MONIPLEX®

MoniPlex® ceramic and metallic coatings are applied as liquid slurry which naturally flows over the surface of almost any shape, including internal diameters as small as 0.5 mm. They are totally dense, pore free and the coating exhibits a spinel-like bond layer with the component.

MoniPlex® coatings can be applied to a variety of ferrous and non-ferrous materials, including carbon steels; nickel based alloys, titanium alloys, aluminium and its alloys and copper alloys.

MoniPlex® has a proven track record in oil, steel, textile and engineering applications. the coatings can be super-finished and exhibit a hardness of between 1800 and 2900 Vickers.

M-Plex 1

C-Plex 7

B-Plex 5

B-Plex 3

Q-Plex 9

SealPlex 2

SealPlex 6

SealPlex 8

Monitor House 2 Elm Road West Chirton (North) Industrial Estate North Shileds NE29 8SE
t: +44 (0) 191 293 7040 f: +44 (0) 191 293 7041
email: bryanallcock@monitorcoatings.co.uk website: www.monitorcoatings.co.uk

The slurry coating process is unlike thermal spray, PVD and CVD techniques, where difficult geometries and small internal bores are difficult or impossible to coat. Slurry coatings are applied like paint consequently there are no “line of sight” problems as with other techniques.

Deposition techniques include pressure spraying for most external surfaces, dipping for complex shapes and draining for internal surfaces such as cylinder liners. The thickness of the deposited slurry can be controlled within the range of 1-250 µm depending upon the geometry and application criteria. Once the deposition of the slurry is complete, the component is heated to a temperature at which the thermo-chemical reaction takes place. At this stage the coating is prepared for final conversion, which produces a totally dense, pore free coating that incorporates a spinel-like bond layer between the coating and the component.

The as-coated surface texture is very smooth, typically 0.5 to 1.5 µm Ra and is often used in this condition. When finishing is necessary for dimensional or surface texture considerations, the coating can be ground, honed or lapped in a similar manner to other ceramics.

MoniPlex® coatings are particularly suitable for applications in corrosive environments. The totally dense pore free structure of a MoniPlex® coating provides an excellent corrosion barrier and the coating itself is inert to most forms of chemical attack. This differs from flame sprayed ceramics which can contain micro cracks and are inherently porous due to the thermal strain created by hot particles cooling quickly on impact with the relatively cool substrate.

MoniPlex® has excellent resistance against wear and solid particle erosion. The average adhesive dry rubbing wear factor is 10-15 M3/Nm, as determined from a pin-on-plate sliding test using a polished hardened steel pin rubbing against the treated plate surface at a loading of 10 Nm-2.

The average high stress abrasive wear factor is comparable to carburised steel at 4000 (no units) and the average erosive wear factor indicated by 1,000 parts per million of silica in water with an impact velocity of 25 ms-1 is 1500 (no units), which in turn is comparable to a PVD coating of titanium nitride.

Frictional characteristics also influence the wear resistance of a coating. The naturally low friction characteristics of MoniPlex® coatings contribute significantly to their superior wear performance over other materials: -

Electroplated hard chrome	0.50
Plasma sprayed ceramics	0.35
MoniPlex® ceramics	0.26

Under normal ASTM B117-73 standard salt spray conditions, chrome plated mild steel samples show 50% of the surface area corroded after 6-8 hours, whereas MoniPlex® impregnated hard chrome plate exhibits minimal surface attack after 48 hours of testing. A MoniPlex® coating applied to an EN40B substrate showed no evidence of corrosive attack after 1800 hours in the same test.

MoniPlex® thermo-chemically-formed ceramic coatings can be modified to satisfy specific application criteria. For instance, the normal objective is to produce smooth, hard, low friction surfaces, but if larger angular shaped abrasive particles are introduced, highly abrasive long lasting surfaces can be created. Abrasive materials such as silicon carbide, boron nitride or diamond can be chemically bonded into the coating matrix or they can be pressed into the wet surface of the slurry coating to create abrasive tip coatings for Turbine Blades and Seals.

	Average Values
Density	3.5 g/cc
Particle size	sub micron
Thickness	1 to 250 µm
Elastic Modulus	35.8 GPa
Shear Modulus	12.8 GPa
Bulk Modulus	58.7 GPa
Rupture Modulus	100 – 275 GPa
Compressive Strength	7.86 GPa
Fracture Toughness	1.4 MPa/m1/2
Tensile Strength	68.8 MPa
Thermal Expansion	8-10 PPM/°K
Thermal Conductivity	2-3 W/m°K
Thermal Diffusivity	0.01 cm^2 /sec
Specific Heat	600 – 1000 J/kg°K
Emittance	0.85 at 260°C
Electrical Resistivity	10-10 ohm cm

Surface Sealing and Densification

The SealPlex® ranges of coatings are used to surface seal and fill the porosity in other materials. Surface treatments such as nitro-carburising and tuftriding create a porous outer layer. This layer has excellent liquid retention properties and when subjected to the SealPlex® densification process, a single-phase ceramic layer is chemically bonded into and over the porous outer layer.

The SealPlex® coating produced in this way is <5µm thick with a hardness up to 2,900 VPN. In addition to the significant increase in surface hardness, corrosion resistance and frictional properties are improved.

The same techniques can be used to seal the surface of other porous materials such as solid ceramics and sintered metals. If the impregnation is vacuum assisted, full penetration of the porous structure can be achieved and filled to produce a harder and stronger component.

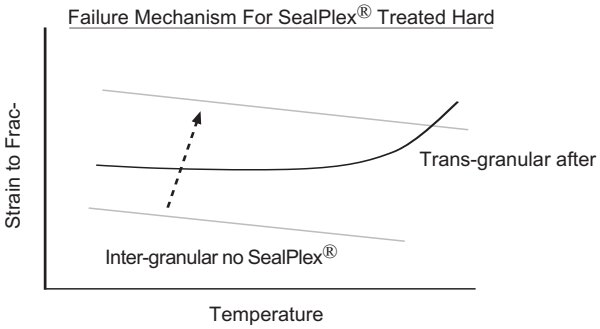
Flame sprayed coatings and electroplated hard chrome can also benefit from the SealPlex® densification process. These coatings are by nature micro-cracked and porous and therefore susceptible to interface corrosion problems. The penetration performance of the SealPlex® is so efficient that the micro-cracks in hard chrome can be filled to improve both wear and corrosion performance.

The SealpPlex® process is capable of infiltrating other surface treatments and coatings thereby sealing the corrosion pathways down to the substrate.

There is no apparent porosity

Wear resistance
Corrosion resistance
Surface sealing
Electrical insulation
Densified structures
Abrasive surface
Low friction characteristics
Wetability

SealPlex® has a unique effect on other coatings and treatments. It can be used to seal hard chrome plate, plasma, HVOF (High Velocity Oxy-Fuel) and Thermal Spray coatings. The resultant duplex coating exhibits increased ductility and increased fracture toughness brought on by a change in failure mechanism from inter granular (around grain boundaries) cracking to trans granular (through grains) cracking. The activation energy associated with this change in failure mechanism and consequently the coatings toughness is greatly increased.



High Temperature Oxidation Resistance

MoniPlex® shows excellent stability at elevated temperatures. Ceramic variants are capable of operating at temperatures up to 2000°C and metallic diffusion slurries can protect components in oxidising environments above 700°C.

Protection for Titanium Alloys

Titanium is seldom used at elevated temperatures due to the structural changes that occur in the presence of oxygen.

Test work with MoniPlex® coatings on titanium components has shown significant improvements in substrate structure. The totally dense nature of the coating combined with its excellent resistance to thermal shock provides a smooth, thin protective layer on the surface of titanium minimising the diffusion of oxygen to the surface of the metal.

Textile Machinery

Yarn contact surfaces on textile machines are required to have extreme resistance to wear and low friction characteristics (0.20 to 0.25) to prevent damage to the yarn such as “snowing”.

Many of the new high technology yarns such as carbon fibre, Kevlar® and other synthetic fibres are very abrasive and extremely susceptible to filament damage. Highly corrosive substances are also used in the manufacturing process. MoniPlex® coatings have proven their ability to provide total corrosion protection in this environment with the kindest of surfaces for the yarn.

MoniPlex® coatings are applied to:
Air jet plates
Cooling tracks
Twist stop pins
Draw rolls
Yarn feeders
Weft tongs

Furnace Protection Coatings

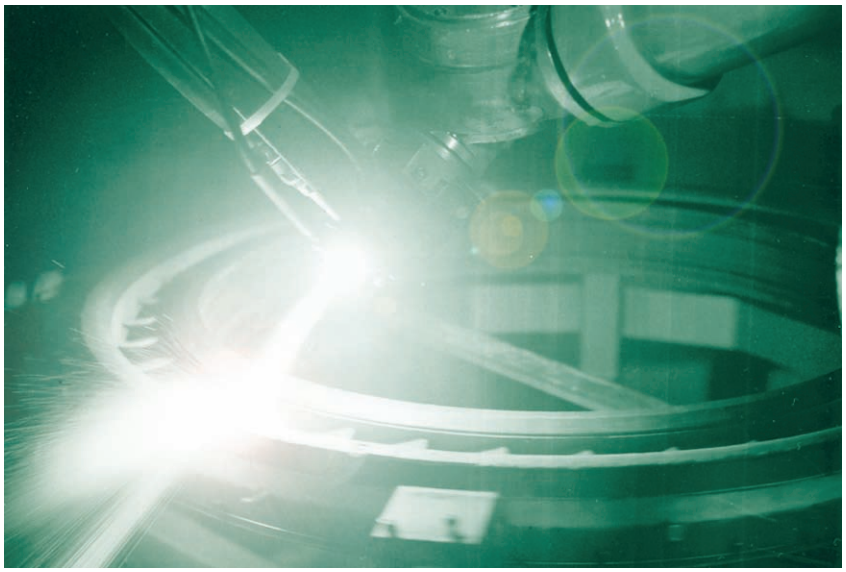
MoniPlex® is a high temperature protection coating for heat treatment furnace retorts, muffles, baskets, trays, hearth plates, fans, recuperater tubes and radiant tubes made of stainless steel, Inconel and Hastelloy.

MoniPlex® coatings of 50 microns thickness is applied by spray gun or brushed on the component. When the coated components are heated to around 850ºC in the furnace the coating diffuses into the base metal and form an adherent layer.

In carburising furnaces, during de-sooting, the carbon deposited on nickel/chromium elements and radiant tubes burns off exothermically. The heat released causes localised pitting and repeated heating and de-sooting causes the pits to increase which eventually leads to rupture. MoniPlex® reduces these effects, extending and improving the heat transfer of high temperature furnaces.

Improves resistance to heat oxidation and scaling
Protects components from corrosion at high temperature
Improves heat resistance and minimises distortion of components
Avoids cracking of weld joints
In the case of retorts and radiant tubes the coating improves heat transfer with a marked reduction in energy consumption
Prevents carburising and nitriding of fixtures and retorts thereby minimising cracking
Coatings withstand severe thermal shock.

Smooth surface of coating prevents carbon deposit
Ceramic coating resists the heat of exothermic reactions during de-sooting
Chromium oxides in the coating improve emissivity from around 0.6 to 0.9 improving the heat radiation.
Improved radiation minimises over heating of elements.
The inert surface created using MIP2 protects the heaters from the corrosive effects of the furnace atmosphere.
Improves furnace temperature uniformity



Steel Industry

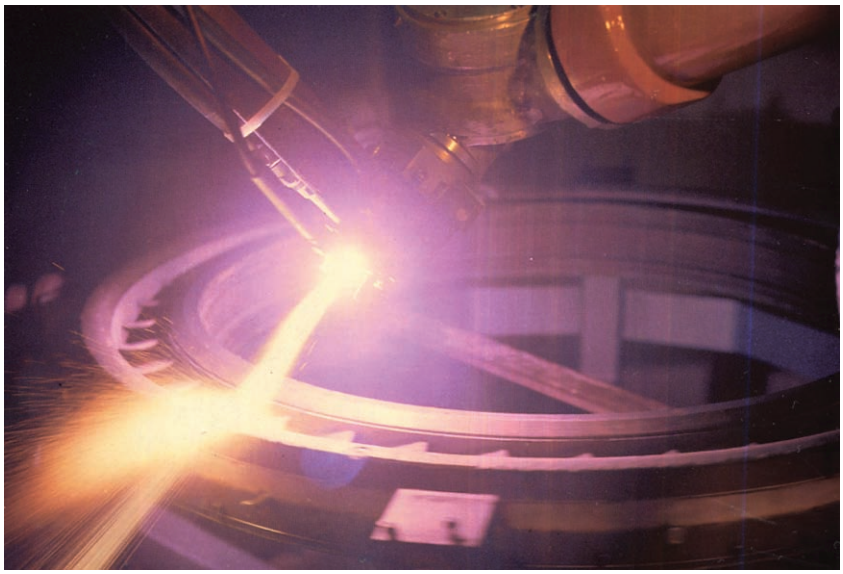
The diversity of MoniPlex® and SealPlex® applications is truly demonstrated in the steel industry. In the protection of Continuous Casting copper mould plates in conjunction with Monitor's strategic partners [patent XX], CastCoat® and CastSeal® are sold world-wide to steel manufacturers. Operators report the life expectancy of Moulds to have increased by a factor of up to 8 while at the same time reducing the risk of break-outs and sticker alarms.

The use of MoniPlex® and SealPlex® in conjunction with thermal spray hard-face coatings for roll applications such as furnace rolls and hearth rolls on the CAPL (Continuous Annealing Process Line) offer significant life extension significantly reducing operating costs. Protection of processing equipment such as pinch and sink rolls for molten zinc and tin coating of continuous cast strip has seen a step-wise improvement in technology since the use of MoniPlex® and SealPlex® coatings.

Oil and Gas Industries

MoniPlex® and SealPlex® are extensively used to combat combined wear and corrosion problems in the Oil and Gas industries. In conjunction with Monitor's patented mud rotor coating system [patent US6,425,745 B1 (US), 058744 (EU)] MoniPlex® can extend the life of directional drilling motors by up to two orders of magnitude in high chloride drilling conditions. Other equipment coating with MoniPlex® and SealPlex® includes valve components, hydraulic shafts and Jars (Jahls).

Blades, rings, valve casings and separators in both gas and steam turbine applications benefit from wide range of MoniPlex® and SealPlex® coating systems.



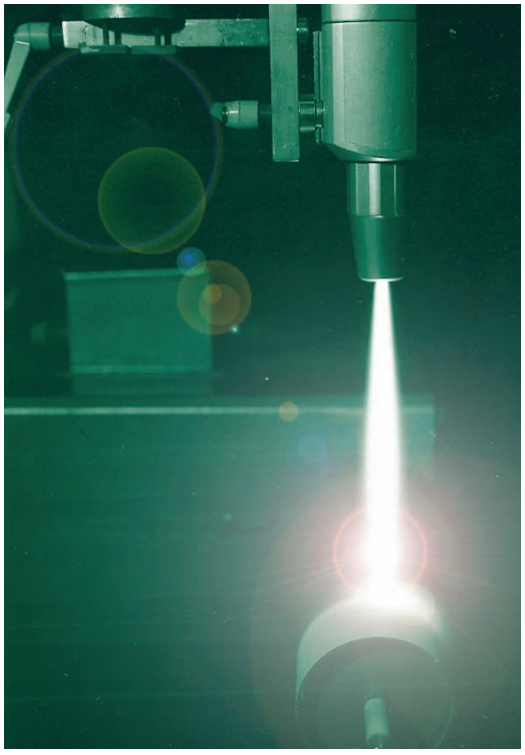
Molten Metals, Glass and Plastics

The low wetability, low friction (non-stick) and high thermal and chemical resistance of MoniPlex® makes it a perfect material for handling and processing molten materials such as aluminium, glass slumping and injection moulding of abrasive plastics.

Protecting Against:

Centrifugal impeller pumps
Reciprocating piston rings
Non-contacting pumps

Acids (HCl, H2SO4, HPO4)
Alkalis (NaOH)
Solvents (Petrochemicals)
Cryogenics
Halides (chlorides, sea water, fluorides, bromides)



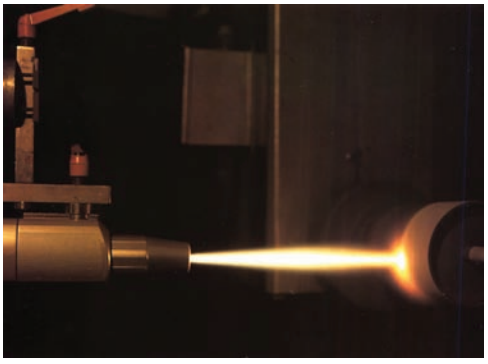
Pumps and Compressors

Reciprocating equipment suffers many wear problems with plungers running in soft packing or cup type pistons running in metal liners. Both have the same requirement for maintaining the surface condition of the stationary and moving components.

Dramatic increases in component life can be achieved where seal materials operate against lapped or honed MoniPlex® coated surfaces, normally with a proportional increase in seal material life.

MoniPlex® is applied to components in the pump, chemical, agro-chemical and sewerage processing industries:

With conventional materials there is often a conflict of interest when both resistance to corrosion and resistance to wear are required. A typical example is equipment in the North Sea; materials such as Inconel are preferred for their corrosion resistance, but these materials have relatively poor resistance to wear. MoniPlex® coatings will provide the wear resistance and they are also inert to most forms of chemical attack.



MONIPLEX® Product Range

Product	Thickness Range	Hardness Hv	Properties & Description	Example Industrial Applications
M-Plex 1	50 - 100 µm	2000	Excellent corrosion, wear and solid particle erosion resistance.	Textile components, pumps, seals and shaft protection. Moulds, forming tools, Chemical Industry, Steel Manufacturing and Wire Drawing Industries.
C-Plex 7	50 – 250 µm	1900	High temperature oxidation resistance.Low friction – high lubricity factor, good sliding wear resistance and thermal shock resistance.	Steel industry, Chemical Industry, gas and steam turbine applications. Metals, glass, and plastics manufacturing.
B-Plex 5	50 - 100 µm	2700	Tough, wear resistant surface – superb abrasion and erosion resistance.	Textile machinery for handling Lycra® and Kevlar®. Mining, drilling and cutting tools.
B-Plex 3	50 - 100 µm	2700	Excellent resistance to molten materials, impermeable barrier coating.	Glass slumping and glass manufacturing, Aluminium and metal smelters and casters.
Q-Plex 9	50 - 100 µm	450	High temperature oxidation resistance, good environmental corrosion protection.	Aerospace, gas turbine, furnace equipment manufacturers, large structure in-situ coating for corrosion protection.
SealPlex 2	1 – 10 µm	1200	Pore-free impregnation coating.	Oil and Gas, Petrochemical, Agro-chemical, pumps impellers and shafts.
SealPlex 6	1 – 10 µm	2000	Chemical barrier coating, electrical insulator. Excellent release properties for molten tin and zinc.	Pinch and sink rolls for molten metal coatings in continuous coil steel plants. Automotive and Electronics Industries.
SealPlex 8	<5 µm	2800	Super hard finish, smooth as coated surface for wear, chemical and solid particle erosion resistance.	Mining, drilling and cutting tools, high tension gears. Handling of corrosive and abrasive fluids.