



Cold Spray

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

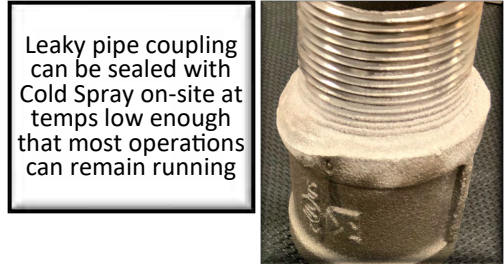
Applications

Aircraft Skin Panel Fastener Hole Repair¹



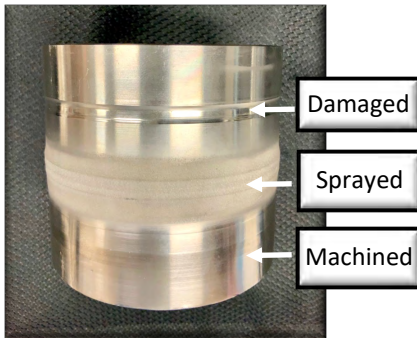
[1] Ch. 9 Cold Spray Applications: V.K. Champagne et al. Cold Spray Coatings, ASM International (2018) pp. 25-56.

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



Damaged

Sprayed

Machined

Corrosion Resistant Layers

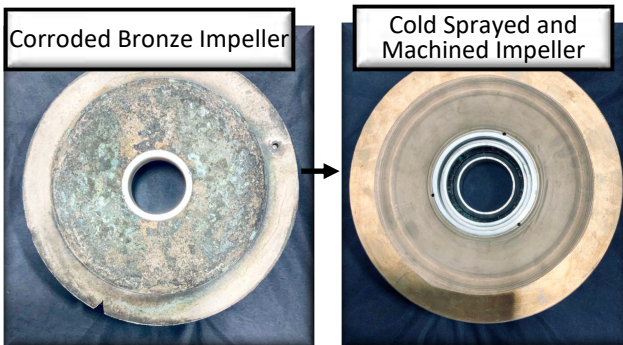


Steel pipe internally sprayed with Aluminum to protect from corrosion



Weld joint sprayed with Aluminum to protect from corrosion

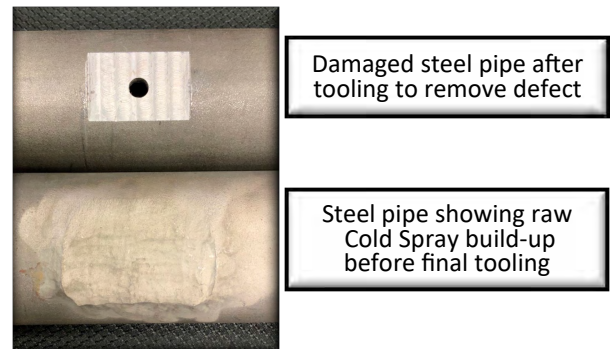
Bronze Corrosion Repair



Corroded Bronze Impeller

Cold Sprayed and Machined Impeller

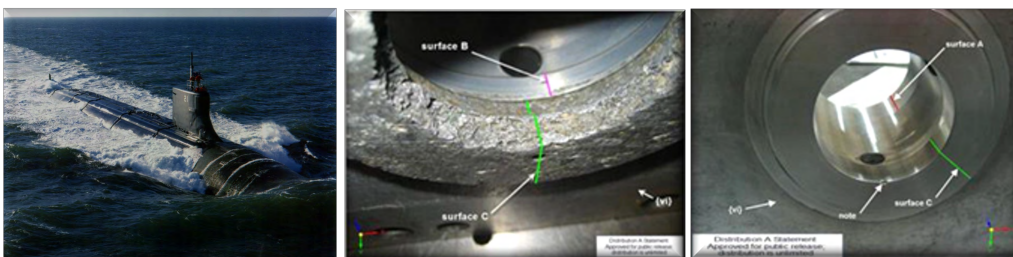
Pipe Repair without High Temp



Damaged steel pipe after tooling to remove defect

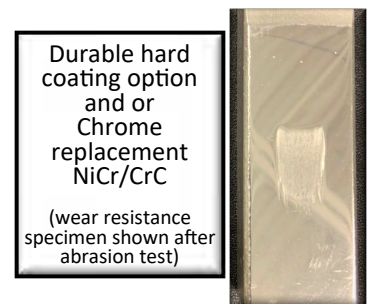
Steel pipe showing raw Cold Spray build-up before final tooling

Navy Valve Actuator Repair²



[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



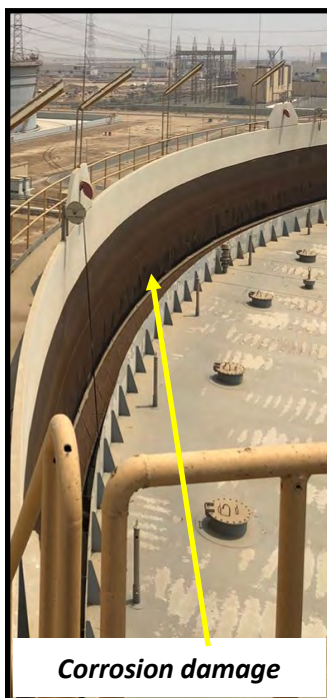
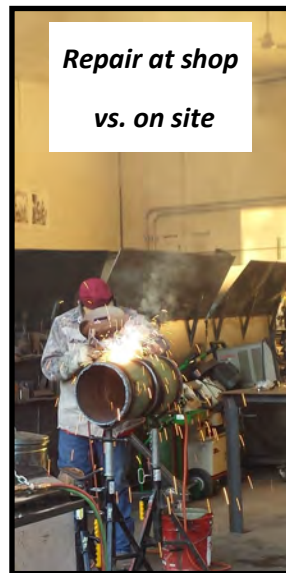
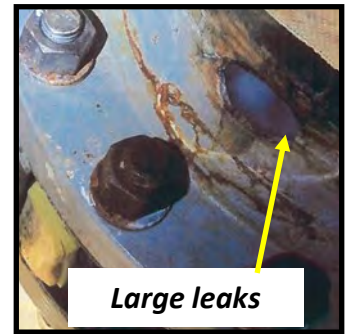
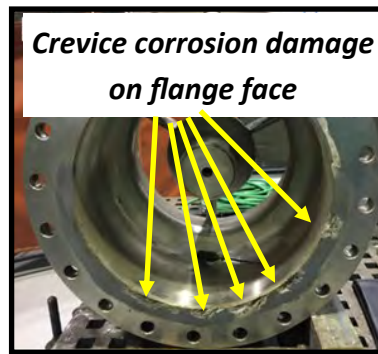
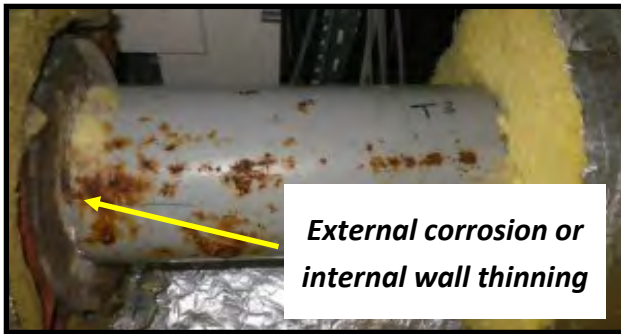
Durable hard coating option and or Chrome replacement NiCr/CrC

(wear resistance specimen shown after abrasion test)

And Many More...

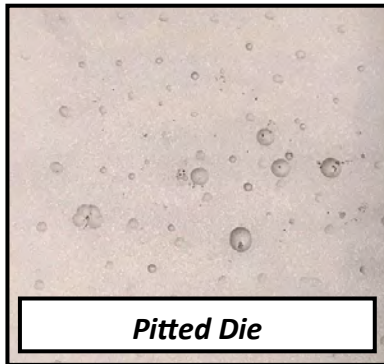
VRC cold spray equipment is currently restoring aircraft, ships, submarines, helicopters, missile systems, mining & industrial equipment, oil & gas components, power plants, and many other high value parts, and saving our customers millions of dollars every year.

Application: Challenges in the Field

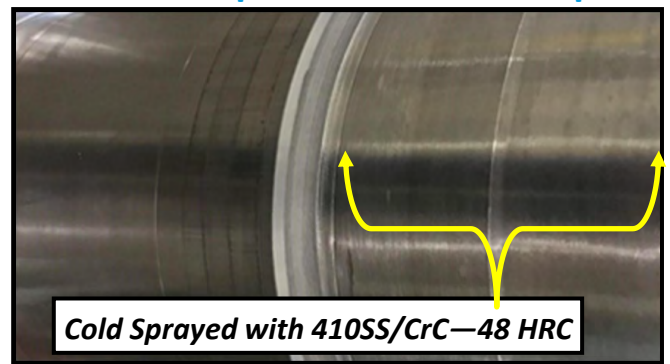


Application: Mechanical Wear Resistance

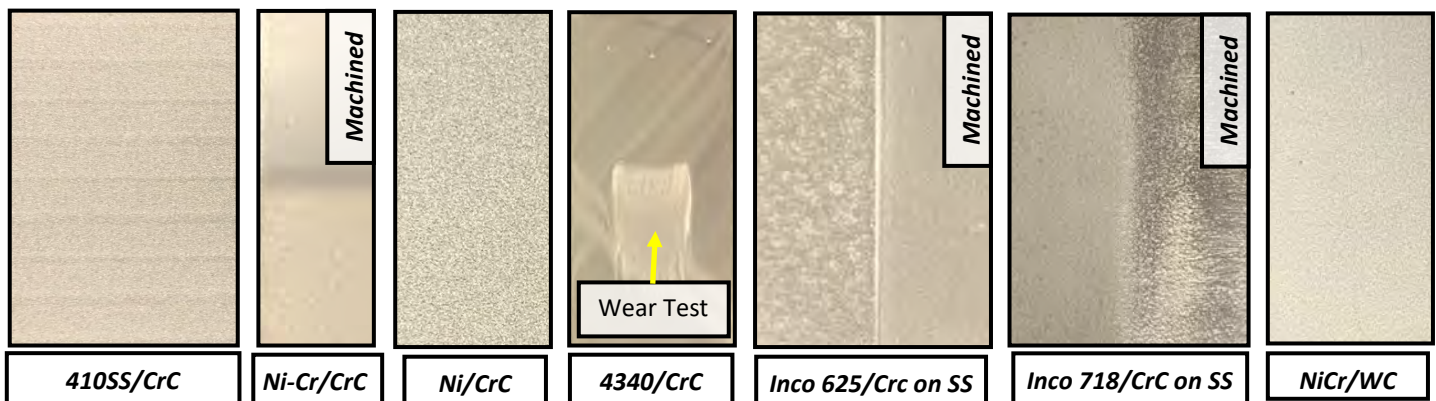
Cast Iron Stamp Die Repair



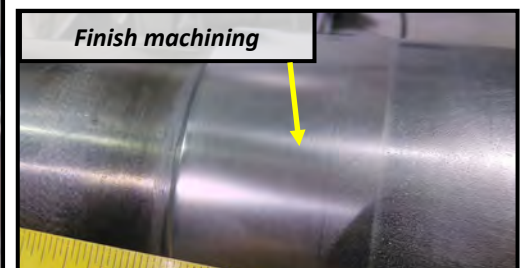
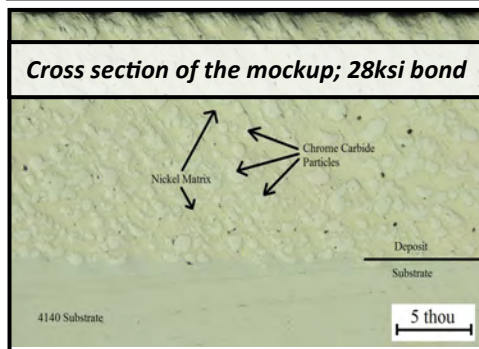
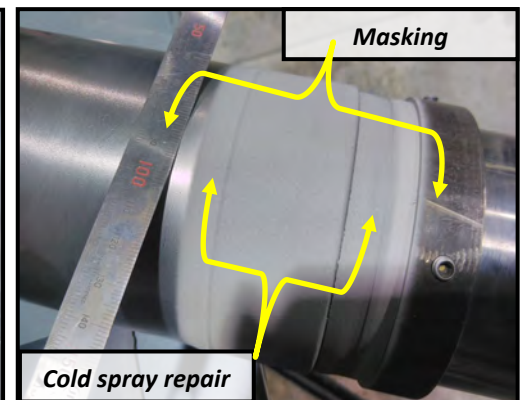
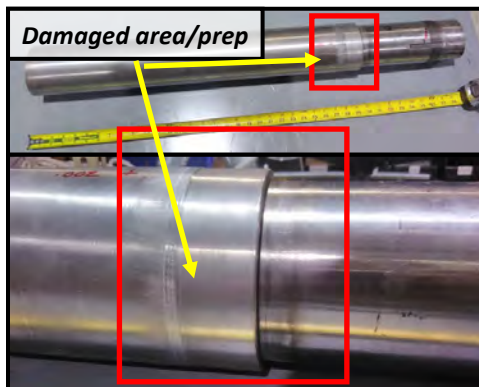
Chrome Replacement Shaft Repair



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



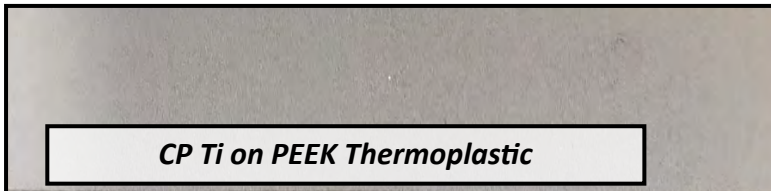
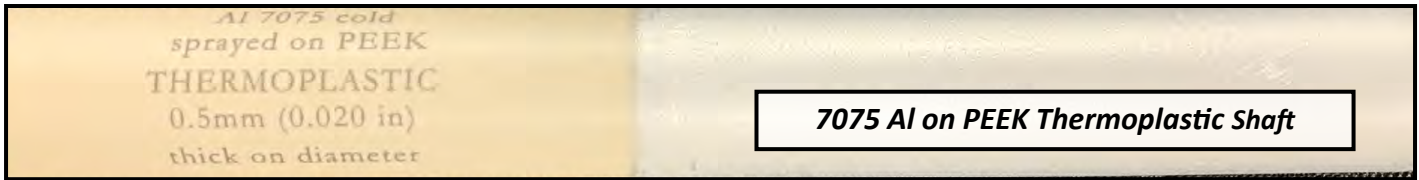
Cold Spray Shaft Repair Process—Ni/CrC on 4140 Steel*



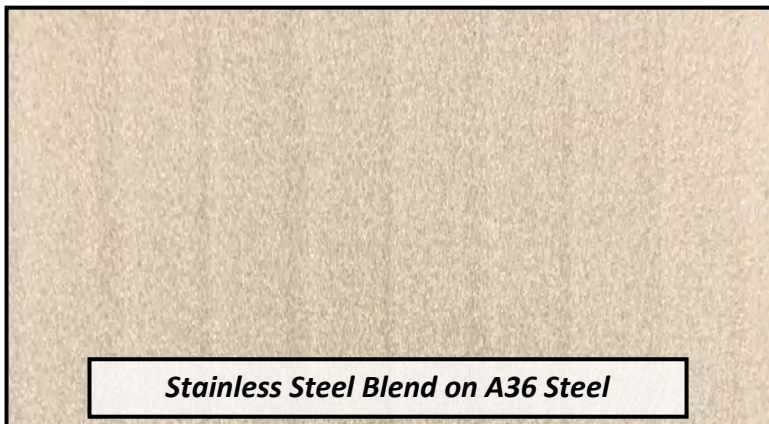
*Pictures courtesy of US Army Research Lab—Victor Champagne, Aaron Nardi, Gehn Ferguson, Isaac Nault, William Story, & Dan Nikolov

Application: Enhancement & Specialty

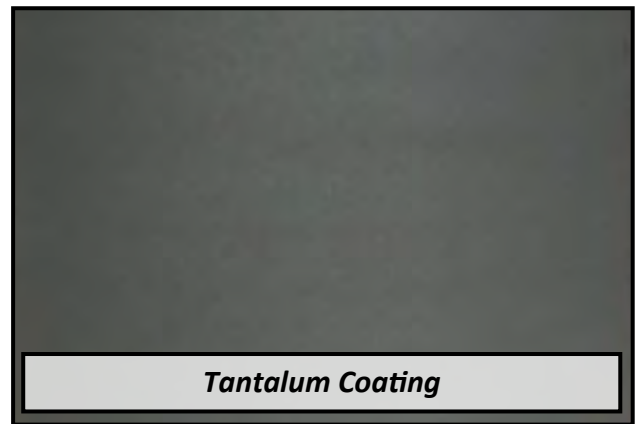
Cold Spraying Metal on Thermoplastic (wear resistance or RF shielding)



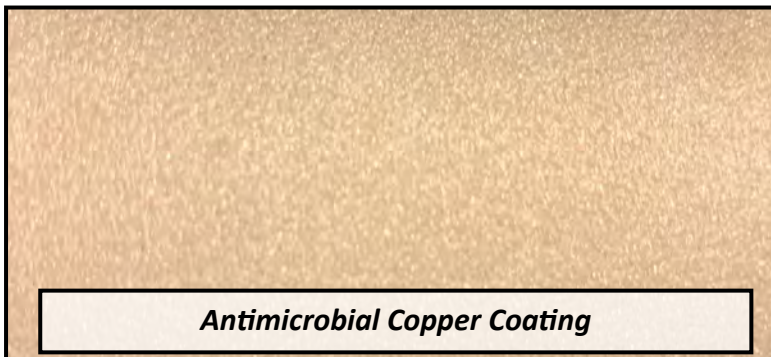
Infrared Energy Reflective



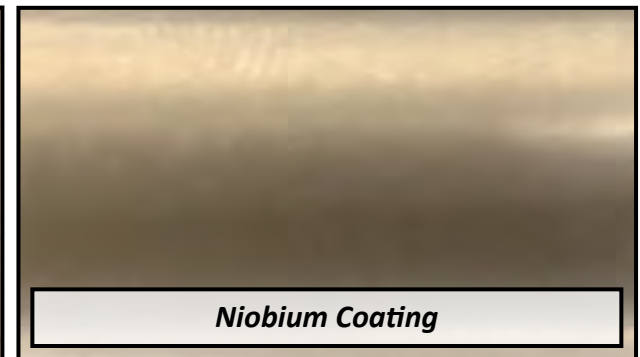
Acid Resistance



Antimicrobial



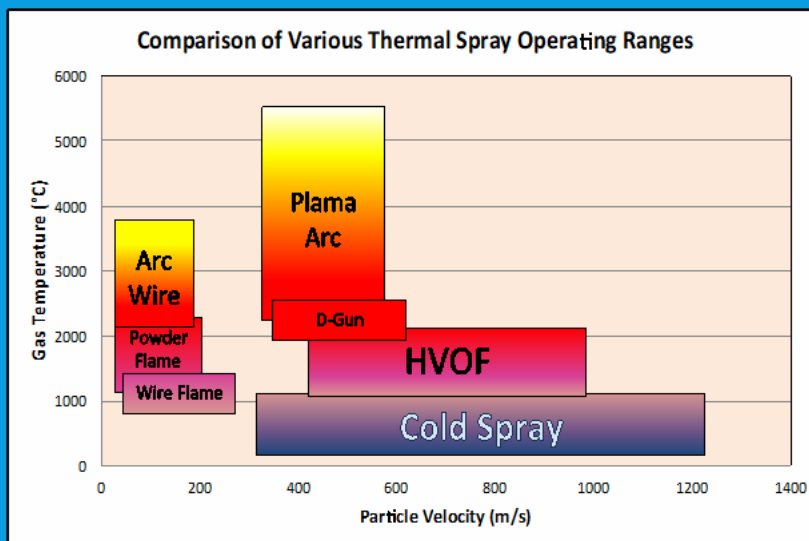
High Heat Resistance



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.

Cold spray repair of the fastener holes on an aircraft skin panel for the Air Force.



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 and material process for your application.

Integrated Additive & Subtractive Systems:

- **VRC VIPER™** line of additive cold spray systems with integrated automation in an acoustical spray booth with dust collection.

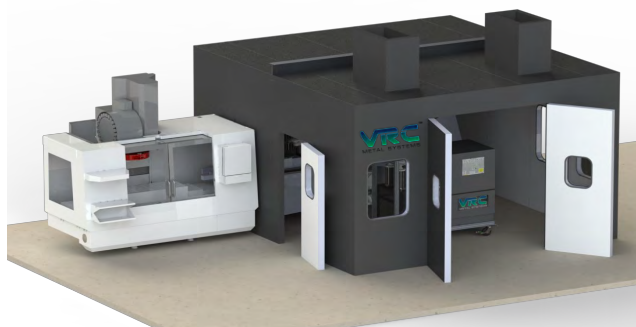


Medium Viper System



© 2017 Airborne Maintenance & Engineering Services

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



Large Paladin Manufacturing System

Compressed Gas Support Systems:

- Helium Recovery, Nitrogen Generation and Compressed Air solutions

We know Cold Spray. With the VRC Gen III™, 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

Gen III™ Cold Spray System



Dimensions: 72 x 34 x 72 inches

(1.83 x .86 x 1.83 meters)

1285 lbs (584 kgs)

Ruggedized Cold Spray System



Dimensions: 32 x 68 x 65 inches

(.81 x 1.72 x 1.65 meters)

900 lbs (408 kgs)

Modular Portable Cold Spray System



Dimensions: 22 x 41 x 12 inches

(.56 x 1.04 x .30 meters)

Heaviest Component 88 lbs (40 kgs)

Max System Pressure	Max Temp Heaters	Max Gas Flow Rate	480 VAC 3 Phase	Hand-Held Robotic Capable
1000 PSI (69 Bar)	800°C (1472°F)	2500 SLPM	Yes	Yes
1000 PSI (69 Bar)	800°C (1382°F)	2500 SLPM	Yes	Yes
950 PSI (65.5 Bar)	800°C (1472°C)	2500 SLPM	Yes	Yes

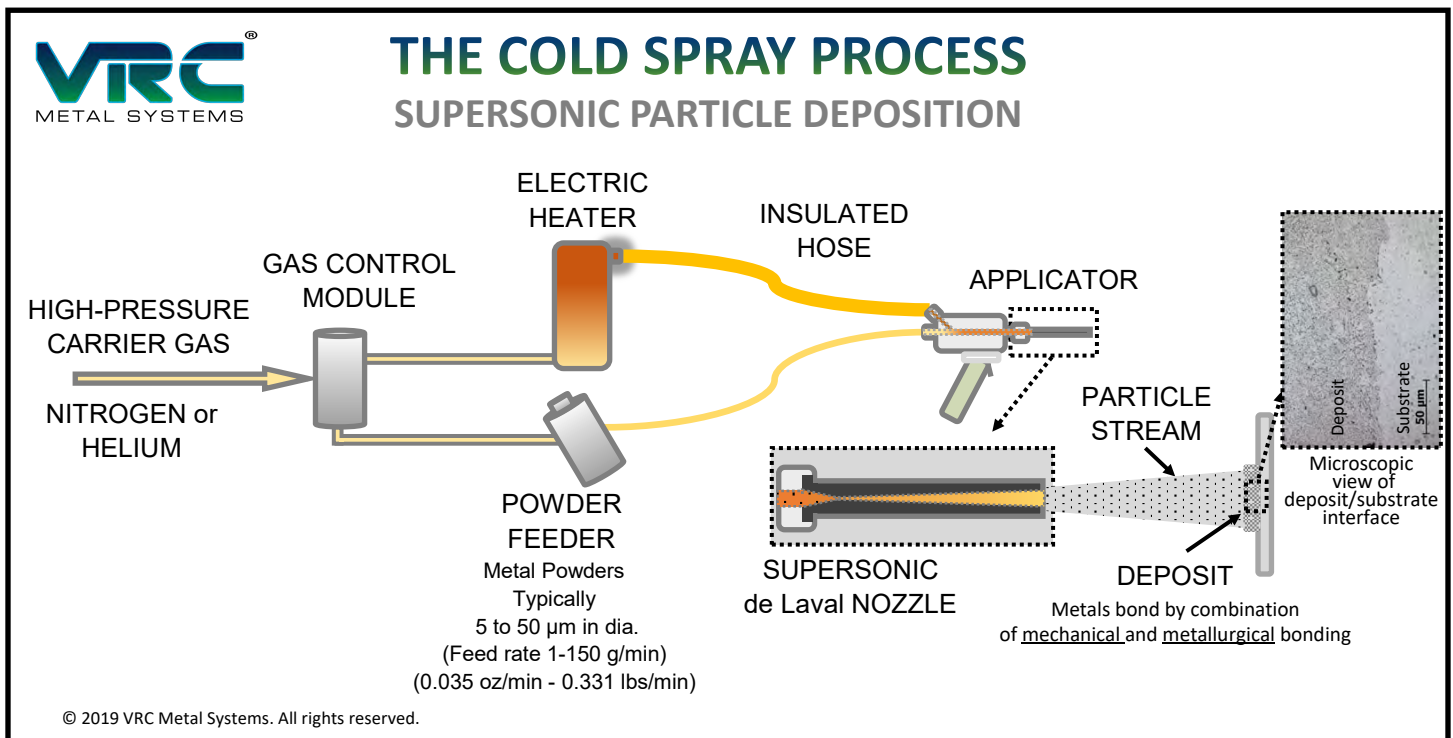
With the Gen III™, the Ruggedized and the Portable System we are able to spray the full range of materials by using HIGH and LOW pressure systems. If it can be done with cold spray, we can do it!

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, 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.

Cold Spray Materials, Properties and Testing

Materials

Single or Mixed Powder Feeding

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

Aluminum

- CP Al
- 2024
- 6061
- 7050
- 7075
And more

Copper

- CP Cu
- Bronze
- 90Cu-10Sn
- Cu-Ni-Inco
- Ni-Al-Cu
And more

Titanium

- CP Ti (all grds)
- Ti-6Al-4V
And more

Steel & SS

- 1018
- 4340
- 17-7 SS
- 316 SS
- 410 SS
And more

Nickel

- CP Ni
- Inco 625
- Inco 718
- Ni/CrC
- NiCr/CrC
And more

Specialty Powders

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

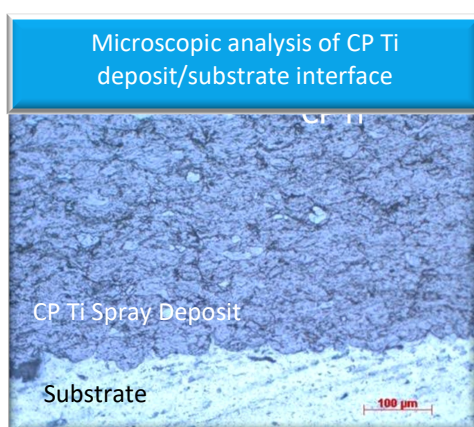
Properties

VRC high-pressure cold spray systems typically create deposits with bond strengths above 10 ksi (68.9 PMa) and can reach 33 ksi (228 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 |
Triple Lug Shear | Abrasion | Corrosion



VRC[®]

METAL SYSTEMS

Inc. 5000

2017, 2018, 2019, 2020



RUSHMORE REGION
south ★ dakota
Startup of the year 2015

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

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

Making Metals Work!

Learn more at vrcmetalsystems.com

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