



InnerArmor

Technical Specifications

InnerArmor® is a revolutionary patented technology for depositing hard, near frictionless coatings on internal and external surfaces. The oil and natural gas industry continues to face downtime and high operating costs created by part failures due to corrosion, erosion and other types of wear. In the past, costly alloys, chrome plating and thermal sprays were used to improve performance, but those alternatives were expensive, limited in effectiveness or environmentally hazardous.

InnerArmor surface enhancement technology uses a safe, benign process to apply a near frictionless, chemically inert, protective surface on products ranging from small components to long production pipes. By creating hard, corrosion and erosion resistant surfaces, InnerArmor extends component operating life and decreases customer's operating costs.



Reduces Wear and Halts Erosion

Offering a unique combination of hardness and smoothness, InnerArmor coatings provide unprecedented protection against erosion, wear and abrasion.

A layered structure allows thickness and composition of individual InnerArmor layers to be adjusted for an application. For example, the toughness factor can be increased for an erosion application just by changing the chemistry of a layer.

Due to InnerArmor technology, many parts that previously required expensive metal alloys can now use less costly base materials to achieve improved performance.

Minimizes Friction and Maximizes Flow

With an exceptionally low coefficient of friction, InnerArmor coatings maximize flow dynamics, help maintain line pressure and reduce the amount of energy needed to move product - all of which reduces costs.

The coatings are also hydrophobic (water repelling) so liquids slide quickly across an InnerArmor coated surface. The net result is that InnerArmor coatings produce substantial operational cost savings.

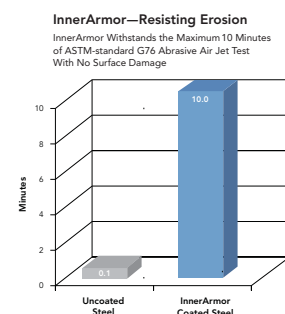
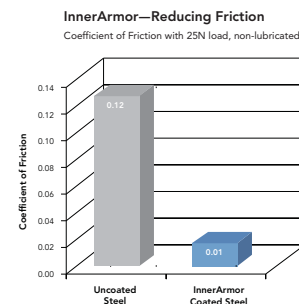
Blocks Corrosion

In transporting and processing oil and gas products, components are often subjected to sour flows, heavy sand, salt water or other conditions. These challenges are magnified when high temperature steam is applied to enhance production. With intrinsic chemical inertness, InnerArmor coatings, provide a high performance barrier against corrosion in salt water, H₂S, CO₂ and other corrosive chemistries. Uniquely amorphous, like glass, the coatings have no crystalline grain structure. Providing smooth, uniform coverage, even across very long lengths, the InnerArmor coatings eliminate pin-holes or "holidays" to maximize protection against substrate corrosion. By reducing failures, InnerArmor technology increases production.



Specifications

Substrates	Stainless / Carbon Steel, Aluminum, Ti/Ti-alloy, Ni/Ni alloys, and others
Corrosion Protection	Hydrogen sulfide (H ₂ S), hydrofluoric acid (HF), hydrochloric acid (HCl), nitric acid (HNO ₃), sulfuric acid (H ₂ SO ₄), salt, methane (CH ₄), CO/CO ₂
Hardness	1000—2000 HV (10—20 GPa) (Note: Carbon steel = 217 HV)
Wear Rate	1E-06—1E-08 mm ³ /Nm
Coefficient of Friction	0.01—0.08
Deposition Temperature	248—392°F (120—200°C)
Max Operating Temperature	1100°F (600°C)
Coating Thickness	1—80 microns
Adhesion	Chemically bonded to substrate
Coating Finish	Identical to substrate
Environment	Safe, Benign application



Improved Energy Efficiency

Exceptionally low surface friction reduces the amount of energy required for sliding motion or fluid transfer in engines, pipes, and other components.

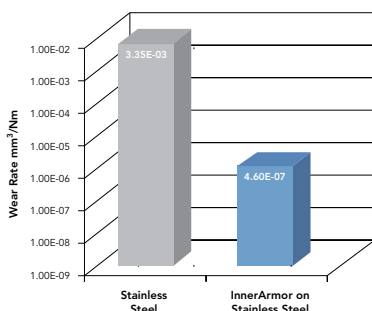
Extended Component Utilization

Increases operating life by protecting internal surfaces against premature failure from corrosion and wear.

Reduced Operating Costs

Improved surface performance reduces downtime and part replacement costs while often eliminating the need for expensive alloys.

InnerArmor—Reducing Wear
Wear Rate with 25N load, non-lubricated



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