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## Properties of Tungsten Carbide

Tungsten carbide is a dense, metal-like substance, light gray with a bluish tinge, that decomposes, rather than melts, at 2,600° C (4,700° F). It is prepared by heating powdered tungsten with carbon black in the presence of hydrogen at 1,400°-1,600° C (2,550°-2,900° F). For fabrication, a process developed in the 1920s is employed: the powdered tungsten carbide is mixed with another powdered metal, usually cobalt, and pressed into the desired shape, then heated to temperatures of 1,400°-1,600° C; the other metal, which melts, wets and partially dissolves the grains of tungsten carbide, thus acting as a binder or cement. The cemented composites of tungsten carbide-cobalt are known by many different trade names, including Widia and Carboloy. Tungsten carbide has very high strength for a material so hard and rigid. Compressive strength is higher than virtually all melted and cast or forged metals and alloys; and is two to three times as rigid as steel and four to six times as rigid as cast iron and brass. High resistance to deformation and deflection is very valuable in those many applications where a combination of minimum deflection and good ultimate strength merits first consideration. For such a hard material with very high rigidity the impact resistance is high because it is in the range of hardened tool steels of lower hardness and compressive strength. It also performs well up to about 1000°F in oxidizing atmospheres and to 1500°F in non-oxidizing atmospheres; it undergoes no phase changes during heating and cooling, retains its stability indefinitely; and retains toughness and impact strength in the cryogenic temperature ranges. (-453°F.) Tungsten carbide has exceptional resistance to galling and welding at the surface, and has sufficient resistance to corrosion-wear conditions for many applications. Tungsten carbide wears up to 100 times longer than steel in conditions including abrasion, erosion and galling. Wear resistance of tungsten carbide is better than that of wear-resistance tool steels.

### Industrial Grade Designation: C-2

#### Physical Properties: (typical)

Density	g/cm <sup>3</sup>	15.0
Thermal Conductivity	W/m°C	100
Electrical Resistivity	ohm-cm	<0.00008
Linear Expansion Coefficient		
20 - 400°C	10-6 °C <sup>-1</sup>	4.9
0 - 800°C	10-6 °C <sup>-1</sup>	5.3
Hardness @ 20 °C	HV 30	1600
	Rockwell A	90-92
Transverse Rupture Strength @ 20°C	N/mm <sup>2</sup>	2600
Fracture Toughness KIC @ 20°C	MN/m <sup>3/2</sup>	12
Compressive Strength @ 20°C	N/mm <sup>2</sup>	6200
Young's Modulus	GPa	630

Poisson's Ratio	0.21
Melting Point	2000° C
Magnetic Properties Magnetic Susceptibility	Slightly Magnetic 0.000010
Coefficient of Friction Tungsten Carbide on Tungsten Carbide without Lubricant	0.25

#### Material Composition:

Tungsten Carbide (WC)	93.5 - 94.5%
Cobalt (Co)	5.5 - 6.5%

### Tungsten Carbide Ball Grades (AFBMA)

AFBMA Grade	Ball Diameter Variation	Deviation from Spherical Form	Lot Diameter Variation	Surface Finish Ra Better than	Basic Diameter Tolerance
5	0.000005" [0.13µm]	0.000005" [0.13µm]	0.000010" [0.25µm]	0.0000005" [0.013µm]	±0.0001" ±0.00254mm
10	0.000010" [0.25µm]	0.000010" [0.25µm]	0.000020" [0.50µm]	0.0000008" [0.02µm]	±0.0001" ±0.00254mm
25	0.000025" [0.64µm]	0.000025" [0.64µm]	0.000050" [1.25µm]	0.000001" [0.025µm]	±0.0001" ±0.00254mm
50	0.000050" [1.25µm]	0.000050" [1.25µm]	0.0001" [2.50µm]	0.000002" [0.05µm]	±0.00025" ±0.00635mm