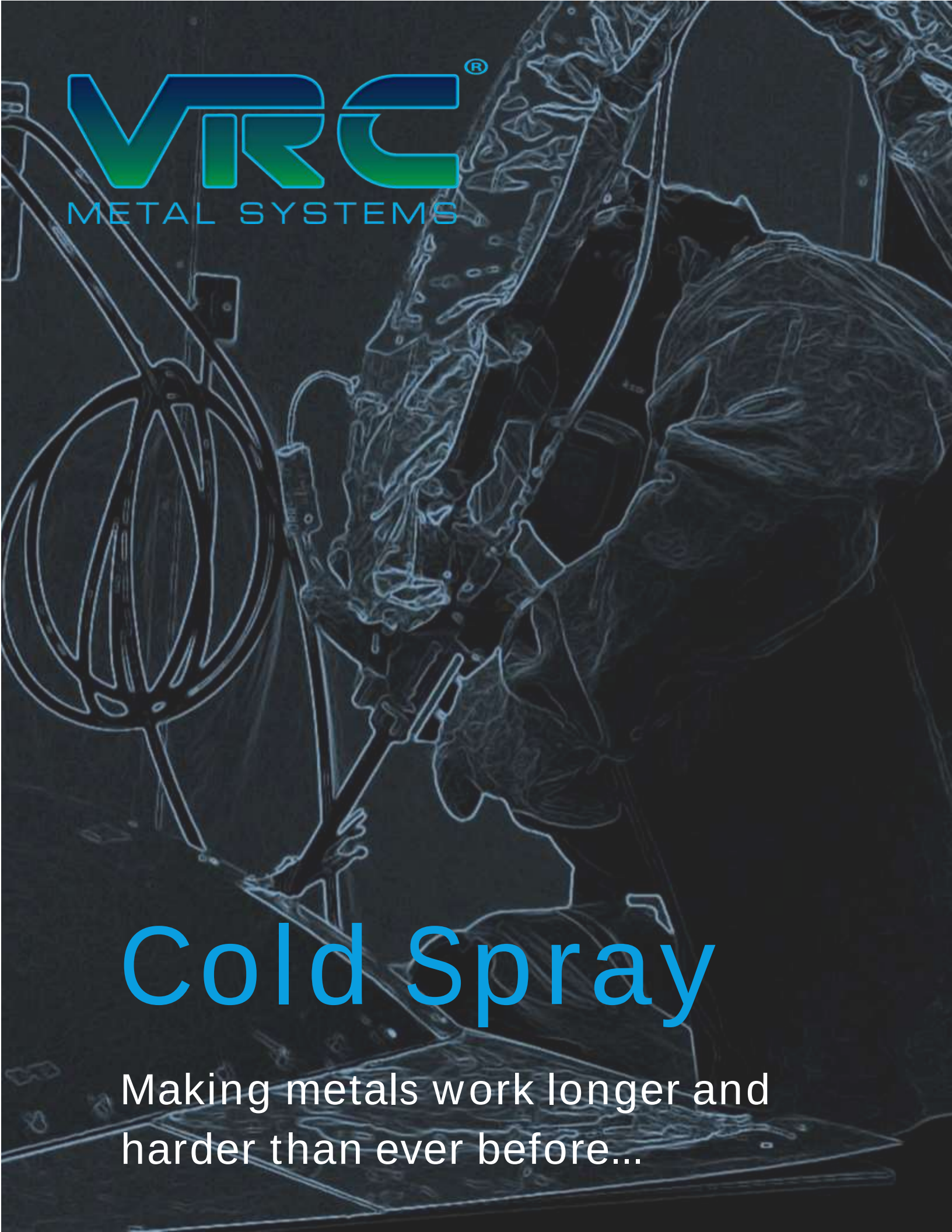


Cold Spray

Making metals work longer and harder than ever before...

Cold Spray Repairs

Aircraft Skin Panel Fastener Hole Repair[1]

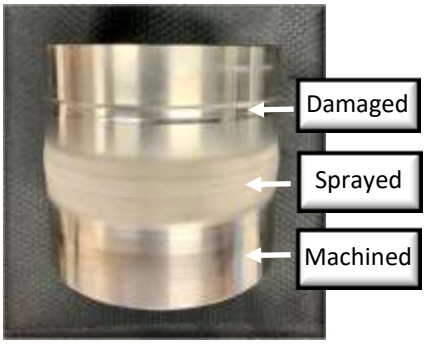


[1] Ch. 9 Cold Spray Applications: V.K. Champagne et al. Cold Spray Coatings, ASM International (2018) pp. 25-56.

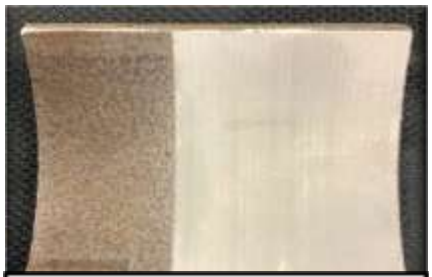
Pipe Joint Leak Repair

Leaky pipe coupling can be sealed with Cold Spray on-site at temps low enough that most operations can remain running

SS Shaft Defect Repair



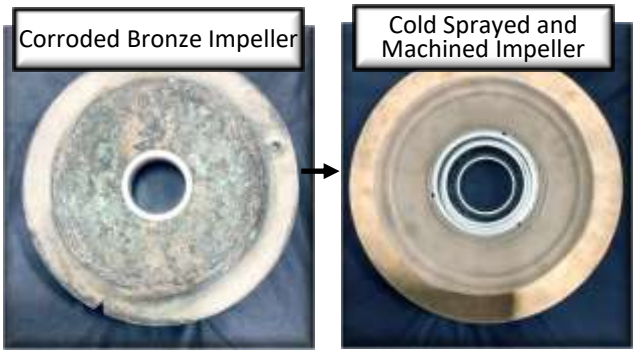
Corrosion Resistant Layers



Steel pipe internally sprayed with Aluminum to protect from corrosion

Weld joint sprayed with Aluminum to protect from corrosion

Bronze Corrosion Repair

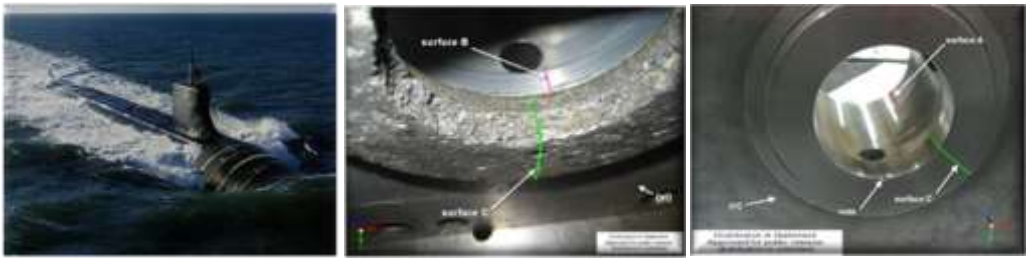


Pipe Repair without High Temp

Damaged steel pipe after tooling to remove defect

Steel pipe showing raw Cold Spray build-up before final machining

Navy Valve Actuator Repair[2]



[2] Cold Spray Repair of a Navy Valve Actuator: Widener, C.A., Carter, M.J., Ozdemir, O.C. et al. Journal of Thermal Spray Technology (2016)25: 193.

Hard Coatings

Durable hard coating option and or Chrome replacement NiCr/CrC

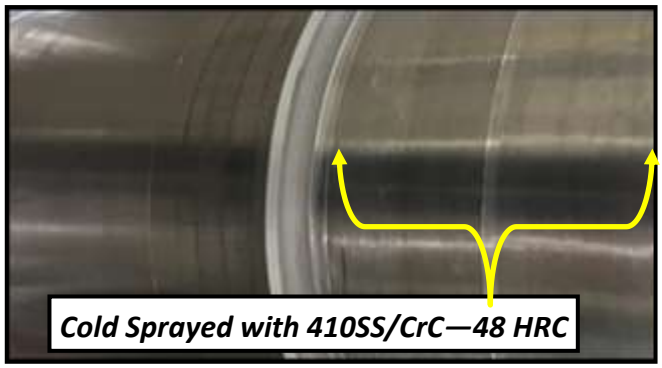
(wear resistance specimen shown after abrasion test)

And Many More...

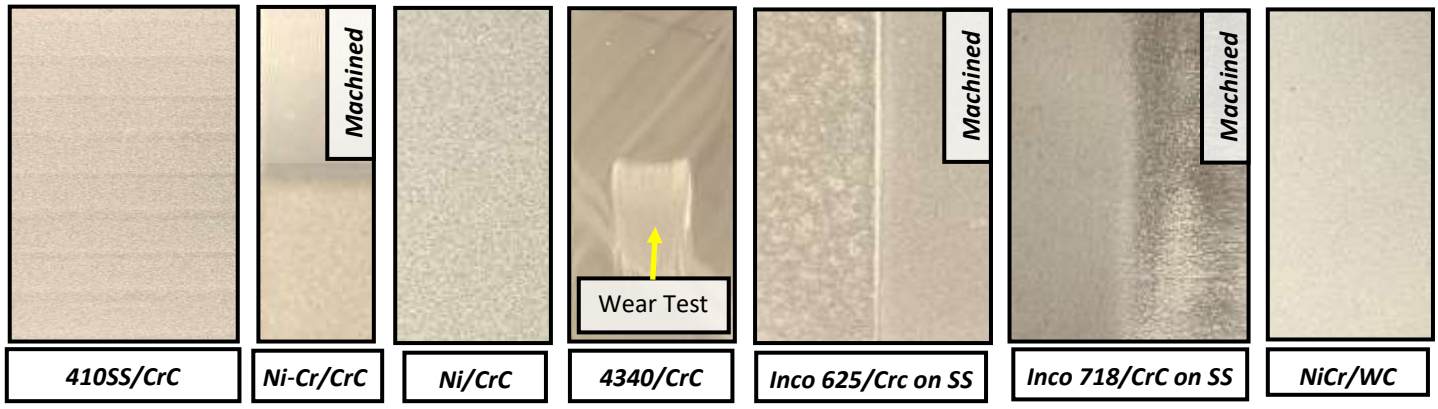
VRC cold spray equipment is saving customers millions of dollars every year by repairing components for aircraft, ships, submarines, helicopters, missile systems, mining and industrial equipment, oil and gas, power plants, and many more.

Mechanical Wear Resistance

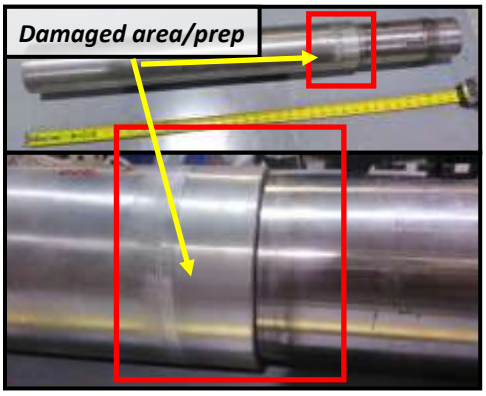
Chrome Replacement Shaft Repair

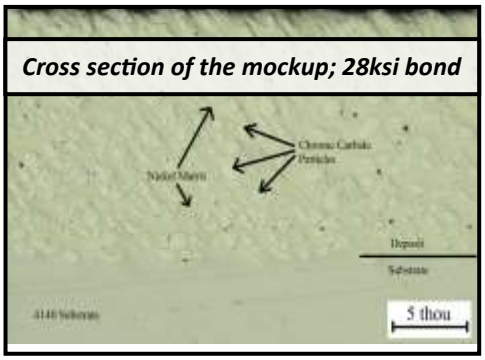


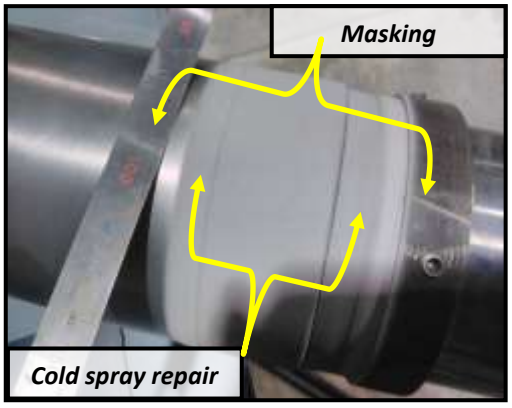
Family of Chrome Replacements / Hard Coating Options—Plus Many More

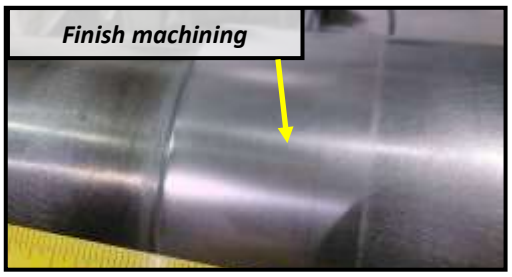


Cold Spray Shaft Repair Process—Ni/CrC on 4140 Steel*





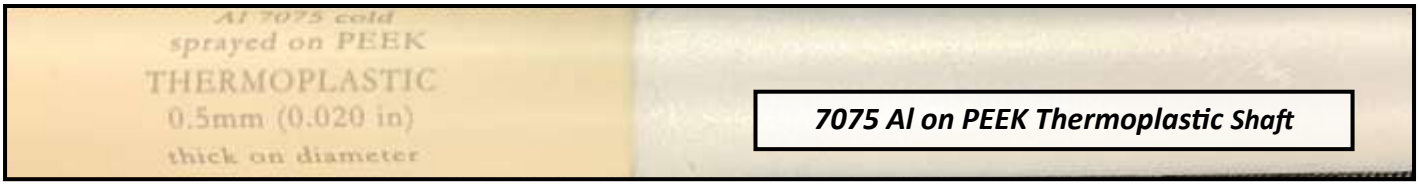




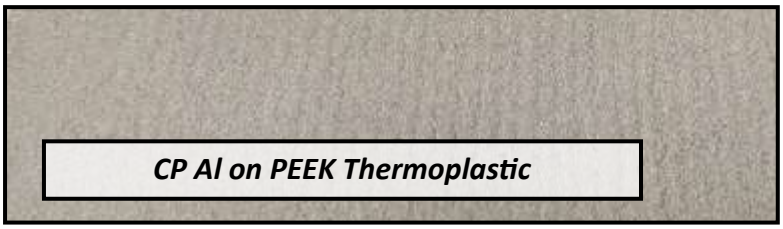
*Pictures courtesy of US Army Research Lab—Victor Champagne, Aaron Nardi, Gehn Ferguson, Isaac Nault, William Story, & Dan Nikolov

Enhancement & Specialty Coatings

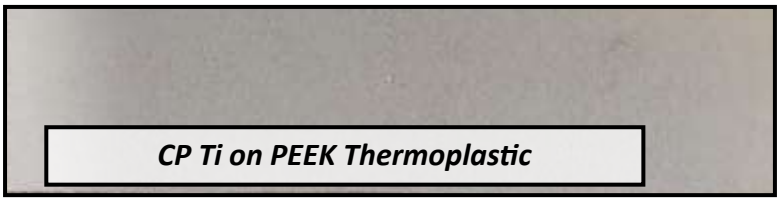
Cold Spraying Metal on Thermoplastic (wear resistance or RF shielding)



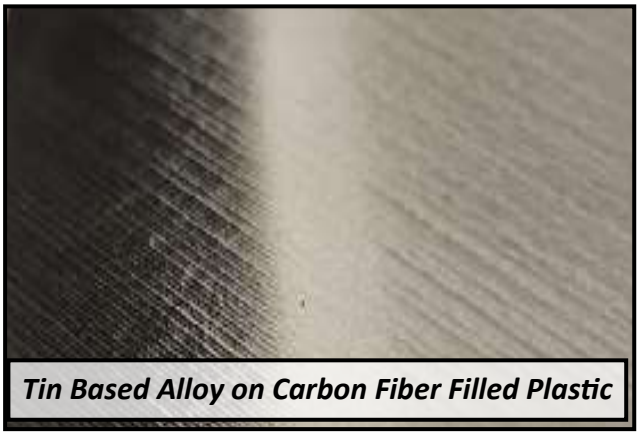
7075 Al on PEEK Thermoplastic Shaft



CP Al on PEEK Thermoplastic

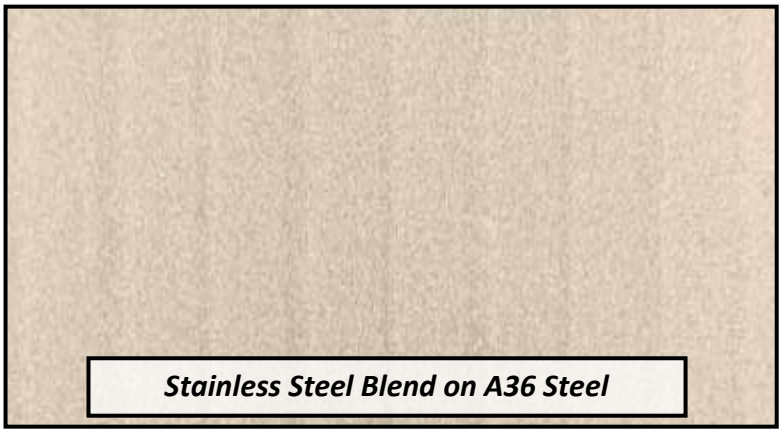


CP Ti on PEEK Thermoplastic



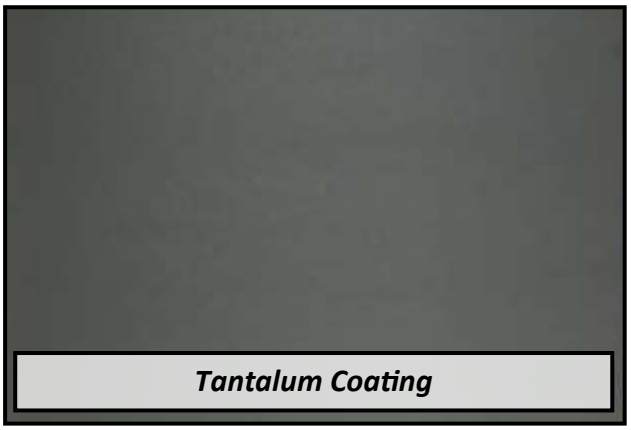
Tin Based Alloy on Carbon Fiber Filled Plastic

Infrared Energy Reflective



Stainless Steel Blend on A36 Steel

Acid Resistance

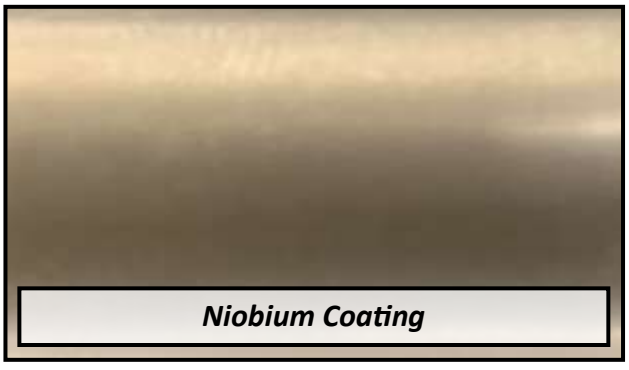


Tantalum Coating

Antimicrobial

Antimicrobial Copper Coating

High Heat Resistance



Niobium Coating

Cold Spray Materials, Properties and Testing

Materials

Single or Mixed Powder Feeding

Unique tumbling drum powder feeder enables uniform coatings with mixed powders - does not separate heavier materials like competitors' vibratory feeders.

Aluminum	Copper	Titanium	Steel & SS	Nickel
- CP Al	- CP Cu	- CP Ti (all grds)	- 1018	- CP Ni
- 2024	- Bronze	- Ti-6Al-4V	- 4340	- Inco 625
- 6061	— 90Cu-10Sn	And more	- 17-7 SS	- Inco 718
- 7050	— Cu-Ni-Inco		- 316 SS	- Ni/CrC
- 7075	— Ni-Al-Cu		- 410 SS	- NiCr/CrC
And more	And more		And more	And more

Specialty Powders

Tantalum, Niobium, Chromium, MCrAlYs Blends, MMCs, Silver, Tin, Babbit, and more

Properties

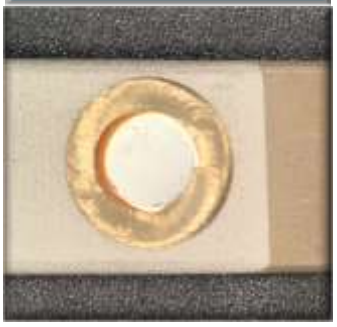
VRC high-pressure cold spray systems typically create deposits with bond strengths above 10 ksi (68.9 PMa) and can exceed 30 ksi (206 MPa) bond strength while maintaining less than 1% porosity, and hardness values ranging from 90 to 1300 Vickers (48 HRB - 72.5 HRC).

Testing

VRC can perform a wide range of material testing to ensure properties meet or exceed customer requirements.

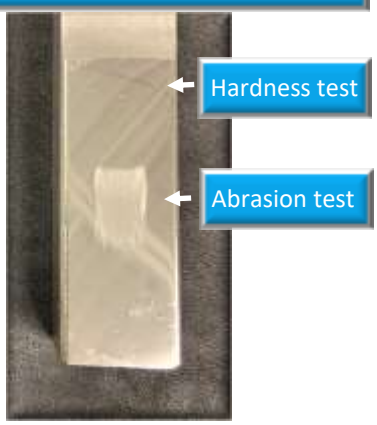
Adhesion | Tensile | Micro Structure Analysis | Hardness | Lug Shear | Abrasion | Corrosion | Sliding Wear

Adhesion Testing NiCr/CrC sprayed on A-36 Steel



Microscopic analysis of CP Ti deposit/substrate interface

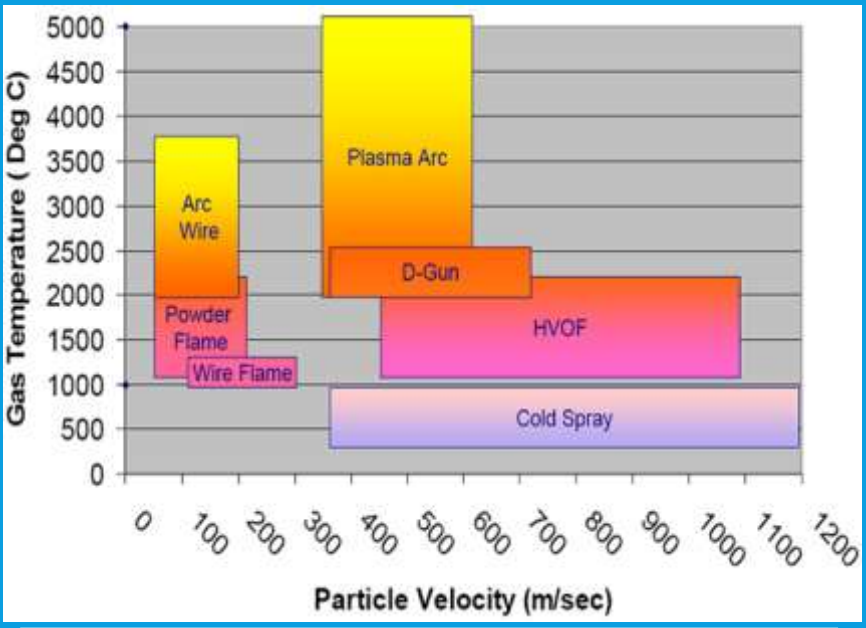
ASTM G65 Wear Test of a Cold Spray Chrome Replacement Coating



High-Pressure Cold Spray is the only thermal spray process that offers structural properties

Benefits of Cold Spray vs. Traditional Thermal Spray

- No heat affected zone
- Negligible oxidation of cold spray materials
- Spot repairable - ability to reapply new cold spray over old coatings
- Superior coating adhesion, strength and toughness
- Fully-dense coatings
- Minimal distortion
- Deposition thickness - no limit
- Minimal masking requirement due to focused particle spray path
- Environmentally friendly - no toxic fumes
- Precise gas temperature control
- Compressive residual stresses rather than tensile



Cold spray operates at much lower temperatures than thermal spray and uses primarily kinetic energy to create solid-state bonded coatings, instead of melting and re-solidification.

The Leader in Complete Cold Spray Solutions

VRC leads the way in designing the most capable cold spray systems with specifications to meet or exceed our customer's expectations. We also specify and integrate complete turnkey solutions for our customers ranging from installation of the equipment into an existing space to integration of complete automation and enclosure solutions needed to do their job.

Each Customer Has Specific Requirements –VRC Designs Customized Solutions To Meet Those Needs

VRC Specializes in Fixture Design and Tooling, to Optimize Repair Cost and Time

The VRC Additive & Subtractive Systems

VRC is the leading U.S. manufacturer of cold spray equipment and is an active developer of cold spray processes for defense and commercial use. We will match you with the right cold spray equipment, material, and process to make you successful.

Integrated Additive & Subtractive Systems:

- VRC's line of additive cold spray systems with integrated automation in an acoustical spray booth with dust collection.

Medium System

- VRC's line of additive & subtractive systems with integrated CNC machining, automation, acoustical booth and dust collection.

Large Manufacturing System

Compressed Gas Support Systems:

- Helium Recovery, Nitrogen Generation and Compressed Air solutions

We know Cold Spray. *With the VRC Cold Spray Systems, we are able to spray the full range of materials depositable by both HIGH and LOW pressure systems. If it can be done with cold spray,* ***we can do it!***

The VRC Cold Spray Systems

VRC Gen III™ Portable High-Pressure System with Removable 21kW Heater and Touch Screen Controls

Raptor Cold Spray System

VRC® Raptor™ High-Pressure System with a Deployable 21kW Heater and Pendant

VRC® Dragonfly™

VRC Dragonfly™ High-Pressure System with Modular Components, a 21kW Heater and Handheld Pendant

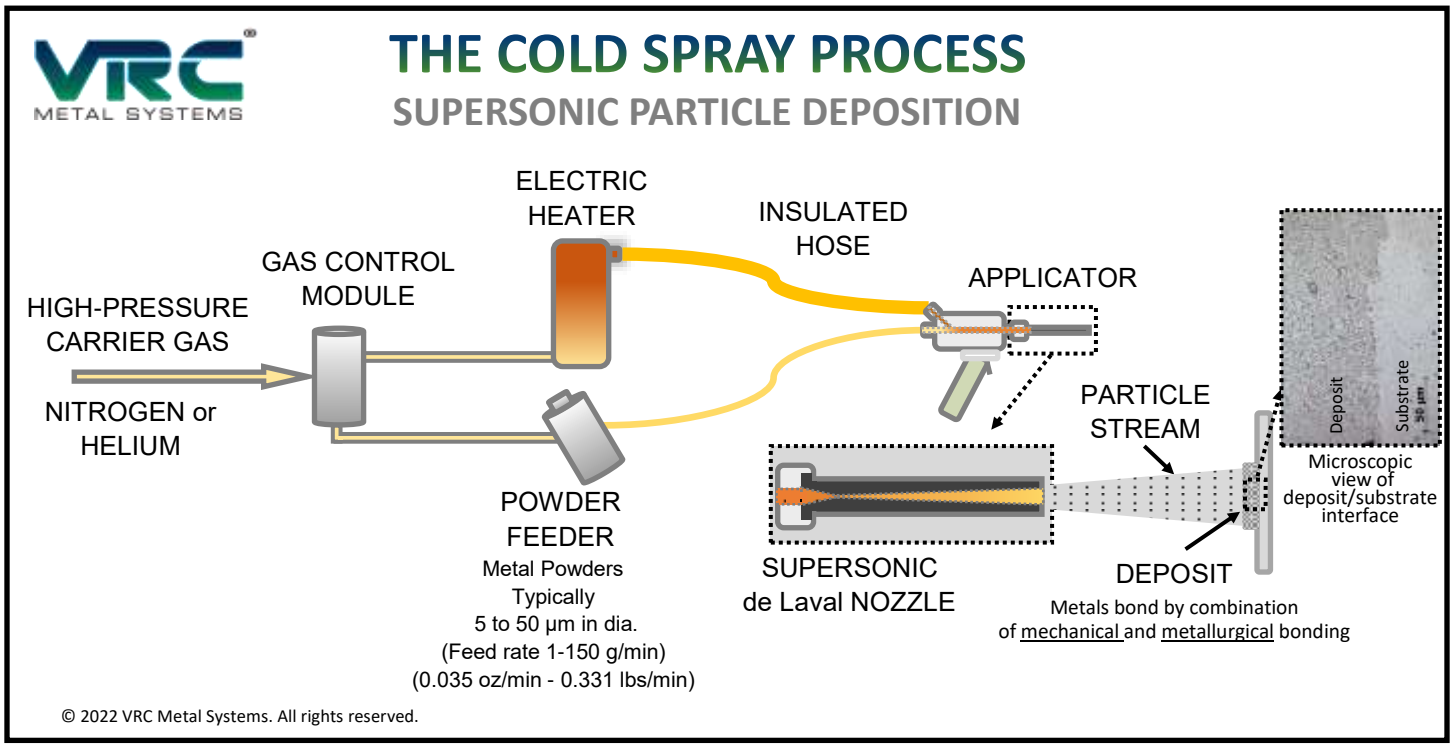
VRC Cold Spray Systems Capabilities

Features	Gen III ™	VRC®Raptor™	Dragonfly™
Dimensions	72”L x 32”W x 66”H (182cm L x 81cm W x 167cm H)	68”L x 32”W x 65”H (173cm L x 82cm W x 165cm H)	41”L x 22”W x 12”H (104cm L x 56cm W x 30cm H)
Overall Weight	1285lbs (583 kg)	900lbs (408kg)	Heaviest Component 88lbs (40kg)
Electrical	480 VAC, 3 PH, 50 Amps	480 VAC, 3 PH, 50 Amps	480 VAC, 3 PH, 50 Amps
Tethered parameter readout w/ touch screen controls	On Board Touch Screen Controls	**X**	Pendant Parameter Readout
Depolyable 21 kW Heater & Powder Feeder	**X** *Additional Equipment Required	**X**	**X**
Hand-Held or Robotic Applicators Applicator Temp Range 1202°-1292° (650°-700°C)	**X**	**X**	**X**
Foldable Tow Hitch		**X**	
Fork Pockets	**X**	**X**	
Lifting Eyes		**X**	
Tie Downs		**X**	
Aluminum Skid with Casters	**X**	**X**	
System Pressure up to 1000 PSI (69 Bar)	**X**	**X**	**X**
Gas Supply: Max Input Pressure 3000 PSI (206 Bar)	**X**	**X**	**X**
Max Temp at Heater up to 1472°F (800°C)	**X**	**X**	**X**
Max Gas Flow 88 CFM (2500 SLM)	**X**	**X**	**X**
Data Capture & Download	**X**	**X**	**X**
Single or Multiple Gas Capable	**Multiple** Can operate Nitrogen *and* Helium	**Multiple** Can operate either Nitrogen, Helium *or* Air	**Single** Can operate with either Nitrogen, Helium *or* Air
Gas Preheaters	**X**		
Remote Operational Capable	**X**	**X**	
Enhanced Integration Controls for NFPA Compliance & Safety	Booth door magnetic lock control, Dust Collector operational interlock, remote operation and ducting airflow detection	Booth Dust Collector operational interlock.	
Post Spray Printed Report	**X**		
Auxiliary Thermocouple Inputs (4 Additional)	**X**		
7 Pin Remote Connector used for integration with robotic controllers	**X**		
Configurable alarm package to alert operator of issues during use	**X**		

Cold Spray – The case for HIGH pressure

Cold spray, also referred to as supersonic particle deposition, is a solid-state coating process utilizing a heated high-pressure carrier gas, like nitrogen or helium, or air to accelerate metal powders through a supersonic de Laval nozzle to bond particles to a substrate. Low-pressure cold spray generates lower particle velocities, and primarily relies on mechanical interlocking with some metallurgical bonding. Low-pressure cold spray adhesion is comparable with other traditional thermal spray processes, which operate at higher temperatures.

However, **high-pressure cold spray coatings** with higher particle velocities and primarily metallurgical bonding are anywhere from **2 to 10 times stronger than low-pressure** cold spray coatings, depending on the material deposited. High-pressure cold spray coatings can be structural, and approach wrought properties of the sprayed material.



VRC not only manufactures state-of-the-art high pressure cold spray equipment, but also develops cold spray applications for its customers in a variety of industries.

VRC® METAL SYSTEMS

Inc. 5000
2017, 2018, 2019, 2020

DEFENSE INNOVATION AWARD 2018

Veteran Owned Business of the Year 2020

Certified AS9100D

Your trusted partner for cold spray applications development, equipment design and integration with the only portable, high-pressure, hand-held capable machines.

DIMENSIONAL RESTORATION & REPAIR | CORROSION-RESISTANT COATINGS | WEAR-RESISTANT COATINGS | ADDITIVE MANUFACTURING | HIGH-STRENGTH DISSIMILAR MATERIAL COATINGS | FIELD REPAIR | EMI SHIELDING

Making Metals

Learn more at vrcmetalsystems.com

VRC Sales Dept: sales@vrcmetalsystems.com; +1 605-716-0065
Asia VRC Rep: asia.sales@vrcmetalsystems.com