



**ISO 9002**

Certificate Number: 31677

# HIGH DENSITY REFRACTORY METALS SERIES 700

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**"A MULTI-CAPABILITY COMPANY...  
 Specializing in Metals and  
 Metal Products"**

- ELECTRICAL CONTACT MATERIALS AND ASSEMBLIES
- HIGH DENSITY METAL ALLOYS
- CUSTOM MACHINING
- METAL STAMPING AND FORMING
- NON-FERROUS POWDER METALLURGY
- COLD HEADING
- DISC CUTTING
- MECHANICAL ASSEMBLY
- HIGH TECHNOLOGY BRAZING AND TINNING
- CUSTOM RESISTANCE WELDING
- RESISTANCE WELDING DISPOSABLE HARDWARE
- COMPLETE PHYSICAL, CHEMICAL, AND MATERIAL ANALYSIS
- APPLICATIONS ENGINEERING

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 January 1998

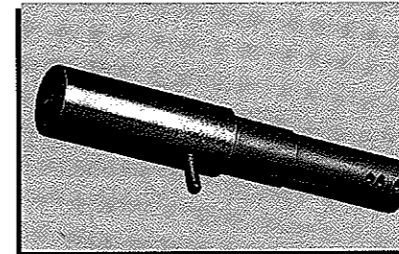
## HIGH DENSITY REFRACTORY METALS

A family of high density metals developed by CMW includes:

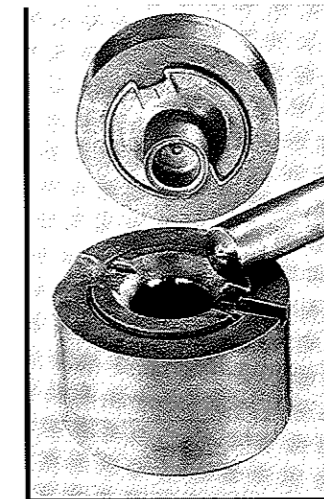
ANVILOY® 1150  
 CMW 1000  
 CMW 2000  
 CMW 3000

CMW 3950  
 CMW 3970  
 ELKONITE® 40W3  
 ELKONITE® 50W3

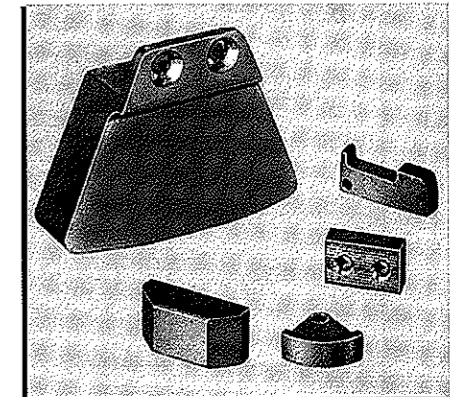
**INTRODUCTION:** These metals have found wide use in aerospace, nuclear and industrial applications.



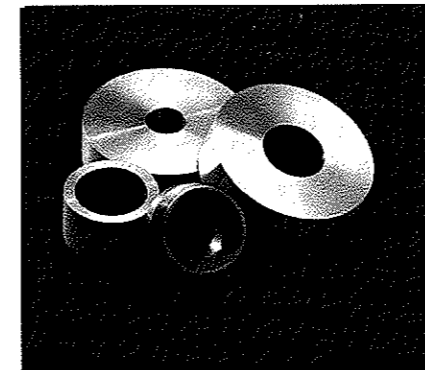
Boring Bars, Grinding Arbors, Quills,  
 Spindles, and Tool Holders  
 (Vibration Damped; NO-CHAT)



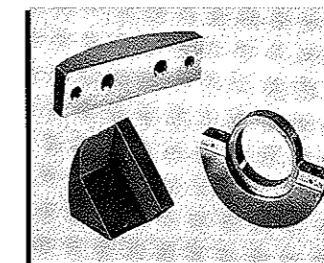
Die Casting Tooling



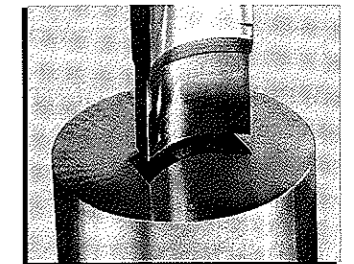
Weights and Counterbalances  
 (maximum weight in confined space)



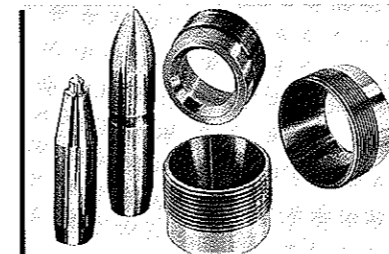
Hot Extrusion Die Inserts



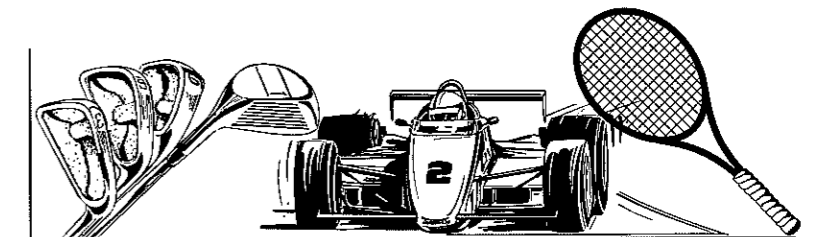
Rotating (High Inertia) Parts  
 (Gyros, Guidance, Flywheels)



EDM/ECM Electrodes



Ordinance (Armor Penetrators,  
 Rocket Nozzles, Shielding)



Sports Applications (Controlled Balance, Ballast, 50% denser than lead)

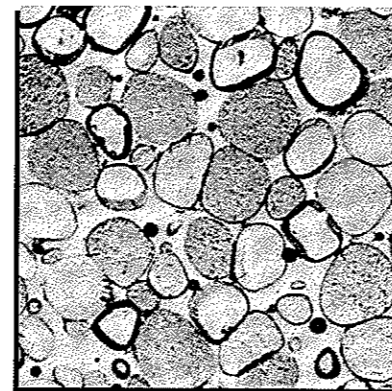
The properties of these unique materials are outlined in this brochure. They may offer the possibilities of solving some of your material problems. If so, CMW can offer you application engineering assistance based on long experience with high density metals.

**CMW high density metals** are a family of tungsten-base materials with densities 50% greater than that of lead. Such additives as copper, nickel, iron and molybdenum, combined with tungsten through powder metallurgy, create materials with unique properties for military and industrial applications. CMW high density metals are more than 85% tungsten, yet are readily machinable.

The range of physical properties exhibited by this family of materials offers the design engineer a wide choice for meeting requirements. Various combinations of density, strength, ductility and magnetic-properties can be selected in developing the basic size and shape and manufacturability of the components involved.

A number of pure metals have high densities. However, all of them have one or more undesirable characteristics:

METAL	DENSITY (gm/cm <sup>3</sup> )	DISADVANTAGES
Osmium	22.48	Costly, limited availability
Iridium	22.42	Costly, limited availability
Platinum	21.45	Costly, limited availability
Tungsten (pure)	19.3	Difficult to machine, brittle
Mercury	13.5	Liquid, difficult to contain, hazardous material
Lead	11.34	Soft, low melting point, low strength, hazardous material



Photomicrograph show typical homogeneous microstructure of CMW 1000.

CMW high density metals overcome these objections by providing a family of materials which combine high strength, good machinability and good availability with high density.

### WHY USE CMW HIGH DENSITY METALS?

#### WEIGHTS AND COUNTERBALANCES

In confined spaces where mass is required for balance, CMW high density metals are often specified. Parts are easily machined to fit the space available. Tennis rackets, golf clubs, and even race cars can be given just the right "feel" or balance to maximize performance.

#### RADIATION SHIELDING

CMW high density metals are effective shielding materials for gamma rays and X-rays.

#### ROTATING INERTIA MEMBERS

Precision-machined homogeneous structural members of CMW high density metals can provide more momentum in a limited space.

#### ORDNANCE

The high density, high strength and ductility, good machinability and low erosion properties of CMW high density materials meet the requirements of many military applications.

#### TOOLING

CMW high density materials meet the requirements of many tooling applications. Such properties as rigidity, low thermal fatigue, good erosion resistance, high temperature strength and good machinability are some of the benefits of these materials.

## SIZE AND AVAILABILITY

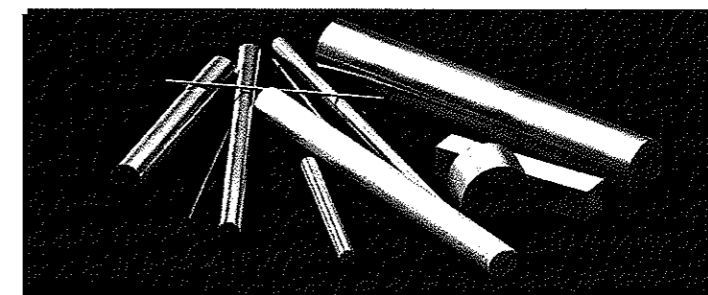
CMW can fabricate high density metal parts in many sizes and configurations. Most parts are produced on special order, but some popular sizes are stocked. The most confining restriction is that the maximum single piece weight is 125 lbs. [50 kg]. This is equivalent to about 0.1 cu ft. or 2500 cm<sup>3</sup> of these materials. Larger items may be constructed by joining smaller pieces.

The range of sizes suitable for normal manufacturing is shown below.

MATERIAL	ROD	ROUND BAR	RECTANGLE
CMW 1000 CMW 2000 CMW 3950 CMW 3970	0.093" to 0.187" [2.36 mm to 4.75 mm] diameter	0.125" to 4" [3.18 mm to 102 mm] diameter	0.187" to 4" [4.75 mm to 102 mm] thick 4" [10.2 cm] max width 12" [39.5 cm] max length
CMW 3000	0.093" to 0.187" [2.36 mm to 4.75 mm] diameter	0.125" to 2" [3.18 mm to 51 mm] diameter	0.187" to 2" [4.75 mm to 51 mm] thick 4" [10.2 cm] max width 12" [39.5 cm] max length
Anviloy® 1150	0.093" to 0.187" [2.36 mm to 4.75 mm] diameter	0.125" to 4" [3.18 mm to 102 mm] diameter	0.187" to 2.25" [4.75 mm to 57.2 mm] thick 4" [10.2 cm] max width 12" [39.5 cm] max length
Elkonite® 40W3 Elkonite® 50W3	0.093" to 0.187" [2.36 mm to 4.75 mm] diameter	0.187" to 1.5" [4.75 mm to 3.8 mm] diameter	0.187" to 1.5" [4.75 mm to 3.8 mm] thick 2.5" [6.35 cm] max width 3.5" [8.9 cm] max length

All stock items are supplied ROTF (Rough Oversize To Finish) within dimensional ranges listed. These materials are readily machined.

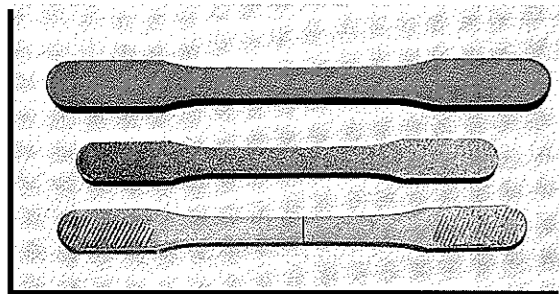
Inquiries for larger sizes and special shapes are invited.



## CHARACTERISTICS OF CMW HIGH DENSITY METALS

The CMW high density materials give the design engineer a good variety of density, tensile, elongation and low magnetic properties. CMW 1000 and CMW 2000 offer density choices of about 17 and 18 g/cm<sup>3</sup> respectively.

More ductility and higher tensile properties can be obtained by using the 3000 series of CMW high density materials. For absolute minimal magnetic properties, CMW Elkonites® 40W3 and 50W3 should be selected. Anviloy® 1150 offers the highest tensile properties with good thermal fatigue resistance. Coupled with excellent wear resistance, it is a superior substitute for many hot work tool steels.



The high ductility of CMW 3000 is illustrated by ASTM "Flat Unmachined Test Bars" shown here.

Top - as pressed to die size

Center- sintered and heat treated

Bottom - tension tested to fracture

Typically an 18% elongation is realized in the one inch [2.54 cm] gauge of the reduced section

The following industrial and military specifications are met by CMW high density materials as listed below:

	AMS-7725	MIL-T-21014D / ASTM B777			
		Class 1	Class 2	Class 3	Class 4
CMW 1000	X	X			
CMW 2000				X	
CMW 3000	X	X			
CMW 3950				X	
CMW 3970					X

## OXIDATION RESISTANCE

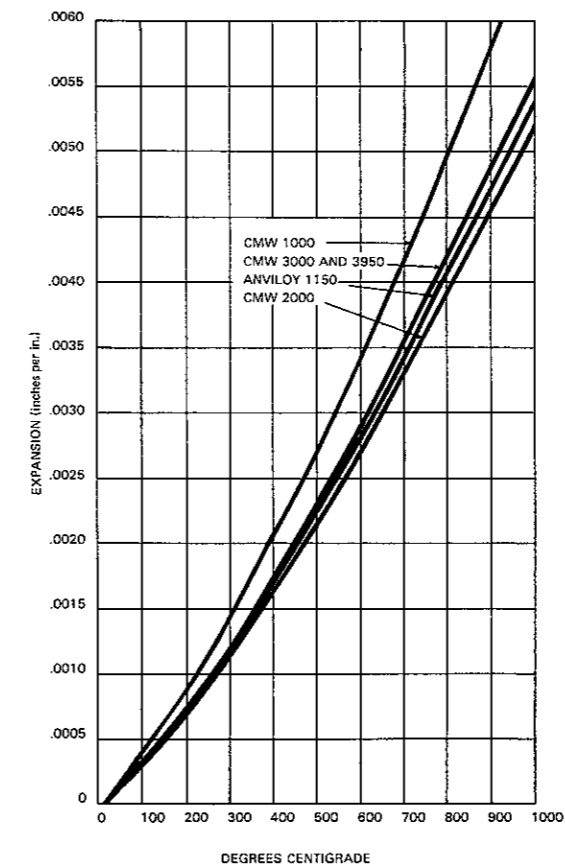
CMW high density metals can be subjected to temperatures as high as 400°C in air without appreciable weight gain, although an adherent blue-black film is formed. Above this temperature, a yellow film is formed and a weight gain takes place. This film flakes to permit further oxidation. Oxidation resistance can be substantially improved by plating. Nickel plated parts will withstand exposure to 1000°C in air without appreciable change. CMW can supply parts with the appropriate plate or finish as required.

## THERMAL FATIGUE

A combination of high thermal conductivity (3 times many tool steels) with low thermal expansion makes Anviloy® 1150 and other CMW high density materials top choice for high temperature die casting tools and hot extrusion dies. Longer life and higher product quality are the benefits.

## THERMAL EXPANSION

All CMW high density materials are characterized by a relatively low and stable thermal expansion curve (compared to other metallic alloys). The following curves illustrate thermal expansion characteristics of five CMW high density metals.



## CORROSION RESISTANCE

CMW high density metals have excellent resistance to corrosive agents such as hydrochloric acid. They offer up to twice the corrosion resistance of 18-8 stainless steel. All tungsten base metals undergo some corrosion. The rate of corrosion will accelerate with higher humidity and temperatures. Physical properties of the metal are not affected.

Galvanic corrosion may occur when CMW high density metals are in contact with other metals. A protective electroplate may be required if a coating of lanolin will not offer sufficient protection. When CMW high density metals must be attached to aluminum surfaces, cadmium plating is used to prevent galvanic reaction.

EMF OF CMW 1000 AND COMMON METALS IN ACID SOLUTION					
Metal	Ion	EMF	Metal	Ion	EMF
Al	Al <sup>+++</sup>	1.66	Ni	Ni <sup>++</sup>	0.25
Ti	Ti <sup>++</sup>	1.63	Mo	Mo <sup>++</sup>	0.20
Zr	Zr <sup>++++</sup>	1.53	Sn	Sn <sup>++</sup>	0.14
Zn	Zn <sup>++</sup>	0.76	W	W <sup>+++</sup>	0.11
Cr	Cr <sup>+++</sup>	0.74	H <sub>2</sub>	H <sup>+</sup>	0.00
Fe	Fe <sup>++</sup>	0.44	CMW 1000	—	-0.067
Cr	Cr <sup>++</sup>	0.41	Cu	Cu <sup>++</sup>	-0.34
Cd	Cd <sup>++</sup>	0.40	Hg	Hg <sub>2</sub> <sup>++</sup>	-0.79
Co	Co <sup>++</sup>	0.28	Ag	Ag <sup>+</sup>	-0.80

# TYPICAL PROPERTIES OF CMW® HIGH

# DENSITY REFRACTORY METALS

	Unit [SI]	Temperature	CMW 1000 (aka NO-CHAT) W 90%, Ni 6% Cu 4%	CMW 2000 W 95%, Ni 3.5% Cu 1.5%	CMW 3000 W 90%, Ni 7% Fe 3%		CMW 3950 W 95%, Ni 3.5% Fe 1.5%	CMW 3970 W 97%, Ni 2.1% Fe 0.9%	Anviloy® 1150 W 90%, Ni 4% Fe 2%, Mo 4%	Elkonite® 40W3 W 87%, Cu 13%	Elkonite® 50W3 W 90%, Cu 10%	Unit [SI]	
PHYSICAL PROPERTIES	Density, gms/cm <sup>3</sup> , up to 5000 grams (Density ranges will be 0.2 g/cm <sup>3</sup> lower for parts above 5000 grams.) Electrical Conductivity, % IACS Resistivity at 20°C, microhm-cm Thermal Conductivity (CGS units) [W·m <sup>-1</sup> ·K <sup>-1</sup> ]	Room Temperature	16.96 14.0 12.30 0.225 [94.1]	18.00 16.0 10.78 0.328 [137]	17.00 10.0 17.24 0.181 [75.7]		18.00 13.0 13.30 0.264 [110]	18.50 13.0 13.30 0.306 [128]	17.25 13.0 13.30 0.306 [128]	16.64 37 4.66	17.2 35 4.93	Density, gms/cm <sup>3</sup> , up to 5000 grams (Density ranges will be 0.2 g/cm <sup>3</sup> lower for parts above 5000 grams.) Electrical Conductivity, % IACS Resistivity at 20°C, microhm-cm Thermal Conductivity (CGS units) [W·m <sup>-1</sup> ·K <sup>-1</sup> ]	
	Coefficient of Thermal Expansion X 10 <sup>-6</sup> /°C	20-400°C 20-800°C	5.40 6.35	4.43 5.05	4.61 5.36		4.60 5.80	4.53 5.25	4.53 5.25	6.68	5.99	Coefficient of Thermal Expansion X 10 <sup>-6</sup> /°C	
	Magnetic Properties Residual Magnetism Br Gausses [T] Coercive Force HC Oersteds [A/m]	Room Temperature	nil nil	nil nil	9,500 [95] 25 [2000]		290 [0.029] nil						Magnetic Properties Residual Magnetism Br Gausses [T] Coercive Force HC Oersteds [A/m]
	Corrosion Rate in 20% Hydrochloric Acid* at 95°C grams/cm <sup>2</sup> /hr	Room Temperature	0.00050	0.00011	0.00053		0.00017						Corrosion Rate in 20% Hydrochloric Acid* at 95°C grams/cm <sup>2</sup> /hr
	Oxidation Resistance in Still Air, Machined sample, weight gain mg/cm <sup>2</sup> , after 100 hrs at	400°C 750°F 500°C 930°F 600°C 1110°F	nil 1.50 50.0	nil 1.00 2.90	nil 0.65 7.60		nil 0.3 7.1		nil 0.5 10.5				Oxidation Resistance in Still Air, Machined sample, weight gain mg/cm <sup>2</sup> , after 100 hrs at
TENSION	Ultimate Tensile Strength, "S <sub>U</sub> ", psi [MPa] Yield Strength (.2% offset) "S <sub>TY</sub> ", psi [MPa] Elongation (% in 2") Proportional Elastic Limit, psi [MPa] Modulus of Elasticity, "E", psi x 10 <sup>6</sup> [MPa] Poisson's Ratio	Room Temperature	112,000 [772] 75,000 [517] 6.0 45,000 [310] 40.0 [280,000] 0.04	110,000 [758] 85,000 [586] 5.0 45,000 [310] 45.0 [310,000]	125,000 [862] 88,000 [607] 18.0 52,000 [359] 51.0 [352,000]		130,000 [896] 90,000 [621] 15.0 44,000 [303] 53.0 [365,000]	125,000 [862] 85,000 [486] 8.0 45,000 [310]	140,000 [965] 125,000 [862] 3.0 70,000 [483] 49.0 [338,000]		110,000 [758]	Ultimate Tensile Strength, "S <sub>U</sub> ", psi [MPa] Yield Strength (.2% offset) "S <sub>TY</sub> ", psi [MPa] Elongation (% in 2") Proportional Elastic Limit, psi [MPa] Modulus of Elasticity, "E", psi x 10 <sup>6</sup> [MPa] Poisson's Ratio	
	Short time Tensile at Elevated Temperature Tensile Strength, psi [MPa]	650°C 1202°F 815°C 1499°F 980°C 1796°F 1095°C 2003°F	35,000 [241] 20,000 [138] 13,000 [90] 10,400 [72]	50,000 [345] 27,000 [186] 18,000 [124] 13,000 [90]	70,500 [486] 45,000 [310] 27,000 [186] 19,000 [131]		72,000 [496] 47,000 [324] 30,000 [207] 20,000 [138]		105,000 [1030] 75,500 [862] 28,500 [197]			Short time Tensile at Elevated Temperature Tensile Strength, psi [MPa]	
	Elongation (% in 1" elevated Temperature)	650°C 1202°F 815°C 1499°F 980°C 1796°F 1095°C 2003°F	4 3 2 2	5 3 2 2	7 5 4 3.5		9.5 5.5 5.0 4.5		6.4 6.7 3.5			Elongation (% in 1" elevated Temperature)	
	100 hr Stress Rupture Elevated temperature psi [MPa]	650°C 1202°F 705°C 1301°F 815°C 1499°F 1000°C 1832°F	14,800 [110] 8,000 [83] 4,000 [28] 600 [4]										100 hr Stress Rupture Elevated temperature psi [MPa]
	1000 hr Stress Rupture Elevated temperatures psi [MPa]	650°C 1202°F 705°C 1301°F 815°C 1499°F 1000°C 1832°F	14,800 [102] 8,000 [55] 500 [3.4] 250 [1.7]										1000 hr Stress Rupture Elevated temperatures psi [MPa]
COMPRESSION	Ultimate Compressive Strength, psi [MPa] Yield Strength (.2% Offset), psi [MPa]	Room Temperature	162,000 [1120] 99,000 [683]	168,000 [1160] 92,000 [634]	87,000 [603]		90,000 [621]					Ultimate Compressive Strength, psi [MPa] Yield Strength (.2% Offset), psi [MPa]	
TORSION	Modulus of Rupture, "S <sub>R</sub> ", psi [MPa] Yield Strength (.2% Offset), psi [MPa] Angle of Twist at Rupture Modulus of Rigidity "G", psi x 10 <sup>6</sup> [MPa]	Room Temperature	108,000 [745] 52,000 [359] 166° 19.2 [132,000]									Modulus of Rupture, "S <sub>R</sub> ", psi [MPa] Yield Strength (.2% Offset), psi [MPa] Angle of Twist at Rupture Modulus of Rigidity "G", psi x 10 <sup>6</sup> [MPa]	
BENDING	Modulus of Rupture (Flexure), "S <sub>b</sub> ", psi [MPa] Deflection (1 1/2" Gauge), inches [mm]	Room Temperature	220,000 [1520] 1/16 [1.6]	220,000 [1520] 1/16 [1.6]	280,000 [1930] 1/3 [8.5]		290,000 [2000] 1/8 [3.2]		220,000 [1520] 1/8 [3.2]	165,000 [1140]	165,000 [1140]	Modulus of Rupture (Flexure), "S <sub>b</sub> ", psi [MPa] Deflection (1 1/2" Gauge), inches [mm]	
FATIGUE	Rotating Beam, Fatigue Limit, "S <sub>f</sub> ", psi [MPa]	Room Temperature	40,000 [276]	43,000 [296]	62,000 [427]		67,500 [465]					Rotating Beam, Fatigue Limit, "S <sub>f</sub> ", psi [MPa]	
IMPACT	Charpy Impact (V-notched) Ft-Lbs. [J] Charpy Impact (Unnotched) Ft-Lbs. [J]	Room Temperature	4.5 [6.1] 11 [14.9]	4.5 [6.1] 9 [12.2]	7 [9.5] 150 [203]		3.5 [4.7] 40 [54.2]		2 [2.7] 17 [23]		2 [2.7] 4 [5.4]	Charpy Impact (V-notched) Ft-Lbs. [J] Charpy Impact (Unnotched) Ft-Lbs. [J]	
HARDNESS	Hardness, Rockwell C (HRC)	Room Temperature	24	27	25		28	30	34	25	27	Hardness, Rockwell C (HRC)	
	Hardness at elevated temperature, Rockwell A (HRA)	20°C 68°F 200°C 392°F 300°C 572°F 400°C 752°F 500°C 932°F 600°C 1112°F 700°C 1292°F 800°C 1472°F	60 54 50 49 46 43 39 10	65 56 52 51 50 49 45 38	63 57 54 49 39 32 30 20		63 58 56 54 47 40 35 29		67 -- 64 -- -- 58 -- 52			Hardness at elevated temperature, Rockwell A (HRA)	

# CMW HIGH DENSITY METAL APPLICATIONS

## DIE CASTING TOOLING

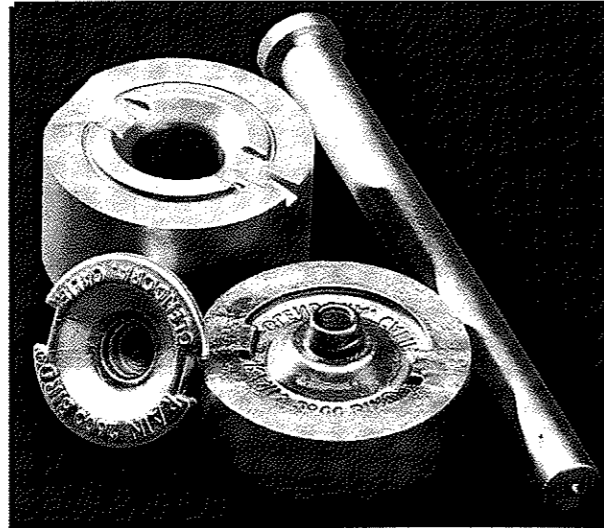
**ANVILOY® 1150** was originally developed as die casting tooling. Through its unique high temperature properties, it has become a logical choice for core rods, and die cast cavities.

Features:

- Resistance to soldering
- Reduced thermal fatigue (heat checking)
- Low erosion
- Readily machined
- No heat treatment required
- Easily welded
- High temperature strength

Results:

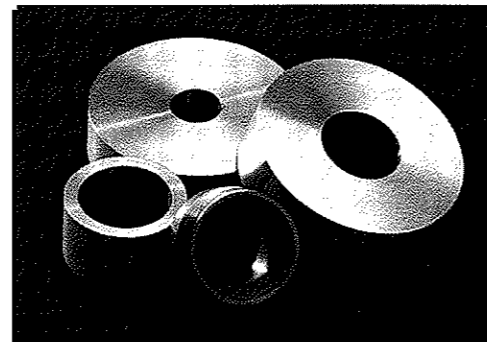
- Longer life
- Less down time
- Improved product surface finish
- Fewer rejects
- Lower piece price
- Greater equipment utilization



Hot work tool steel does a good job in many die casting applications, but as casting temperatures increase (as in brass casting) its life decreases. Anviloy® 1150 was developed for these higher temperature applications. Additionally, cracked tools can be readily repaired using CMW Anviloy® Weld Rod.

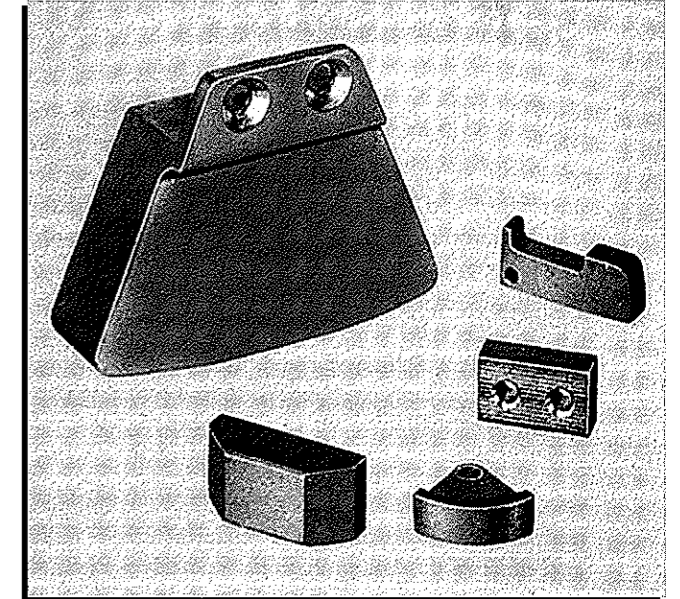
## EXTRUSION DIES

For precisely the same reasons Anviloy® 1150 is superior for die casting, it also provides extended service as extrusion die inserts for the copper, brass, and other higher temperature extrusion applications. CMW can supply finish extrusion dies or blanks from which to customize extrusion die inserts.



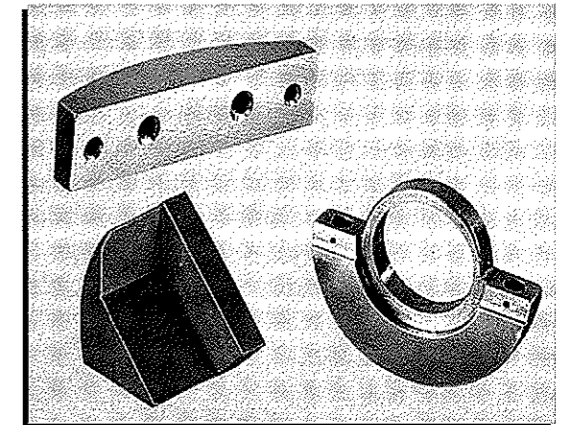
## WEIGHTS AND COUNTERBALANCES

CMW 1000 and CMW 2000 have been specified for control surface counterbalances in many military and commercial aircraft. Large mass in a small space is required to balance and stabilize control surfaces which must operate at high speeds. A savings in total aircraft weight can result from the use of CMW 1000 because the small high density piece requires less surrounding material to enclose it. In addition, the high strength of the material permits the part to be located for the most efficient weight effect and therefore the use of a minimum amount of material. When the application requires more ductility, CMW 3000 may be used to good advantage.



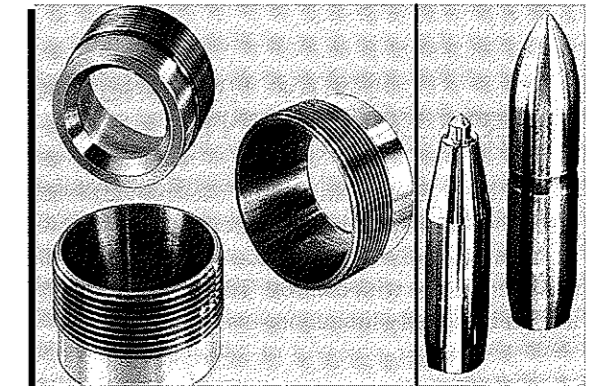
## ROTATING INERTIA MEMBERS

CMW high density materials are used in inertial guidance systems, navigation devices and similar equipment. These materials possess a high elastic modulus, high strength and density, low magnetism and good machinability. The design engineer may select the most desirable combination of properties from the CMW materials. Anviloy®1150 and Elkonite® selections have solved miniaturization problems in guidance systems.



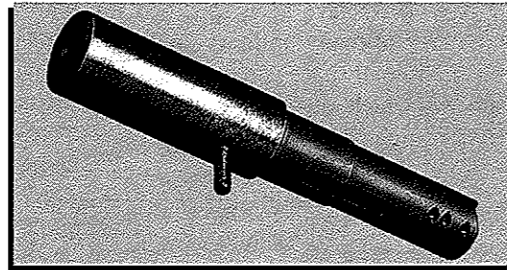
## ORDNANCE

CMW high density materials are often specified for military use. Their density, hardness, strength, ductility, non-magnetic and heat resistance properties make them excellent choices for ordnance applications. They are used as armor piercing projectiles, gyroscopes, counterweights, shielding, rocket nozzles and additional applications.



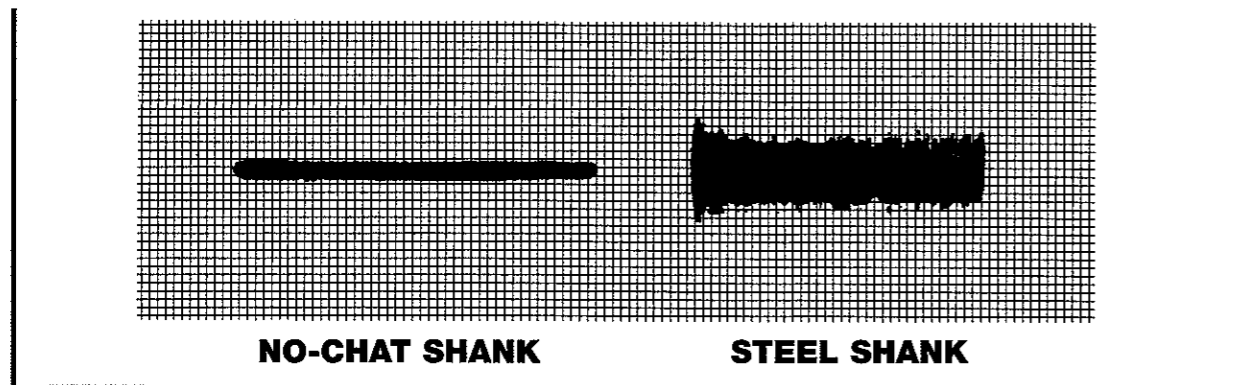
## BORING BARS / TOOL HOLDERS GRINDING ARBORS, QUILLS, SHANKS, SPINDLES

CMW 1000 has an inherently high mass and high modulus of rigidity. These properties make it ideally suited for as tool support material where less rigid and less massive materials will chatter. High thermal conductivity (3 times that of steels) provides an additional benefit in allowing tools to run cooler, extending tool life.



CMW offers a line of rough shapes and finished products for such applications called **NO-CHAT®**. (NO CHATTER).

Actual tests using an oscilloscope show the comparative tool vibration between **NO-CHAT®** and steel when machining a one per cent Cr-Cu material, feed 0.008 IPR, and speed 375 FPM, cut 0.020 inches. Style C-8 LATHE TOOLS (using identical non-ferrous grade carbide tips).



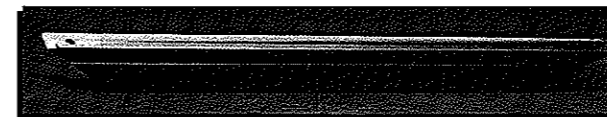
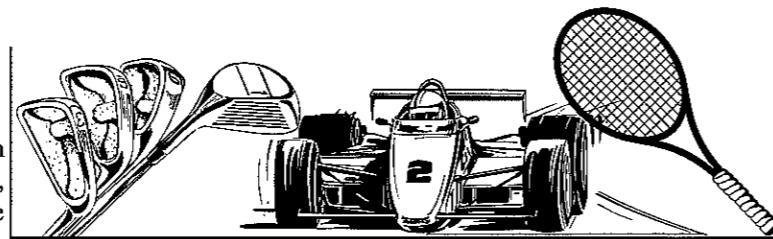
**NO-CHAT®** stock products include:

- Round bars
- 3/16" - 1" diameter x 7.0" long
- 1 1/4" diameter x 12.0" long

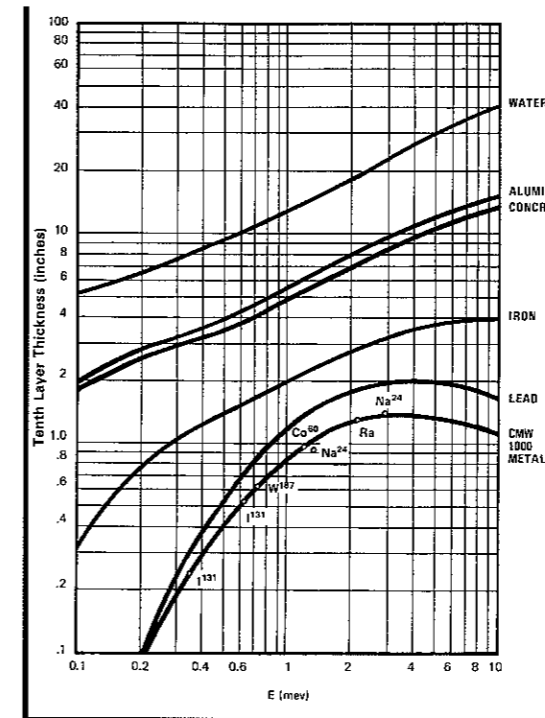
**NO-CHAT®** is stocked as rough oversize to finish (ROTF) round bars. Rectangular bars and finished products are not stocked, but can be readily manufactured to your specifications.

## SPORTS EQUIPMENT

CMW high density materials can provide such diverse solutions as giving the golf ball more drive, the tennis racket the right feel, or the racing car the ability to corner with control. The engineer's imagination is the only limitation.



## NOMINAL GAMMA ABSORPTION CHARACTERISTICS



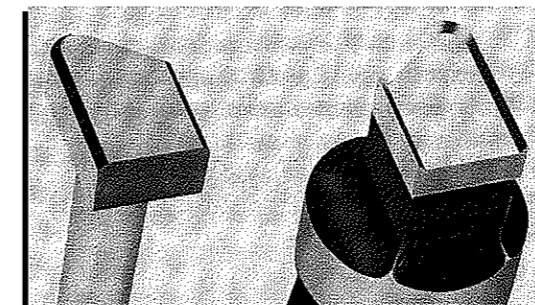
## RADIATION SHIELDING

Gamma radiation is absorbed most effectively by high density materials. The high density, good mechanical strength and excellent machinability of CMW materials make them ideal for shielding applications.

They have been used in isotope shipping containers, cobalt teletherapy machines, oil well logging equipment, portable reactors and satellites.

A variety of sizes and shapes are available for shields. Low intensity neutron bombardment causes only moderate activity in the CMW high density materials.

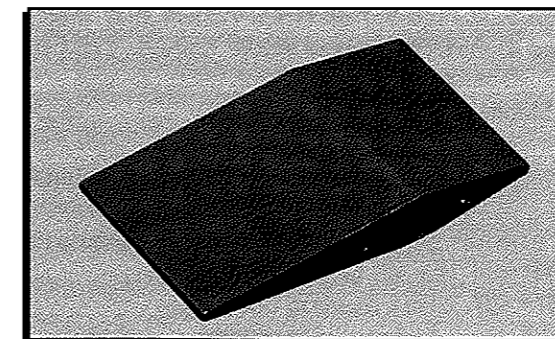
## EDM / ECM ELECTRODES (ELECTRICAL DISCHARGE / CHEMICAL MACHINING)



ELKONITE EDM ELECTRODE (LEFT) AND RESULTANT PUNCH

**ELKONITE®** material by CMW is a standard for production of long lasting electrodes for EDM and ECM applications. Usually the less dense (and more electrically conductive) Elkonites are used for these applications, but where maximum wear resistance is mandatory, the high density grades of Elkonite® 40W3 or Elkonite® 50W3 are practical solutions.

## DEFLECTOR VANES



One of the most successful recent applications of high density **Elkonite** has been as deflector vanes for missile guidance. These vanes are short lived, being subjected directly to the main rocket exhaust stream. However the combination of high melting temperature, resistance to erosion, and thermal conductivity inherent in Elkonite, permits the vane to do its job completely before disintegrating.

# MACHINING CMW HIGH DENSITY METALS

Pure tungsten is brittle and extremely difficult to machine. The addition of other metals and the use of special powder metallurgy techniques overcome this problem in CMW high density metals.

Excellent surface finishes can be produced by turning, boring, drilling, tapping, milling, shaping and grinding. In general, machining CMW high density metals is similar to machining gray iron. Avoid notches where possible, at least eliminate sharp corners.

## MACHINING GUIDELINES

### Tools

Roughing or finishing- non-ferrous grade carbide tool material.

When grinding tools, use a 0° rake, a 12°-14° clearance and a radius as generous as possible. Where sufficient power is available a negative rake will increase tool life. Tools for Elkonites should have a positive rake.

### Turning and Boring

Roughing- .050" to .200" depth of cut  
.008" to .010" feed

Finishing- .010" to .030" depth of cut  
.003" to .005" feed

Turning speed- 250 to 350 surface feet per minute; no coolant required. Coolant or air may be used for ease of handling. A water soluble oil will increase tool life for Elkonite machining and is recommended.

### Drilling and Tapping

Use carbide drills. For tapping, use a very small amount of cutting oil or Moly-Dee® cutting fluid. Use a negative rake / straight flute steel tap. (Moly-Dee® trademark of Castrol Inc.)

### Reaming

Leave .010" to .020" on I. D. for reaming with carbide tools.

### Grinding

Use a soft wheel and treat as hardened tool steel.

### Milling and Shaping

Feeds and speeds correspond to those for gray cast iron. Light feeds, or beveling of the work piece eliminates breakout.

### Sawing

High speed steel blades are recommended at speeds of 250 to 350 surface feet per minute.

### Polishing

If a file is used, do not use oil but fill with chalk. Finish with a soft stone.

# JOINING CMW HIGH DENSITY METALS

CMW high density metals may be joined to themselves and to other materials by several methods. These include, copper brazing, silver brazing, shrink fitting, press fitting, mechanical joining and welding.

## Copper Brazing

Should be done at 1100°C in a reducing atmosphere, using pure copper or a 92% copper-nickel alloy. Standard practice can be employed with respect to metal surface finish, copper braze sheet thickness, brazing temperature and time. No flux is required. Surface etching with potassium ferricyanide or fused sodium nitrate prior to brazing will help insure a good braze. Elkonite® 40W3 and 50W3 can not be brazed per the above.

## Silver Brazing

Should be done in a reducing atmosphere using a non-phosphorous bearing silver braze alloy. The surface may first be tinned with copper in a reducing atmosphere before brazing. Elkonite® should be etched prior to silver brazing.

## Press Fitting and Shrink Fitting

Essentially the same as with other metals. The low expansion of CMW high density metals make them well suited as internal members in shrink fitting.

## Stress Relief

On parts held to precise tolerances or used in highly stressed applications, a stress relief treatment may be needed. The recommended treatment is two hours at 600° F [316 C] in a protective atmosphere, just prior to finishing.

# WELDING CMW HIGH DENSITY METALS

CMW high density materials (except Elkonite®) can be welded to themselves or to other metals using the TIG or MIG process. Welds have good strength but low ductility.

Rod- CMW Anviloy® weld rod should be used (available 0.120" [3.05mm] diameter x 7" [20.3cm] long)

Equipment- A TIG setup with 300 amp power supply. Use argon gas shielding.

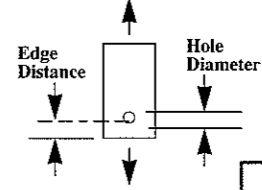
Procedure- Use a high d.c. setting adjusted to maximum output. Preheat the work area using the electrode. Do not preheat the acetylene torch. When the work-piece is heated, begin the weld. Do not work beyond preheated area. Allow the weld to cool in the shield of argon gas. Do not quench. No post treatment is required.

Welding is not recommended for Elkonite®, (see silver brazing above).

## Mechanical Joints

Design specifications should include:

- Edge distance to be a minimum of 1.5 times hole diameter
- Avoid hole diameters greater than 3 times material thickness
- Use a design strength of 75,000 psi.



For CMW 1000

Bearing properties (psi)	Edge Distance		
	1.5 x diameter	2 x diameter	3 x diameter
Proportional Limit	94,000	114,000	113,000
Yield Strength (.2% offset)	107,000	128,000	131,000
Yield Strength (2% offset)	136,000	161,000	172,000
Ultimate Bearing Strength	159,000	208,000	248,000

