APPLICATION BULLETIN

KENNAMETAL®

Standard Conforma Clad™ Tungsten Carbide Formulations — Power Generation

Engineering Formulas

Kennametal has compiled over 20 years of scientific testing to develop three standard tungsten carbide cladding formulas that meet most of your severe wear protection needs. Our standard cladding formulas are designed to protect equipment from multiple modes of wear including abrasion, erosion, corrosion, or any combination of the three. Kennametal engineers evaluate individual components and their operating environments in order to recommend a standard cladding formula, or create a custom cladding to meet customer-specific requirements.

Our unique infiltration brazing process combines the hardness of tungsten carbide with the corrosion resistance of nickel chrome boron to create a protective barrier with unmatched wear-resistant properties. With a metallurgical bond strength in excess of 70,000 psi, our cladding is extremely resilient to chipping, cracking, and flaking.

Cladding Specifications

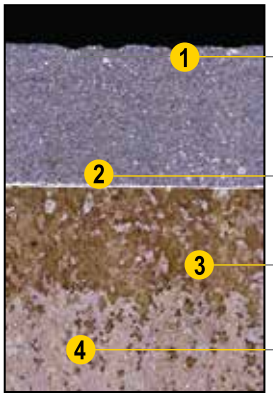
Cladding Composition (Weight Percentage)			
	WC 200	WC 210	WC 219
Tungsten Carbide*	62%	55%	48%
Nickel	30%	34%	39%
Chromium	6%	7%	8%
Other	2%	4%	5%
Total carbide loading from other carbide formation	68%	66%	62%

*Tungsten Carbide (WC) includes cobalt-bonded WC.

Cladding Properties			
	WC 200	WC 210	WC 219
Density (lb/in^3)	0.44	0.42	0.40
Thermal Conductivity (BTU in/h•ft^2•°F)	230	200	170
Metallurgical Bond Strength (psi)	>70,000	>70,000	>70,000
Porosity	<3%	<3%	<3%
Rockwell Hardness (HRC)**	64–70	60–66	56–62

**Cladding is a composite of tungsten carbide particles dispersed in a nickel-based alloy matrix. The extremely hard carbide particles, with a Vickers Diamond Pyramid Hardness of about 2000 DPH_{50g} [1865 DPH_{50g} is equivalent to 80 Rockwell C Hardness (HRC)], are surrounded by a two-phase matrix (300-800 DPH_{50g}, equivalent to 30–64 HRC). Because of the heterogeneous structure of the cladding, direct Rockwell hardness measurements are an average of the hard particles and matrix, and are not representative of the individual components of the composite.

Cladding Photomicrograph



CLADDING

Dense tungsten carbide loading with uniform carbide distribution. High wear resistance with predictable wear rates and continuous operation up to 1900°F.

No interconnected porosity. Superior corrosion and impact resistance.

BOND LINE

True metallurgical bond (>70,000 psi) with high interparticle bond strength. Provides unsurpassed strength and prevents chipping, flaking, and check-cracking.

DIFFUSION ZONE

Minimal dilution. Substrate retains uniform properties in diffusion zone.

SUBSTRATE

Heat treatable. After cladding process to restore substrate's mechanical properties.

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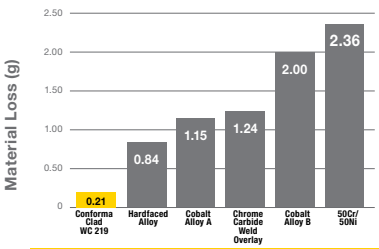
Performance Data

EPRI field studies verify that 1/16" of Conforma Clad™ tungsten carbide cladding provides the same erosion protection as approximately 1" of chrome carbide weld overlay or 3" of carbon steel.

BLACK BEAUTY COAL SLAG EROSION TEST

90° Impingement Angle, 240 ft/sec (30-minute test)



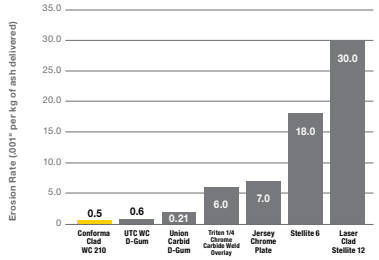
Laboratory testing, following ASTM G73 standards, on low swirl coal spreaders determined Kennametal's WC 219 provides the best erosion protection from fine grit black beauty coal slag.

Babcock Power, CCV-DAZ Development Project

UP TO 10X BETTER
Erosion Resistance versus Cobalt Alloys

FLY ASH EROSION TEST

40° Impingement Angle, 550 ft/sec — 30 Minute Test



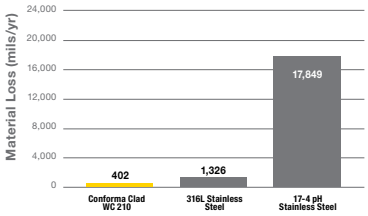
EPRI testing found that Kennametal's WC 210 provides superior erosion protection for power boiler fan blades exposed to high-velocity bituminous coal fly ash.

EPRI CS - 6068, Project 1649-4

UP TO 12X BETTER
Erosion Resistance versus Chrome Carbide Weld Overlay

CORROSION TEST

10% Sulfuric Acid at 212° F (100° C)



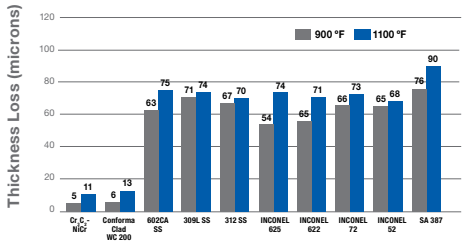
ASTM G31 testing shows Kennametal's WC 210 provides superior corrosion resistance.

Laboratory Testing, ASTM G31 Standards

UP TO 44X BETTER
Erosion Resistance versus 17-4 pH Stainless Steel

HOT EROSION TEST

30° Impingement Angle, 141 ft/sec — 180 Minute Test



EPRI testing at elevated temperatures confirms that Kennametal's WC 200 protects boiler tube applications from erosive wear better than other accepted alternatives.

EPRI Report 1008037

UP TO 6X BETTER
Erosion Resistance versus INCONEL's

Cladding Properties

Properties	Kennametal	Thermal Spray	Weld Overlay	Wear Tiles	AR Plate
Bond Strength	Very High	Very Low	High	Low	N/A
Complex Geometries	Yes	No	Difficult	Difficult	Very Low
Abrasion Resistance	Very High	Moderate	High	Very High	Very Low
Erosion Resistance	Very High	Low to Moderate	Low	Low	Very Low
Corrosion Resistance	High	Low	Low	Low	Low
Impact Resistance	Moderate	Low	Moderate	Very Low	Low
Oxide Level	Low	High	Low	Low	Low
Temperature Resistance	High	Moderate	Low	Very Low	High
Resists Multiple Modes of Wear	Yes	No	Yes	No	No

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