	13 (100°C)	13 (100°C)	13 (100°C)	13 (100°C)	13 (100°C)
Mechanical Properties					
TENSILE STRENGTH					
ksi	65	65	65	65	65
MPa	449	449	449	449	449
YIELD STRENGTH					
ksi	20	20	20	20	20
MPa	138	138	138	138	138
ELONGATION					
% in 2 in.	40	40	40	40	40
TYPICAL HARDNESS Ann.					
Rockwell	HRB 80	HRB 80	HRB 80	HRB 80	HRB 80
MODULUS OF ELASTICITY					
Mpsi	30	30	30	30	30
kMPa	207	207	207	207	207
Chemistry					
maximum % unless noted					
Iron	0.25	0.25	0.20	0.20	0.005
Nominal Nickel	99.5	99.5	99.5	99.5	99.97
Nominal Cobalt	-	-	-	-	0.001
Carbon	0.07	0.02	0.07	0.10	0.02
Silicon	0.25	0.25	0.15	0.10	0.001
Sulfur	0.01	0.01	0.008	0.008	0.001
Chromium	-	-	-	-	-
Titanium			0.05	0.005	
Magnesium			0.01- 0.10	0.01- 0.10	
Specifications					
ASTM	B-160 / B-162	B-160 / B-162	F-3 Gr 2	F-3 Gr 3	F-3 Gr 4

NICKEL 200/201/205/233

Description: Commercially pure, un-alloyed Nickel; used in electronics for packaging, leads, and lids.

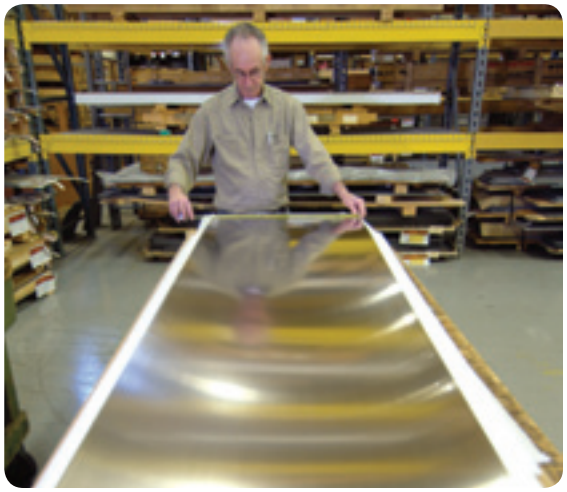
Applications: Electronics industry, getter tabs, heating element sheathing, anodes, special purpose electron tubes, fuel cells, Ni-Cd batteries, transistor enclosures, spark gaps, terminals, anodes, cathode shields, semi-conductor supports, etc.

AKA: The Huntington Alloys

NICKEL 270

Description: Commercially pure, un-alloyed Nickel; used in electronics for packaging, leads, and lids.

Applications: Electronics industry, anode plates, hydrogen thyratron components, passive cathodes, cathode shanks, plater bars, and transistor enclosures.



FORMS AVAILABLE

	Nickel 200/201	Nickel 205/233	Nickel 270
Rod	0.125″ - 3.0″	*	0.125″ - 3.5″
Sheet	0.030″ - 0.125″	*	
Plate	*	*	*
Strip	0.010″ - 0.062″	*	*
Coil	0.010″ - 0.062″	0.010″ - 0.062″	*
Photo-Etch	*	*	*

**Though not a standard stock item, we may be able to supply you with the exact size, shape & quantities you require. Please call.*

SOFT MAGNETIC ALLOYS

EFI ALLOY 79

Description: A soft magnetic alloy consisting of 80% Nickel, 5% Molybdenum, and balance Iron used where extremely high initial & maximum permeability and minimum hysteresis is needed.

Applications: Electro-magnetic shielding, specialty transformer laminations, toroidal tape wound cores, high quality motor laminations, stepping motors.

AKA: Magnifer 7904[2], Carpenter HyMu 80[1], Hipernom[1], Moly-Permalloy, Permalloy 80

EFI ALLOY 50

Description: A soft magnetic alloy, consisting of 49% Nickel, balance Iron used where high initial permeability, maximum permeability, and low core loss is needed.

Applications: Transformer cores, highly efficient motors, shielding, and specialized electronic devices, such as LF power transducers, chokes, relay parts, solenoids & oscillators.

AKA: Magnifer 50[2], Carpenter High Permeability 49[1], Alloy 47-50

RADIOMETAL 4550

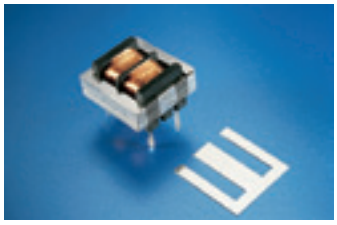
Description: Radiometal 4550 is a Soft Magnetic Alloy consisting of 45% Nickel, balance iron alloy, and has excellent permeability with high saturation flux density.

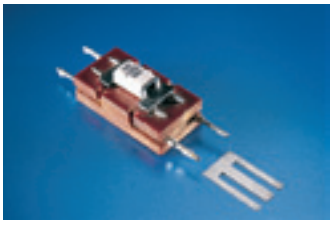
Applications: Sensitive relays that need to respond to very weak currents. Radiometal 4550 is also widely used in transformers, chokes and special motors where the properties of silicon-iron do not provide the required magnetic performance.

Footnotes

1. Trademark Carpenter Technology Corp., Reading PA

2. Trademark ThyseenKrupp-VDM, Germany





HIPERCO 50[1]

Description: An alloy of 49% Cobalt, and 2% Vanadium. This alloy exhibits the highest magnetic saturation of any commercial alloy and excels in applications where this attribute is needed. This alloy has higher mechanical strength than other soft magnetic alloys.

Applications: Electrical generators, pole pieces for electromagnets, magnetic bearings, and high magnetic flux devices and instruments.

VIM VAR CORE IRON

Description: Carpenter VIM VAR Core Iron is a low carbon magnetic iron produced using vacuum induction melting plus vacuum arc remelting practices. Other elements commonly found in low carbon irons are held as low as possible to ensure good DC magnetic properties. This double melting technique controls the distribution of nonmetallic inclusions to a minimum length and frequency so that thin wall sections will not contain leaks due to internal discontinuities.

Applications: Carpenter VIM VAR Core Iron is often used in the manufacture of soft magnetic components where vacuum integrity is needed such as in power tubes and microwave devices. In addition, relays, solenoids, and magnetic pole pieces for scientific instruments may be made utilizing the qualities of VIM VAR Core Iron.

AKA: Carpenter Consumet Core Iron[1]

TYPICAL DC MAGNETIC PROPERTIES

	EFI Alloy 79	*EFI Alloy 50*	*Hiperco 50*	*Vim Var Core Iron*	*Radiometal 4550*
Saturation Induction - Gausses	8,700	14,500	24,200	21,500	16,000
Minimum Mu Max Permeability	230,000	100,000	10,000	10,000	40,000
Coercive Force - Oersteds	0.015	0.06	0.4	1.0	-
Coercive Force - A/m	1.19	4.77	31.83	79.58	8.0

TYPICAL AC MAGNETIC PROPERTIES

	EFI Alloy 79	*EFI Alloy 50*	*Hiperco 50*	*Vim Var Core Iron*
Core Loss W/lb @400Hz & 20k G	N/A	N/A	34	N/A
B-40 Permeability @60 Hz	45,000	6,500	N/A	N/A

N/A = not a typical application value

SOFT MAGNETIC ALLOYS

Physical Properties	UNIT	EFI Alloy 79	EFI Alloy 50	Hiperco 50	Vim Var Core Iron	Radiometal 4550
Density	*lb/cu in*	0.316	0.295	0.293	0.284	0.30
Specific Gravity		8.74	8.18	8.12	7.86	-
Curie Temp	*˚F* *˚C*	860 460	840 450	715 380	1400 760	840 450
Melting Point	*˚F* *˚C*	2650 1454	2600 1427	2600 1427	- -	- -
Electrical Resistivity	*micro-ohm-cm* *ohm-cir mil/ft*	59 349	49 290	41 240	13 78	45 270
Thermal Conductivity	*W/cm ˚C* *BTU-in/sq. ft-hr-˚F*	0.35 240	0.13 90	0.29 200	0.73 508	0.13 89
Specific Heat	*Cal/g-˚C* *BTU/lbm-˚F*	- -	0.12 0.12	- -	0.11 0.11	- 0.11
Thermal Expansion	*ppm/˚F (75˚F to 842˚F)* *ppm/˚C (25˚C to 450˚C)*	7.5 13.6	5.0 9.0	5.6 10.2	8.2 14.7	- -
Mechanical Properties						
Tensile Strength	*ksi* *MPa*	98 676	75 518	118 814	50 345	68 470
Yield Strength	*ksi* *MPa*	38 262	23 159	63 435	27 190	- -
Elongation	*% in 2 in.*	40	40	9	45	-
Typical Hardness	*Rockwell*	HRB 85	HRB 80	HRC 20	HRB 60	-
Modulus of Elasticity	*Mpsi* *kMPa*	31.4 217	24 166	30 207	30 207	24 -
Chemistry						
maximum % unless noted	*Iron*	Bal	49	49 nom.	99.8 nom.	Bal
	Nominal Nickel	80	51	-	0.08	45
	Nominal Cobalt	-	-	49 nom.	-	-
	Molybdenum	5.0 nom.	-	-	-	-
	Carbon	0.03	0.02	0.01	0.02	-
	Manganese	0.95	0.50	-	0.12	-
	Silicon	0.42	0.35	0.05	0.12	-
	Vanadium	-	-	2 nom.	0.05	-
	Niobium	-	-	0.05	-	-
	Phosphorus	0.02	-	-	0.01	-
	Sulfur	0.008	-	-	0.01	-
Specifications						
	ASTM	A753	A753	A801	A848	
	MIL	N-1441C	N-1441C	A47182	-	
	AMS	N-1441C	N-1441C	A47182	-	

FORMS AVAILABLE

	EFI Alloy 79	EFI Alloy 50	Vim Var Core Iron	Hiperco 50	High Perm 49FM	HyMu 80 Unannealed	High Perm 49 Rotor Gr	Radiometal 4550
Rod	0.500″ - 1.5″	0.140″ - 4.0″	0.500″ - 10.25″	*	–	–	–	0.50″ - 2.0″
Sheet	0.010″ - 0.062″	*	–	–	–	–	–	–
Coil	0.004″ - 0.025″	0.004″ - 0.025″	–	0.014″	–	0.006″ - 0.014″	0.007″ - 0.014″	0.015″
Square Bar	1.812″	1.030″ - 2.030″	*	–	1.781″ - 2.030″	–	–	–

*Though not a standard stock item, we may be able to supply you with the exact size, shape & quantities you require. Please call.

**For more specifications see Radiometal 4550 data sheet.

REFRACTORY METALS & ALLOYS

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 elevates 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. In alloyed form, sometimes referred to as heavy metal or alloy, it is used in munitions, radioactive shielding, and counter balances.

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.

REFRACTORY METALS & ALLOYS

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	19.30	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

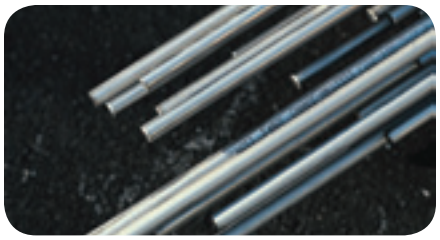
** N - Non-Magnetic Compositions Note: Typical Hardness for all grades is RC 32 MAX*

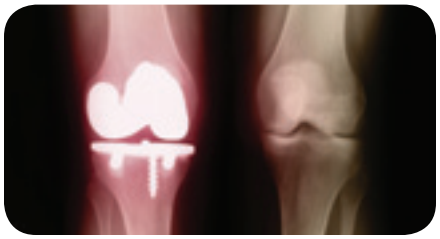
FORMS AVAILABLE

	Molybdenum	TZM Molybdenum	Tantalum	Niobium	Tungsten	Tungsten Alloys*	Rhenium
Rod	0.040″ - 2.0″	0.187″ - 1.0″	0.187″ - 2.0″	0.062″ - 4.0″	0.035″ - 2.0″	0.060″ & up	0.100″ - 4.0″
Sheet	0.005″ - 0.125″	-	0.010″ - 0.125″	0.010″ - 0.125″	0.010″ - 0.250″	to order	0.010″ - 0.125″
Foil / Coil	0.001″ - 0.020″	-	0.010″ - 0.062″	0.010″ - 0.070″	-	to order	0.005″ - 0.060″
Plate	0.187″ - 1.0″	0.187″ - 0.250″	-	0.187″ - 1.0″	0.187″ - 0.750″	to order	0.150″ - 0.500″

**Tungsten Alloys also available as crankshaft weights, boring bars, and other shapes.*

HARD-TO-FIND SPECIAL PURPOSE METALS, ALLOYS & MATERIALS





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