POWER GENERATION SOLUTIONS

for Coal-Fired or Biomass Power Plants

KENNAMETAL™
CONFORMA CLAD

COAL-FIRED AND BIOMASS POWER GENERATION

Kennametal Conforma Clad™ is a:

- Global solutions provider for wear, heat, and corrosion problems.
- World-class manufacturer of clad components.
- Service provider for the power generation market.

Kennametal Conforma Clad offers custom-engineered solutions to meet demanding needs. For over 25 years, we have worked with end users and OEMs to increase efficiencies and extend the life of critical components, with a focus on coal-fired and biomass power plants.

Our proprietary processes allow cladding technology to be used in a broad range of applications, including:

- **Boiler Tubes**
- **Fan Blades, Liners, & Housings**
- **Coal Nozzle Tips & Fuel Handling**
- **Screens & Ash Handling**
- **Pumps & Conveyance**

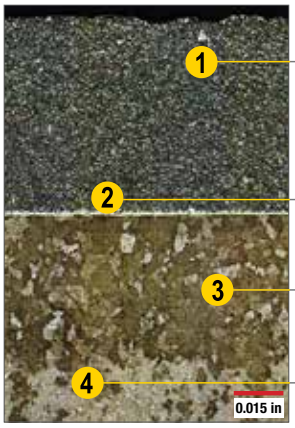
Pioneers in Cladding Technology

Kennametal Conforma Clad™ has completed over 30 years of scientific testing to develop various cladding materials and application processes for severe wear protection. Our cladding formulas are designed to protect equipment **from multiple modes of wear**, including:

- Abrasion
- Erosion
- Corrosion
- Or any combination of the three.

Conforma Clad wear experts evaluate components and operations environments to find a customized cladding solution.

Our unique infiltration brazing process combines the hardness of tungsten carbide with the corrosion resistance of nickel chrome boron, creating 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
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.

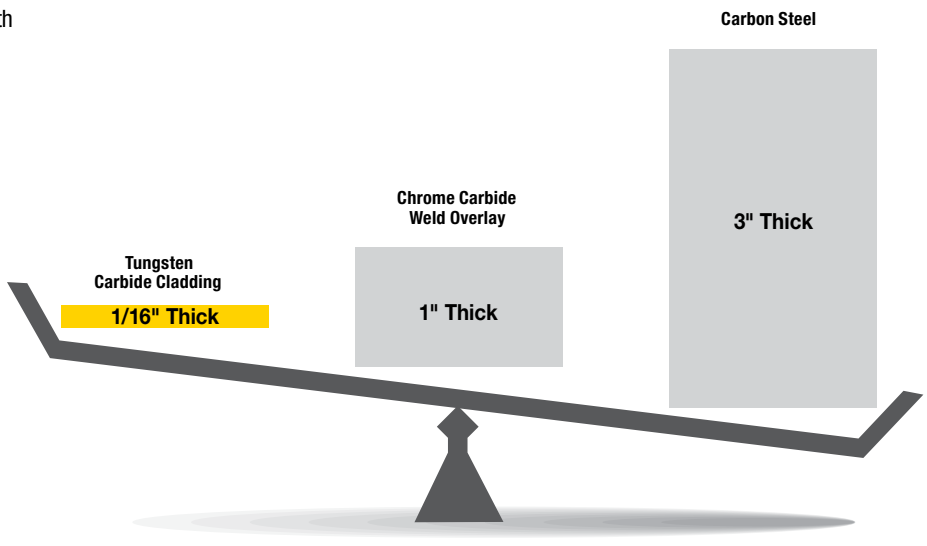
Diffusion Zone
Minimal dilution. Substrate retains uniform properties in diffusion zone.

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

Transformational Performance

The Electric Power Research Institute (EPRI) field trials* have shown 1/16" of Conforma Clad cladding provides equivalent erosion resistance to 1" of chrome carbide weld overlay at 1/10th the weight and 3" of carbon steel at 1/30th the weight.

Equivalent Erosion Resistance



** Based on a joint Tennessee Valley Authority (TVA) & Electric Power Research Institute (EPRI) research project to improve life of I.D. Fans. The study examined blades from six different suppliers and metal loss due to erosion was measured.*

Clad Fan Components

Significantly extend fan life and reduce unplanned downtime.

Fan failures triggered by high-velocity ash impingement often result in reduced gas flow and fan efficiency, sudden fan imbalance, and catastrophic detachment of blades. Failures occur in many areas, including leading and trailing edges, centerplate weldment areas, and fan inlet hubs.

Conforma Clad™ inflitration-brazed tungsten carbide wear protection has helped operators increase fan runtimes by more than 4x. Typical fan components that benefit from this technology include:

- Induced draft
- Forced draft
- Hot primary
- Gas recirculation
- Boosters
- Exhausters
- Mechanical collectors

Why Use Conforma Clad?

Superior Erosion Resistance-to-Weight Ratio

Cladding is significantly thinner and lighter when compared to chrome carbide overlay.

Resists Chipping and Spalling

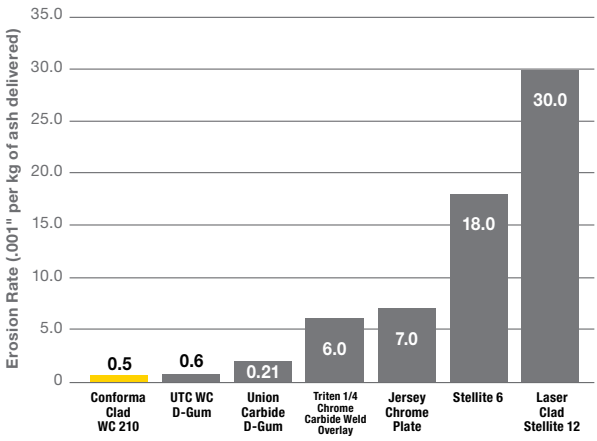
Fan blades that last longer increase overall fan efficiency, reduce downtime, and avoid catastrophic failures.

Versatility and Flexibility

Cladding can be applied to leading and trailing fan edges, centerplate weldment areas, and fan inlet hubs — protecting the entire fan.

Fly Ash Erosion Test

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



Up to 12x Better
Erosion Resistance versus Chrome Carbide Weld Overlay

EPRI testing found that the Kennametal 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

Conforma Clad™ protection can be applied to a wide range of geometries, some of which include…

Leading edge and center plate protection.

Complex liner designs, including hub, blade, and shroud.

Forward Curve

Variable Pitch Axial Fan Blade Shield

We will clad customer-supplied fan components or provide turn-key solutions for custom designs.

Proven Results

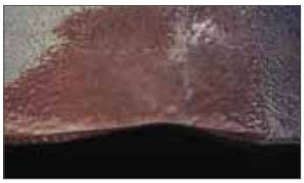
Over 3x Fan Life Extension

Field erosion experiments conducted by the Electric Power Research Institute (EPRI) and the Tennessee Valley Authority (TVA) Kingston Power Plant on the plant's power boiler I.D. fans show Conforma Clad™ fan solutions offer a significant performance advantage.

The plant was able to increase fan life from 5–8 months to over 30 months using Conforma Clad.

I.D. Fan After 69 Days in Operation

Conforma Clad Tungsten Carbide Cladding



WC Thermal Spray with Post-Spray Fuse

Tungsten Carbide HVOF

Chrome Carbide Weld Overlay

Fan blade protected with Conforma Clad liner.

Fan blade protected with chrome carbide weld overlay liner.

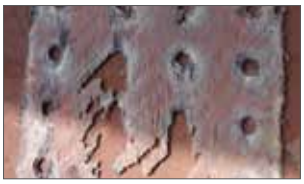
4x Runtime Improvement

An unscheduled 96-hour outage at a 640MW coal-fired power plant cost approximately $3.7M in lost generation. Unpredictable wear characteristics of the chrome carbide weld overlay liners used on the I.D. fan resulted in unit failure. By replacing the chrome carbide weld overlay liners with Conforma Clad blade and wheel hub liners, run times of hot gas fans were extended by 4x, from 9 months to 36 months.

Wear Comparison

Superior wear properties of Conforma Clad protection can significantly extend fan life at a much lower weight vs. chrome carbide.

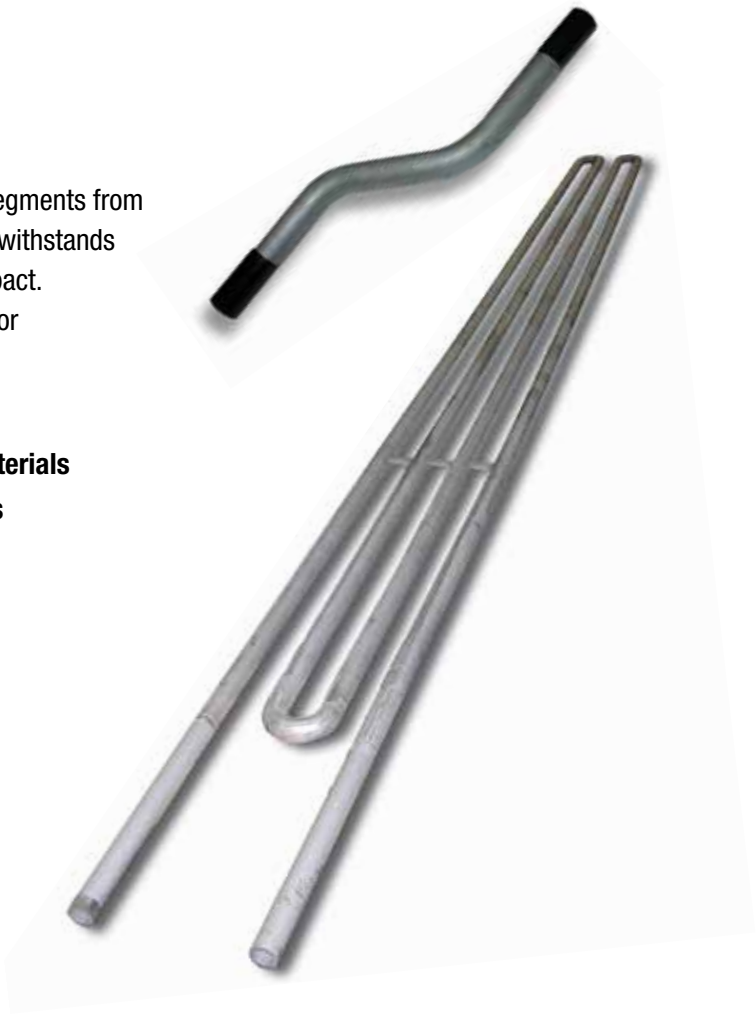
Conforma Clad fan blade after six months.



Chrome carbide fan blade after three months.

Clad Boiler Tubes/ Fluidized Bed Boiler Tubes

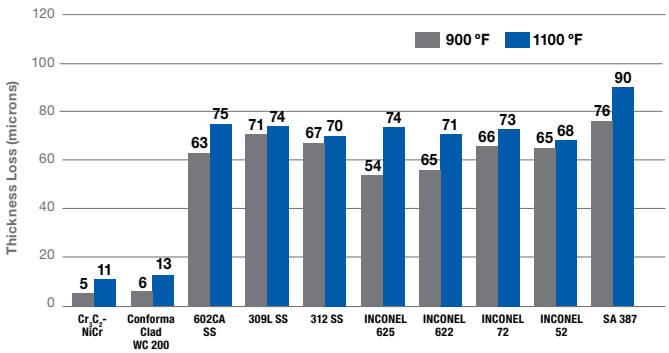
Kennametal Conforma Clad™ protects replacement boiler tube segments from severe wear, reducing the risk of boiler tube leaks. Our cladding withstands extremes of thermal shock, erosion, abrasion, corrosion, and impact. Let our team of experienced experts develop a custom solution for improved boiler reliability.



- **Hot erosion protection up to 10x better than INCONEL® materials**
- **Selectively protect high-wear sections of your boiler tubes**
  - – Cladding can be applied to entire tubes or to specific high-wear areas exposed to significant erosion.
- **Consistent cladding thickness and minimal dilution**
  - – Get reliable linear wear through the full life of the Conforma Clad protected tube.
- **True metallurgical bond**
  - – No loss of protection due to flaking or spalling.
- **Meets requirements of the ASME Boiler and Pressure Vessel Code (S Stamp).**

Hot Erosion Test

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



Up to 10x Better
Erosion Resistance vs. INCONEL®

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

EPRI Report 1008037

Cladding Specifications	
Substrates	Cladding can be applied to most carbon steels, and low alloy steels. (SA210, SA213, T11, T12, T22, etc.)
Temperature	Continuous operation at temperatures up to 1900º F (1038 ºC) with nominal performance impact. Able to withstand transients in excess of 2000º F.
Chemical Resistance	Compatible with chemicals commonly found in coal and fly ash, including hydrochloric acid, hydrogen fluoride, and sulfuric acid.

Boiler Tube Shields

Get the same erosion protection from our direct-clad boiler tubes with a tube shield.

- Protect specific high-wear areas of boiler tubes with shields sized to suit.
- Standard weld procedures can be used to attach shields onsite in desired wear locations.
- Shield any substrate tube material — no limitations on what can be protected.
- Conforma Clad offers turn key shields – ready to assemble in a wide range of sizes.

> ***"These shields have been installed in our boiler in the highest wear zones where the tubes are exposed to ash containing flue gas with velocities of up to 50 meters/second. I want to thank the entire Kennametal team for another flawless delivery. We are certainly very happy knowing we have these coated shields in place, protecting our boiler tubes!"***
>
> ***— Satisfied Kennametal customer***

Clad Burner Components

Conforma Clad™ protected burner components last longer and sustain maximum performance levels by maintaining critical component geometries for extended run times.

Our unique cloth delivery system enables densely-packed tungsten carbide to be uniformly applied to complex geometries, providing a protective barrier that wears at a uniform and predictable rate.

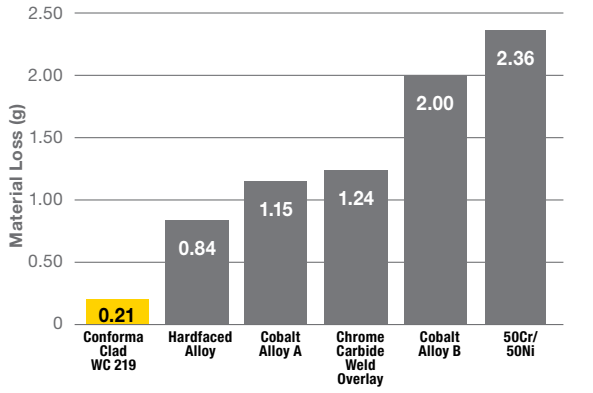
Conforma Clad Weld Overlay

Results of a 1 year side-by-side trial comparing burner tips protected with Conforma Clad (left) versus weld overlay (right).

Coal spreaders are essential components in distributing pulverized coal to the burner flame and are designed to enhance combustion by controlling the flame length and minimizing NOx and Unburned Carbon (UBC). To maintain critical geometries and coal distribution patterns, coal spreader vanes are protected with Conform Clad™ tungsten carbide cladding.

Black Beauty Coal Slag Erosion Test

90° Impingement Angle, 240 ft/sec — 30 Minute Test



Up to 10x Better
Erosion Resistance vs. Cobalt Alloys

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

Babcock Power, CCV-DAZ Development Project

"Riley Power conducted laboratory testing, following ASTM G73 standards, on low-swirl coal spreaders to determine the best erosion protection from fine-grit black beauty coal slag. Testing was conducted at a 90° impingement angle with a particle velocity of 240 ft/sec for 30 minutes.

Kennametal WC 219 cladding provided top wear protection while retaining critical component geometries. Kennametal increased Riley Power's low-swirl coal spreader's life from 1–2 years to 3–4 years."

— Babcock Power, CCV-DAZ Development Project

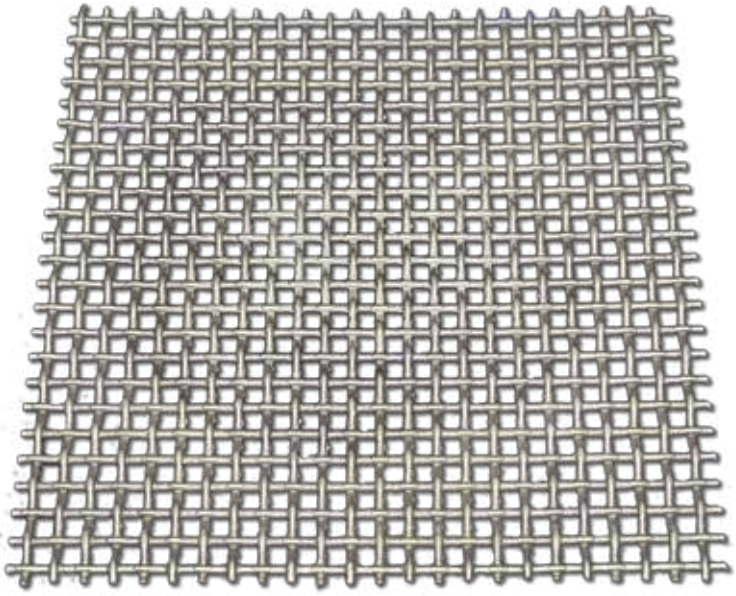
Clad Screens

Extend the life of SCR popcorn screens by 5–8x longer vs. stainless steel

The Conforma Clad™ process is capable of completely protecting entire screens with metallurgically bonded tungsten carbide cladding. We can clad screens up to 4 x 12' with screen openings 1/4" and larger.

Conforma Clad screens after nine months.

Stainless steel screens after less than six months.

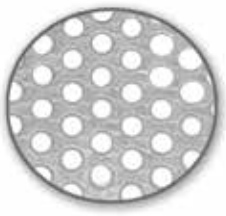


Common Screen Types

Woven Mesh

Wedge Wire and Grates

Expanded Diamond



Perforated

POWER GENERATION

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