



# Corrosion Repair using Cold Spray Technology

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Materials Engineering Department  
Fleet Readiness Center Southwest (FRCSW)  
Naval Air Station North Island  
San Diego, CA 92135

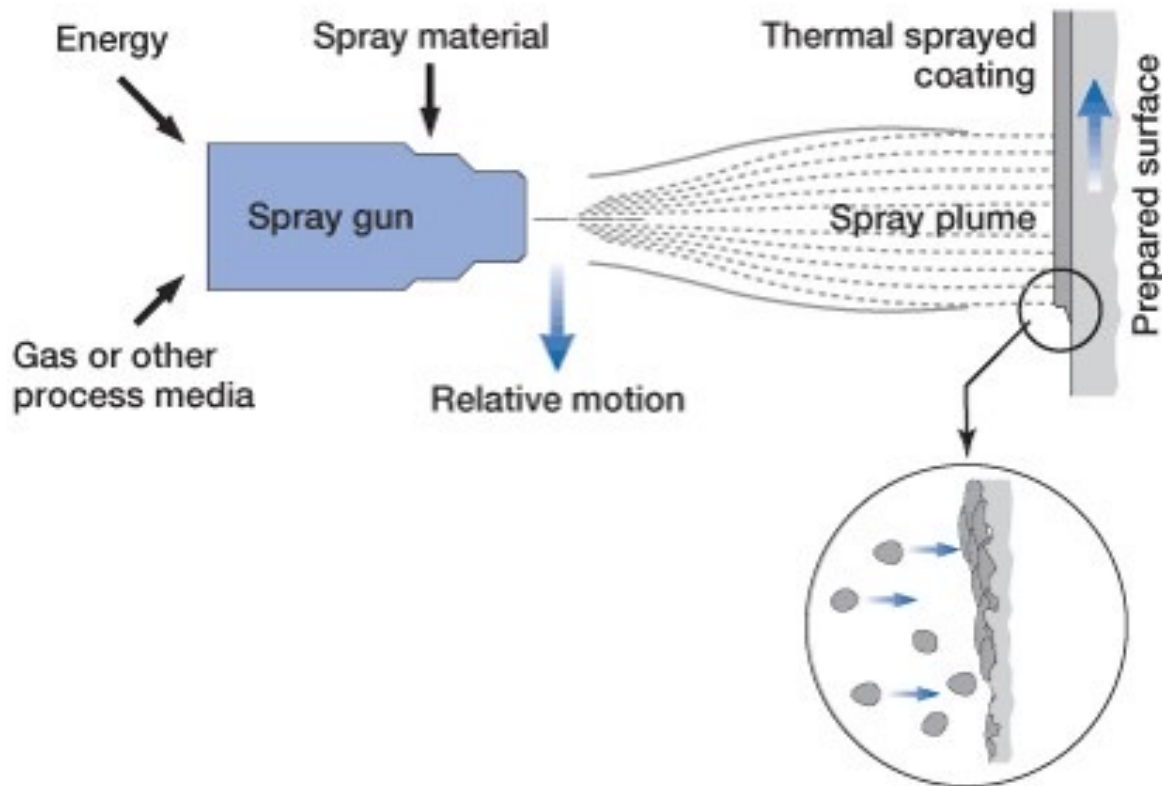
Presented By:  
Matthew Chu  
Fredrick Lancaster  
Luc Doan  
Stoney Middleton  
Conrad Macy



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# What is Cold Spray?

**Cold Spray** is a coating deposition method that deposits a layer of solid metal by spraying very fine metal powders **Extremely Fast**, so they splat and stick.



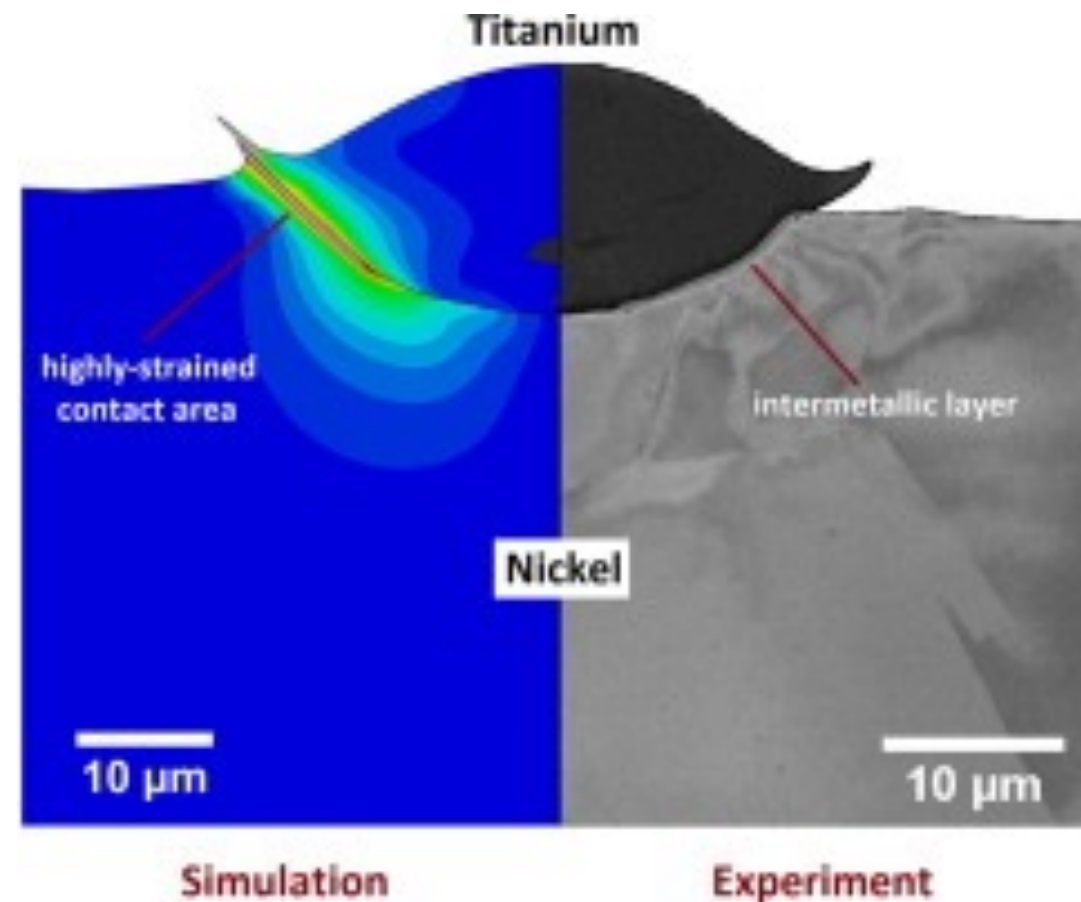
# Powder Particle Deformation

## Large Deformation

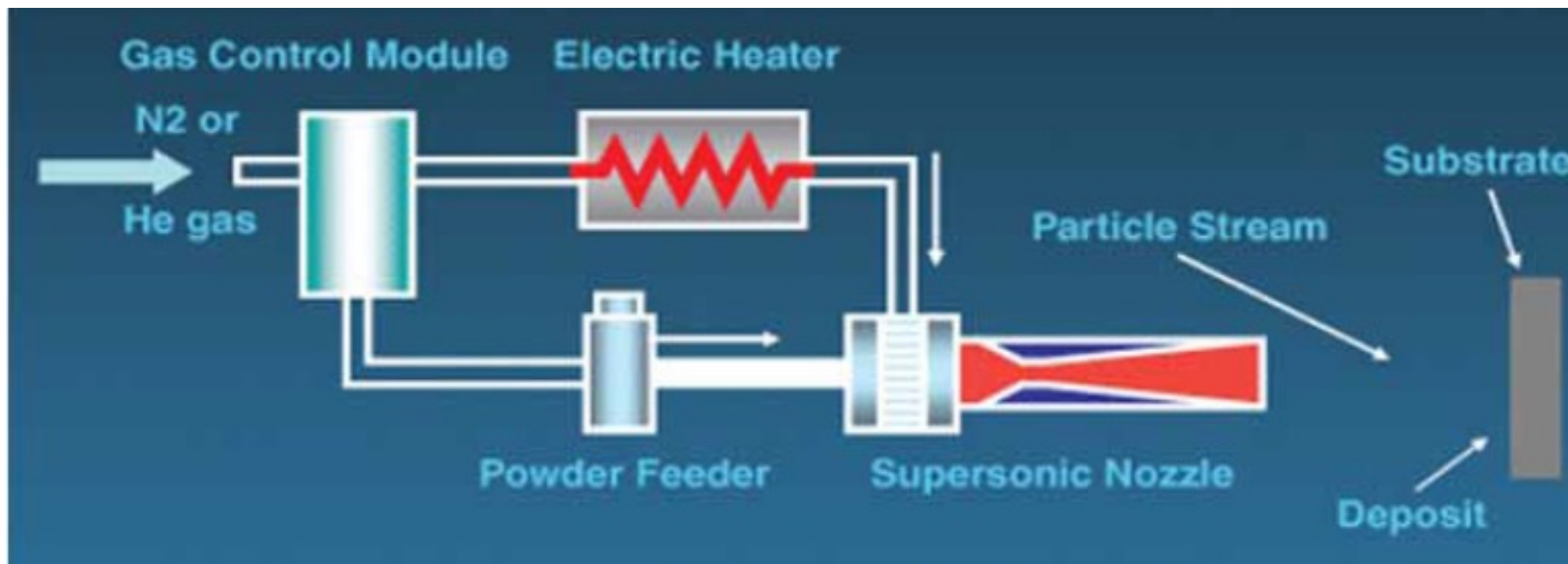
The powder particles are going so fast that during impact with the substrate, particles and the substrate undergo extreme deformation, especially at the edges.

## Micro-Edge-Welds

The edges get very hot, and the particle and the impacted surface essentially melt into and each other where they meet. This melting is like a “micro weld” and is how particles adhere to each other and the substrate surface



# Cold Spray Process

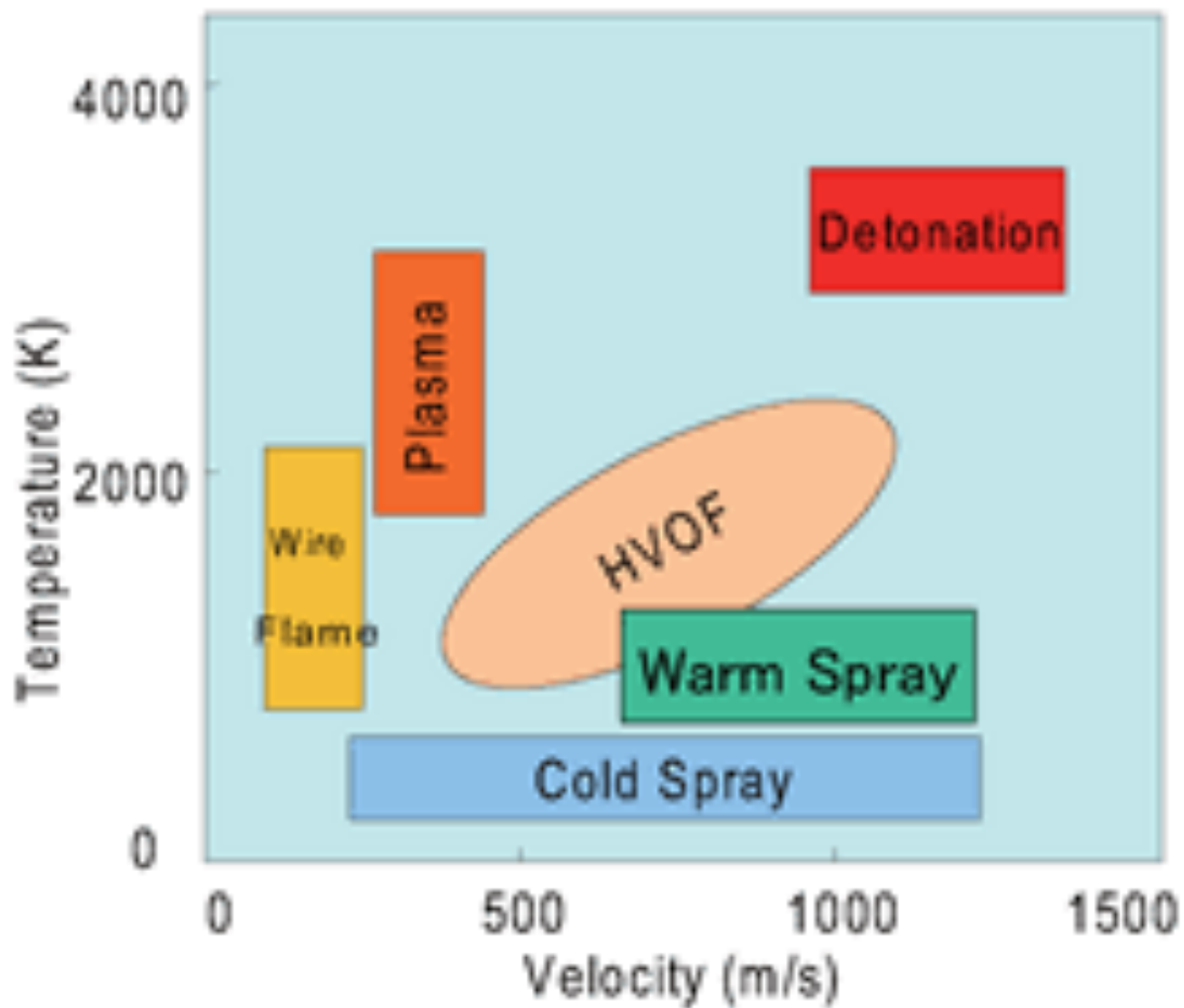


**Speed:** The powder is injected in a supersonic heated gas stream (like a rocket nozzle but without combustion) and accelerated to ~2600 mph (about Mach 3.5 at sea level).

**Acceleration:** The drag of the particles makes them accelerate into the flow. The faster the gas, the faster the particle.



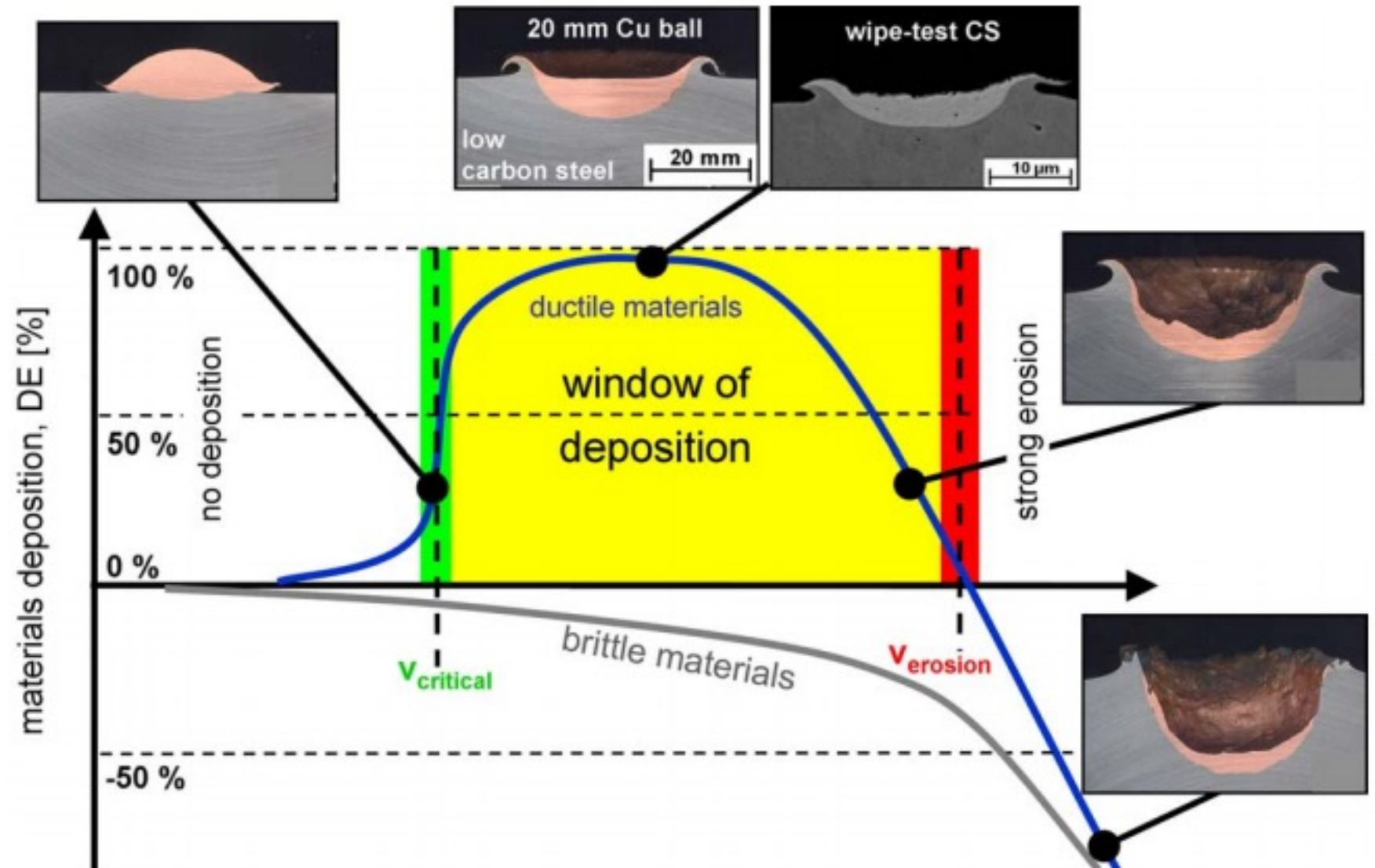
# Thermal Spray Family



Cold Spray is a relative “cold process”.

# Critical Velocity Deposition

- Before the critical velocity the powder does not deposit
- The Cold Spray parameters are set for the “Window of Deposition”.
  - Depending on the parameters, the Cold Spray coating properties vary within this window.
- After the erosion velocity the powder erodes the surface.





# NAVAIR Cold Spray Capability



OEM	Centerline		Inovati	VRC Metal Systems
Equipment	SST PX	EPX	HDR 5.0	Gen III
Cold Spray Approach	Low Pressure	High Pressure	Low Pressure	High Pressure
Maximum Gas Pressure	250 psi	1000 psi	130 psi	1000 psi
Maximum Gas Temperature	550 C	800 C	700 C	1200 C
Gas Types	Compressed Air, Helium, Nitrogen	Compressed Air, Helium, Nitrogen	Helium, Nitrogen	Helium, Nitrogen
Powders	Aluminium & Nickel Powders	Most Powders	Composite Powders	Most Powders





# NAVAIR Cold Spray Repairs



- NAVAIR has 45+ approved repairs and 500+ components repaired.
- Main reasons these components require a Cold Spray Repair is:
  1. Long Turn- Around-Time (TAT)
  2. Shortage in Supply
  3. High Component Cost
- The substrates varies from component to component (i.e. Aluminums, Steels, Titaniums, and Nickels).
- The powder sprayed on each component varies depending on damage area (i.e. Aluminum, Aluminum Composite, Nickel, and Tungsten-Carbide Cobalt)



# Types of Cold Spray Repairs



## Blend and Fill

- Corrosion Damage Dimensional Restoration
  - Wear Damage Dimensional Restoration

## Repair Process Replacement

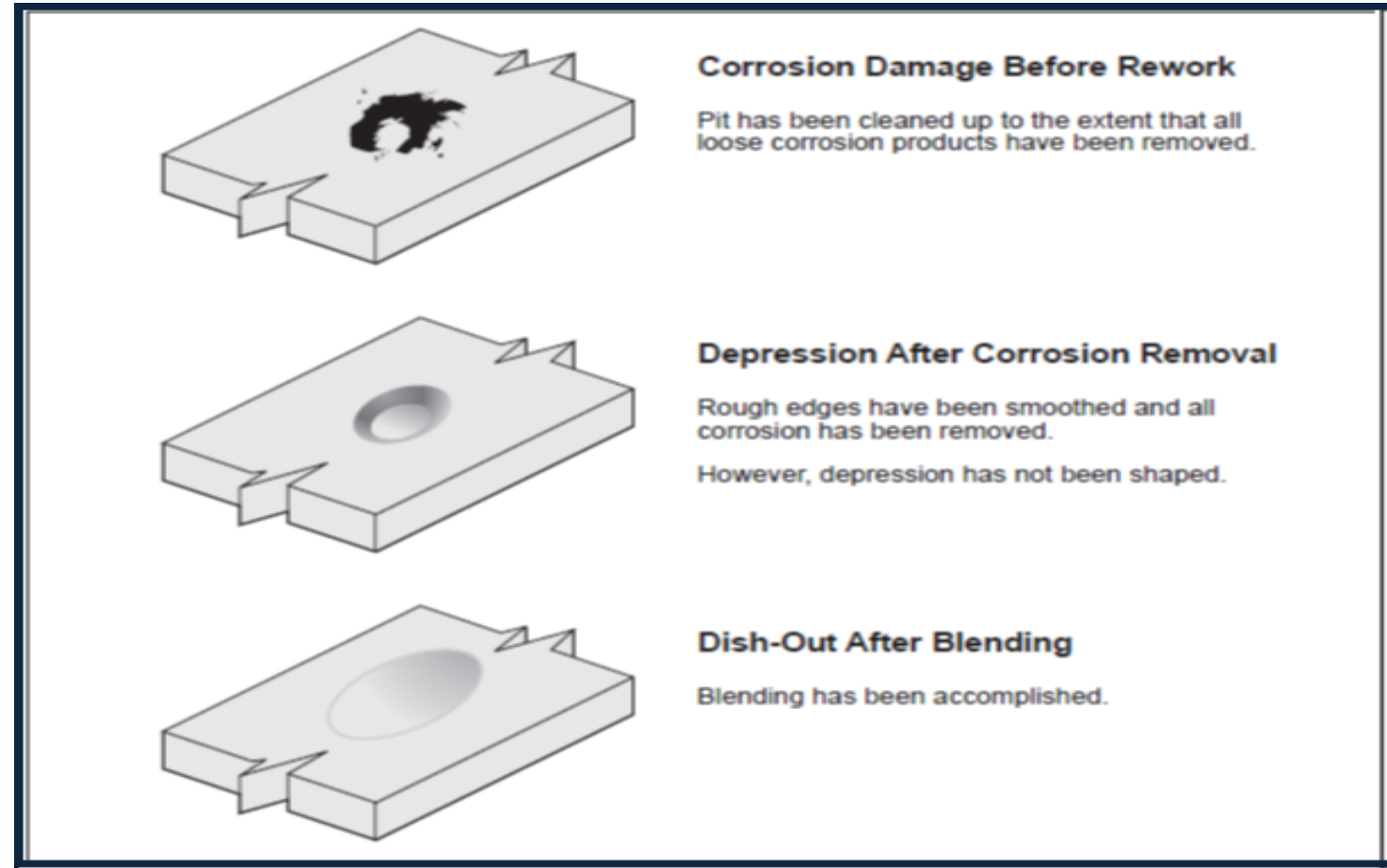
- Thermal Spray Replacement
- Hard Chrome Replacement

# Blend and Fill

## Blend and Fill –

general repair method for surface corrosion, physical damage or wear that is within structural limits.

NAVAIR has authorized the use of Cold Spray as a blend and fill rework method alternative from polymers/adhesives.



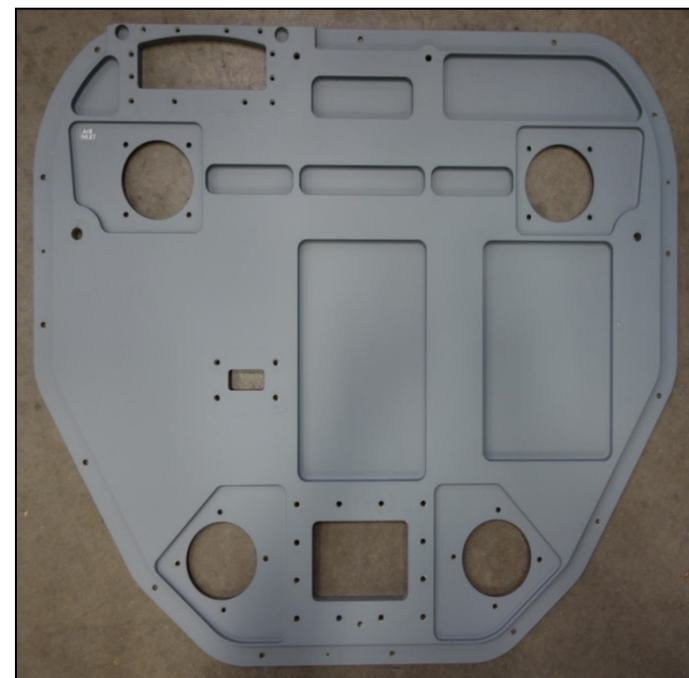
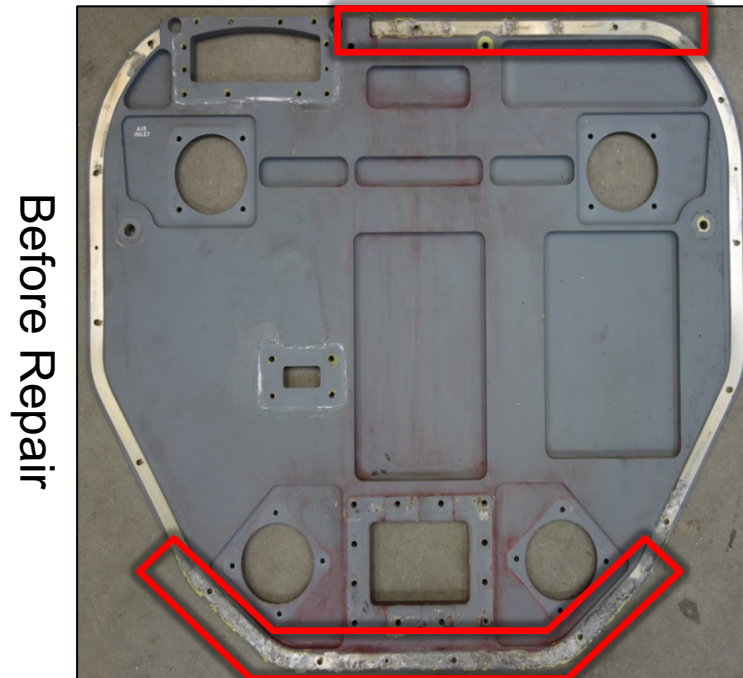


# Corrosion Damage Dimensional Restoration



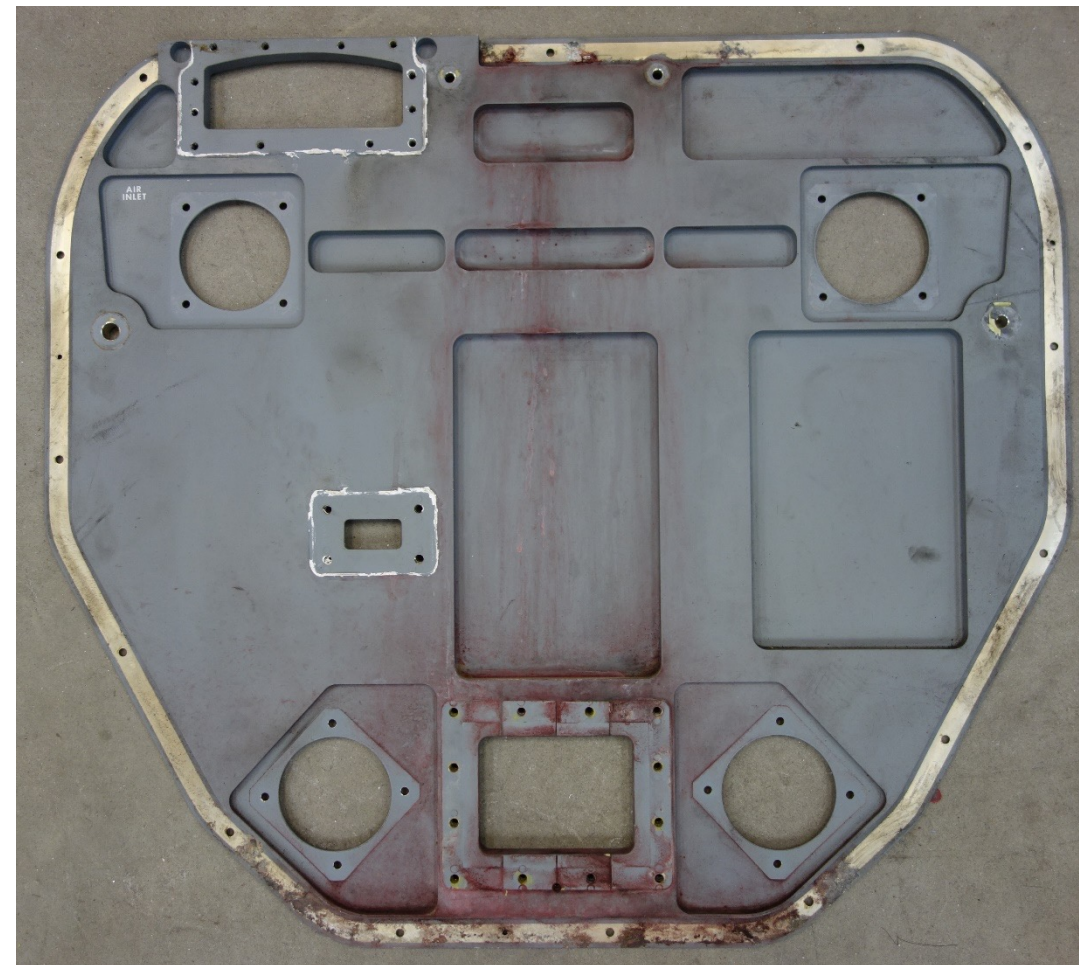
Galvanic corrosion between dissimilar metals on the aircraft leads to high scrap rates. Using Cold Spray as a repair process increases fleet readiness, component stock, and component life cycle.

Example: Aluminum Panels



# Corrosion Damage Dimensional Restoration

- Substrate: Aluminum
- Cold Spray System: Handheld
- Powder: Aluminum Powder with Chrome
- Repair Depth: 0.020"
- Main Reasons:
  - Long Turn-Around-Time due to match drilled hole locations
  - Shortage of Supply

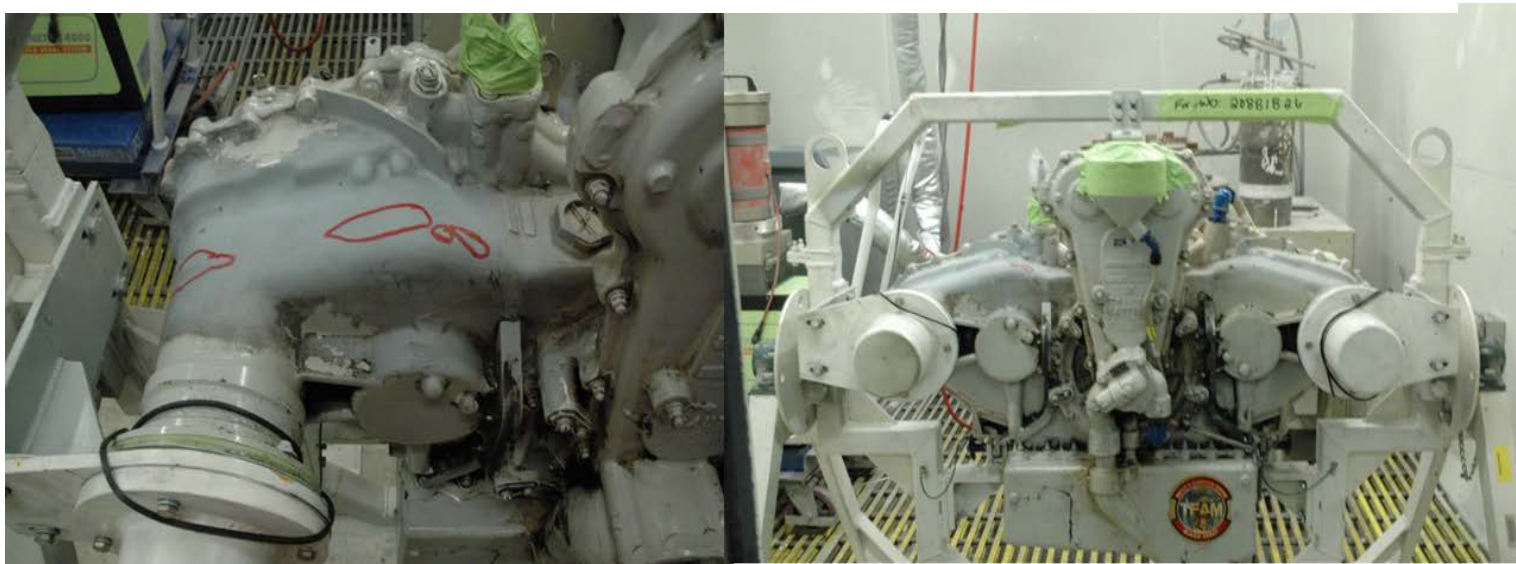




# Wear Damage Dimensional Restoration

Wear damage from components chaffing and interferences on the aircraft leads to scrapped components. Using Cold Spray as a repair process increases fleet readiness, component stock, and component life cycle.

Example: Magnesium Casting Gearbox



# Wear Damage Dimensional Restoration

- Substrate: Magnesium Casting
- Cold Spray System: Handheld
- Powder: Aluminum Powder  
Repair Depth: 0.060"
- Main Reasons:
  - Long Turn-Around-Time due to match drilled hole locations
  - Shortage of Supply
  - Major Replacement Cost

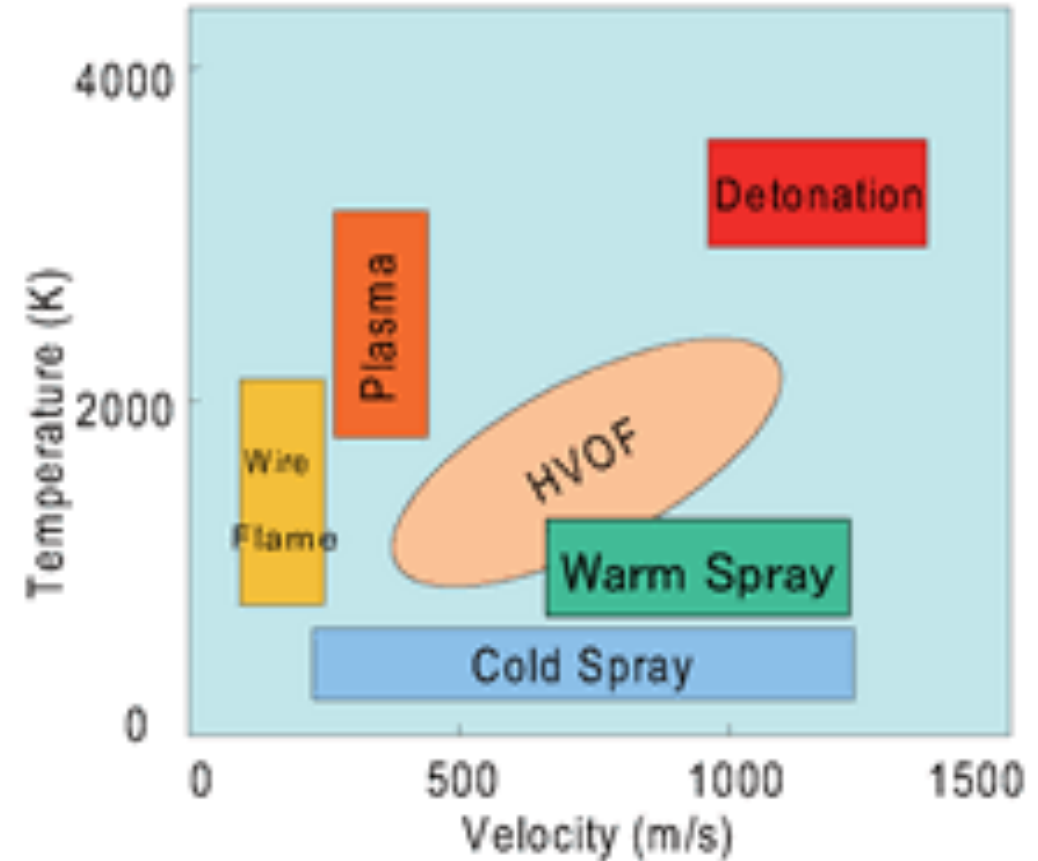




# Thermal Spray Replacement



- Thermal Spray has been an approved repair process, however, many manuals only call out the use of Plasma Spray, Flame Spray, and High Velocity Oxygen Fuel.
- Similar powders/coats can be created for a Cold Spray system.
- Advantages of using Cold Spray
  - Higher Adhesion of Coating.
  - Lower Porosity in the Coating.
  - Lower Heat Affected Zones on Substrates.





# Thermal Spray Replacement

- Substrate: Aluminum
- Cold Spray System: Handheld
- Original Thermal Spray: Tin-Zinc Flame Spray
- Cold Spray Alternative: Aluminum Powder with Chrome
- Main Reasons for Alternative Repair:
  - Tin-Zinc coating is corroding the substrate
  - Low adhesion of Tin-Zinc coating
  - Low supply of component

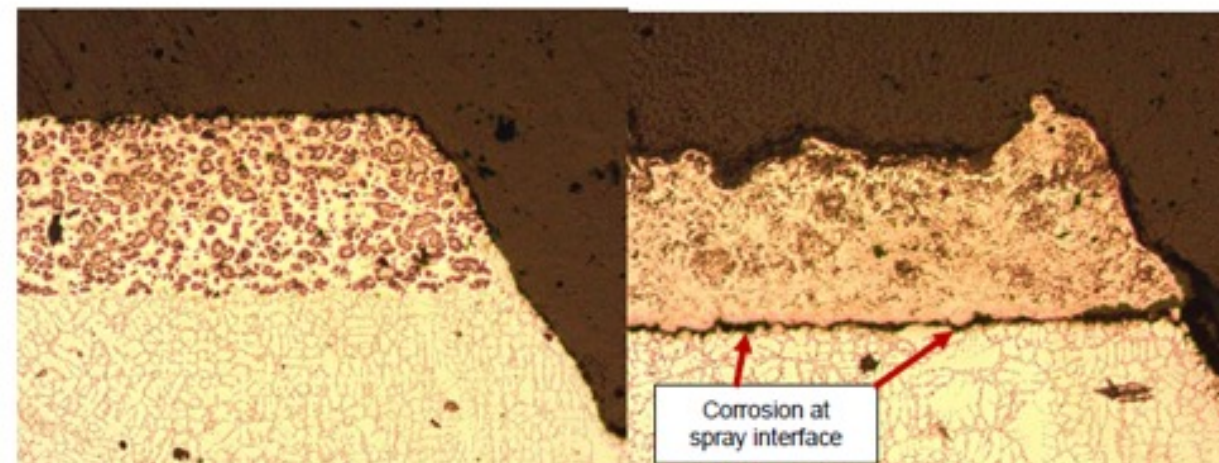
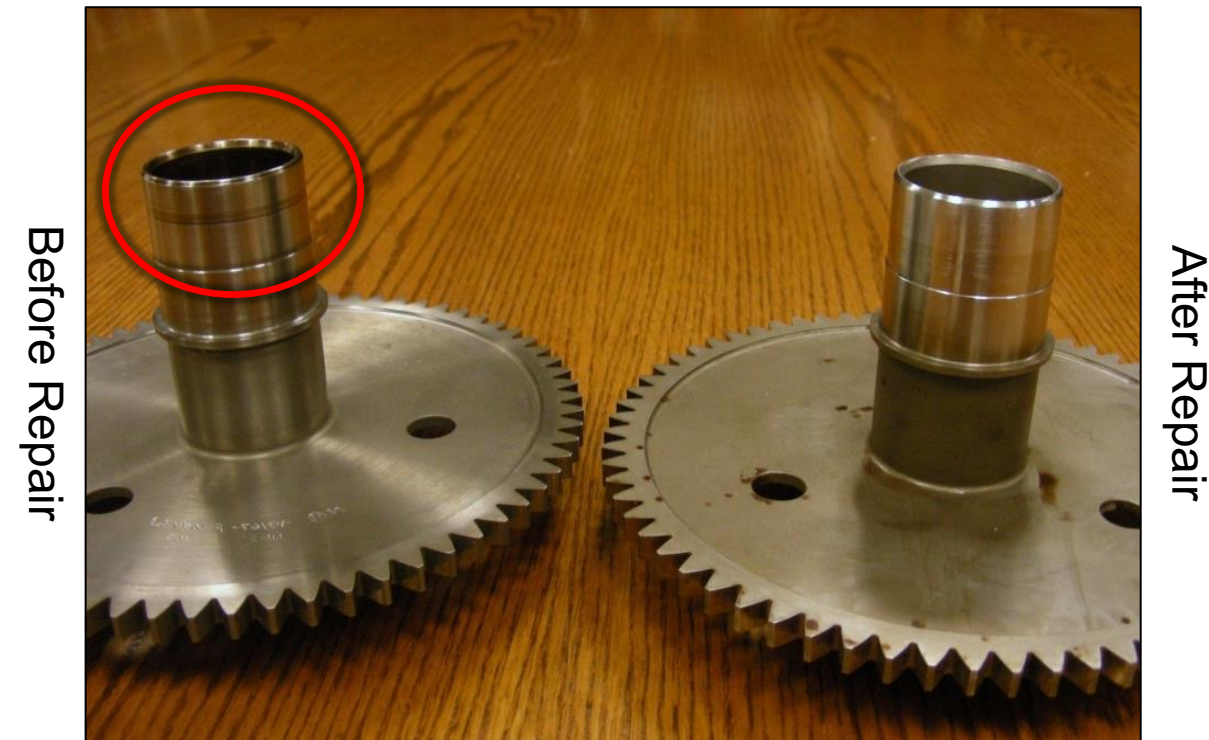


Figure 10: Cross-sectioned Cold Spray (left) and Wire Spray (right) samples.

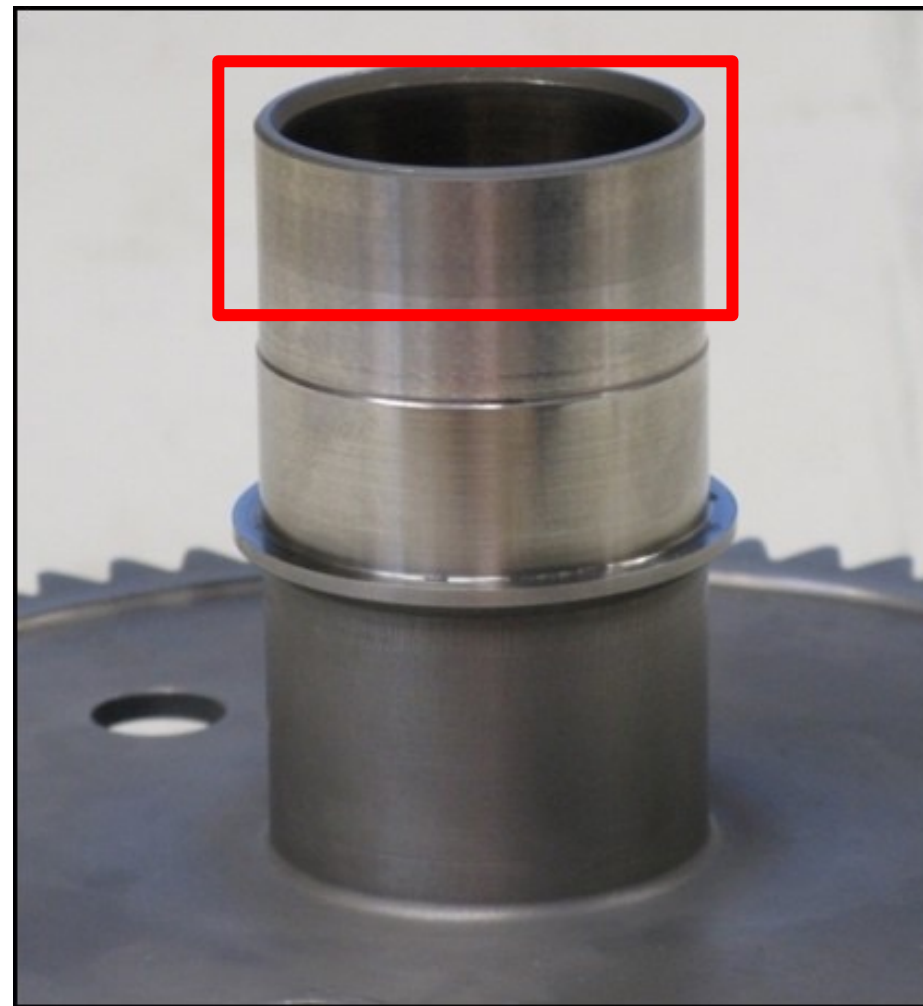
# Hard Chrome Replacement

- European Union (EU) and California Air Resources Board (CARB) have been pushing for the elimination of hexavalent chromium ( $\text{Cr}^{6}$ ). Therefore, Hard Chrome plating is looking to be substituted with Cold Spray
- Advantages of Cold Spray:
  - Spot repair on pre-existing coatings.
  - No hexavalent chromium.
  - No hydrogen embrittlement during the process.
  - Decrease application time.



# Hard Chrome Replacement

- Substrate: Steel
- Cold Spray System: Robotic
- Hard Chrome Plating (61 HRC)
- Cold Spray Alternative: Tungsten-Carbide Cobalt (65 HRC)
- Main Reasons for Alternative Repair:
  - Decrease Application Time.
  - Low in Supply.
  - Environmental Regulations.
  - Hard Chrome Plating – Not Available.





# Future of Cold Spray at NAVAIR

- Increase Cold Spray capability at various sites.
- Educate more team members of the technology to determine more Cold Spray candidates.
- Research and Development using Cold Spray for Structural Repair.
  - Developing MMPDS data for specific substrate and powder combinations



# **Back-up Slides**