

MOOG



Cold Spray Qualification of T700 Engine Front Frame

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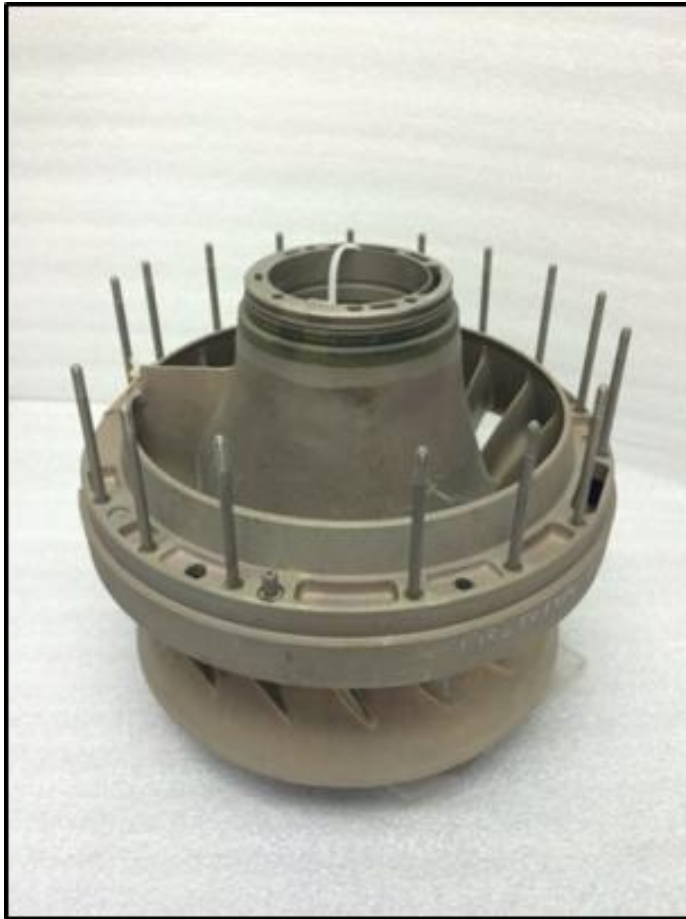
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T700 Engine Family

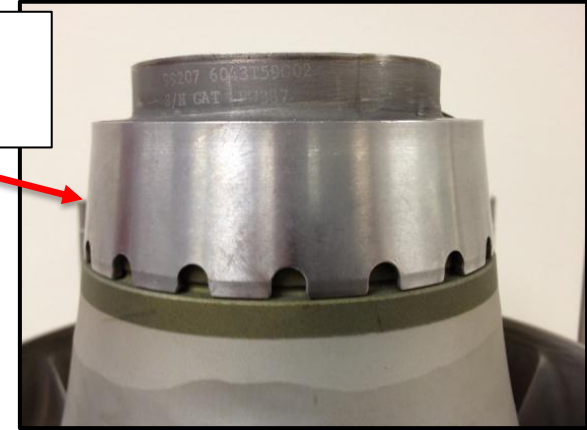


The General Electric T700 engine family is the most widely-used in its class, powering 25 types of rotary and fixed wing aircraft for 50 countries and is extensive used in all US military branches in service throughout many difficult environments.

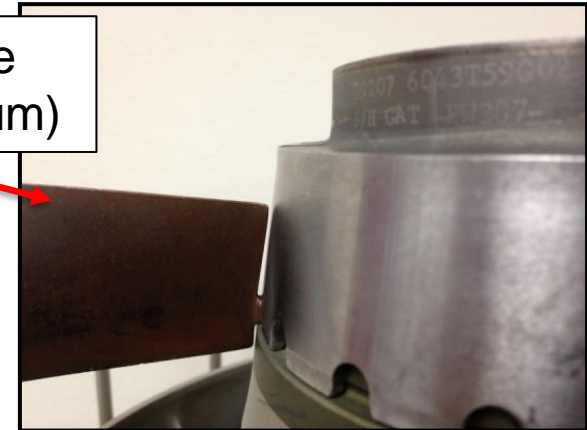
T700 Front Frame



Inlet Guide
Vane Support

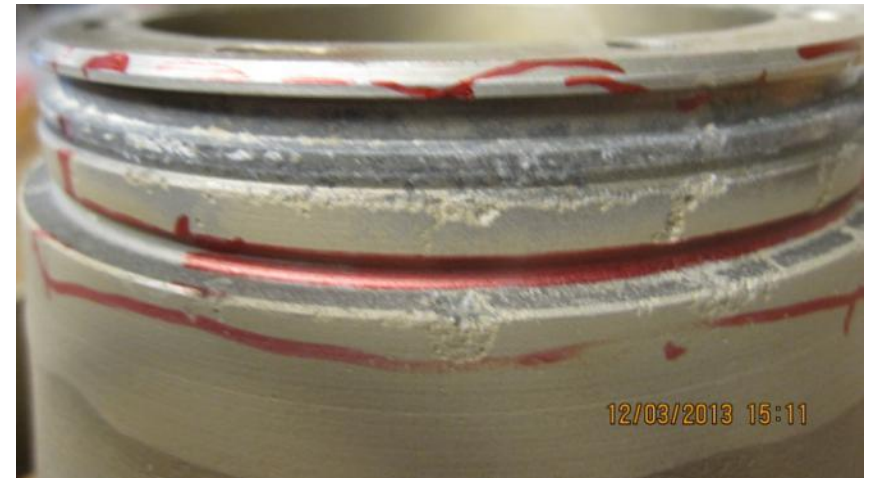


Inlet Guide Vane
(Copper Beryllium)

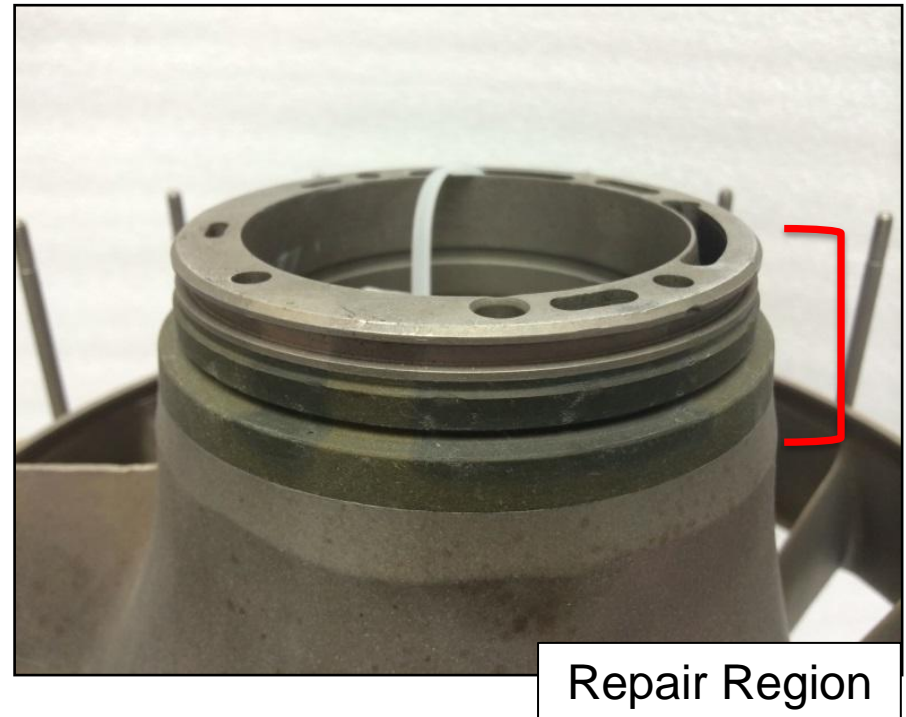


The T700 Front Frame Housing that sits at the front of the engine is prone to corrosion and damage. The inlet guide vane spindle contacts the front frame housing inducing corrosion and wear to the mating surface.

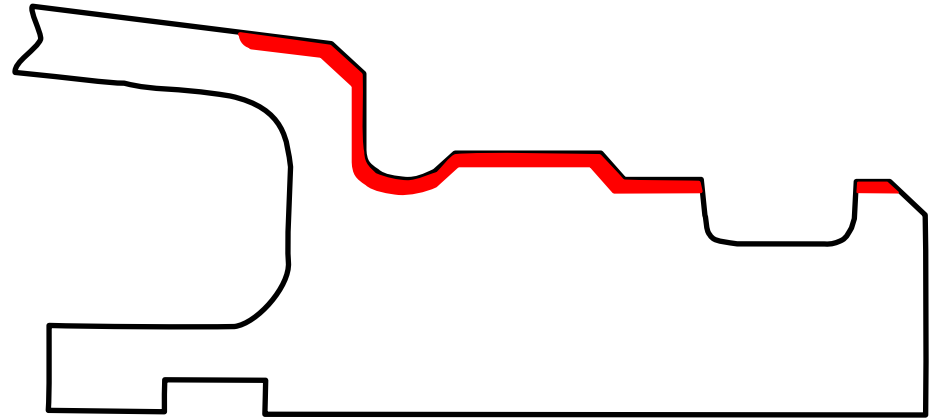
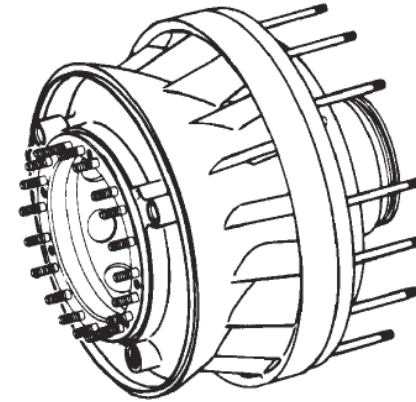
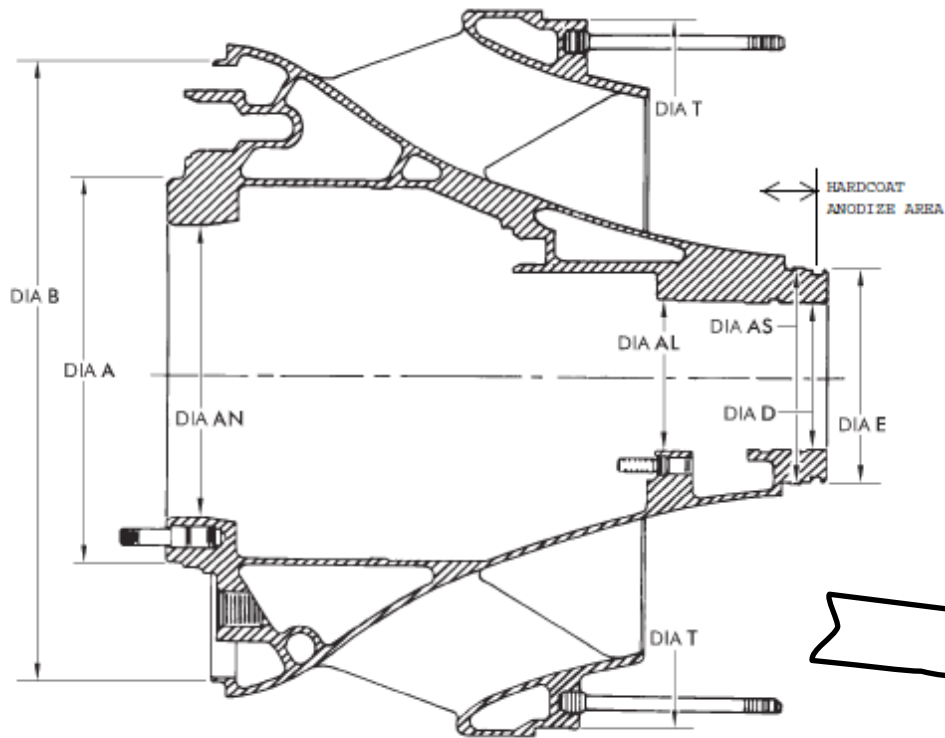
T700 Front Frame



T700 Front Frame Repair



T700 Front Frame Repair



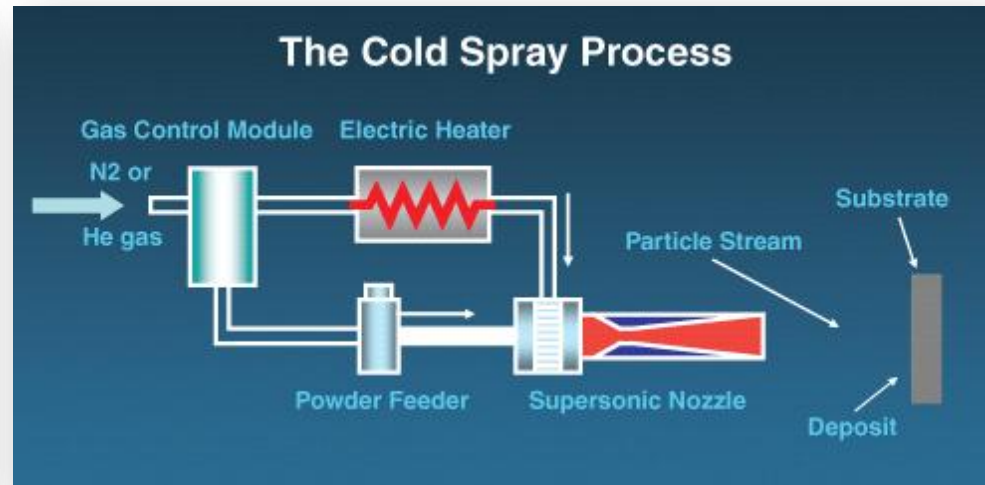
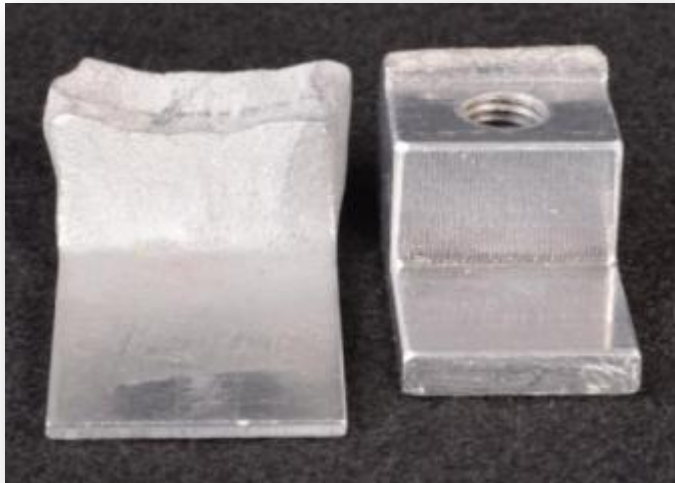
Cold Spray Repair Qualification



Cold Spray Repair Qualification

1. Define Required Material Properties – ARL, RDECOM/AMRDEC, GE Aviation, Moog
2. Repair Substantiation Requirements – GE Aviation
3. Repair Procedures – GE Aviation, Moog
4. First Article Evaluation – Moog
5. Approval of First Article – GE Aviation, RDECOM/AMRDEC
6. Maintenance Engineering Order (MEO) – RDECOM/AMRDEC
7. Component Repair – CCAD, Moog

Cold Spray – Technology



Cold spray is an additive manufacturing method where micron sized, metallic powder material is driven to high speed by a compressed carrier gas through a nozzle and directed at a substrate material. The resulting impact and associated particle/substrate's plastic deformation build a coating of the feedstock material onto the substrate. The resultant coating can be machined, heat treated or otherwise handled like stock material.

- Lowest operational temperature in thermal spray family
- Capable of highest particle velocity in thermal spray family
- Does not rely on melting/solidification of feedstock for adhesion

Cold Spray – Characteristics and Benefits

- HP Bond strengths ~ 80-100 MPa (12-15ksi)
- No oxidation
- Compressive residual stress
- Strain hardening
- High density – low porosity (<1%)
- Thick coatings
- Heat treatable free forms
- Minimal surface preparation
- No distortion of substrate
- Limited masking
- Low substrate temperatures heating < 120°C (250°F)
- Variety of substrates (Al, Mg, Cu, Ti, Steel, Glass)

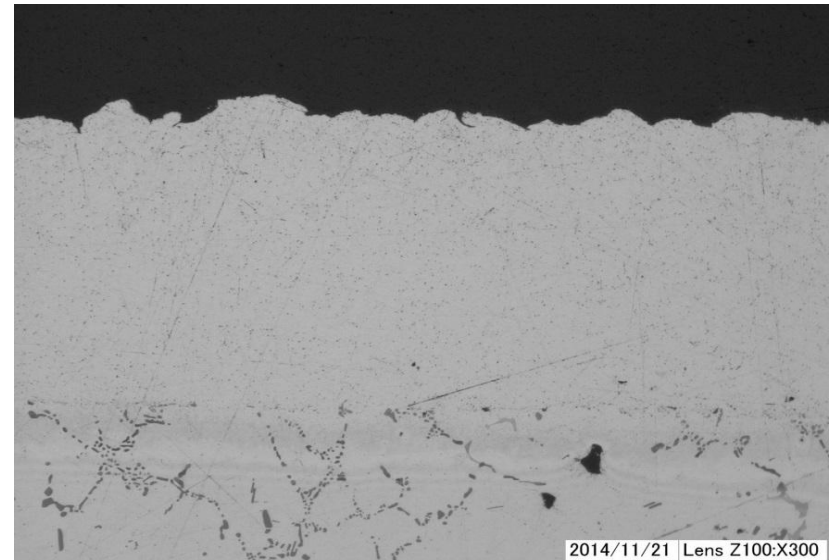
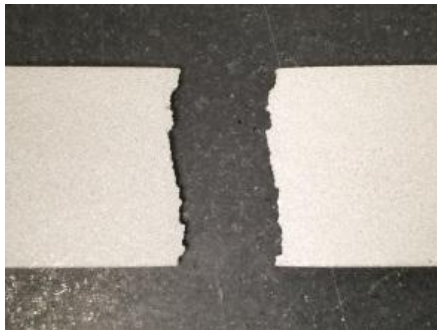
Powders	HP	LP
Aluminum	●	●
Copper	●	●
Nickel	●	●
Zinc	●	●
Tin	●	●
Metal Matrix Composites	●	●
Brass	●	
Bronze	●	
Silver	●	
Alum Alloys	●	
Titanium	●	
Tantalum	●	
Niobium	●	
Ti-6Al-4V	●	
Inconel 625, 718	●	
SS 316L	●	
SS 403	●	
SS 430	●	
Monel	●	
Ni-Cr	●	
Ni-Al	●	

First Article Test Requirements

- AS9100 First Article Report
- Microstructure Evaluation of Repair Part
- Porosity Measurement
- Adhesion Testing
- Hardness Testing
- Bend Testing
- Dimensional Inspection
- Fluorescent Penetrant Inspection
- Fit Test

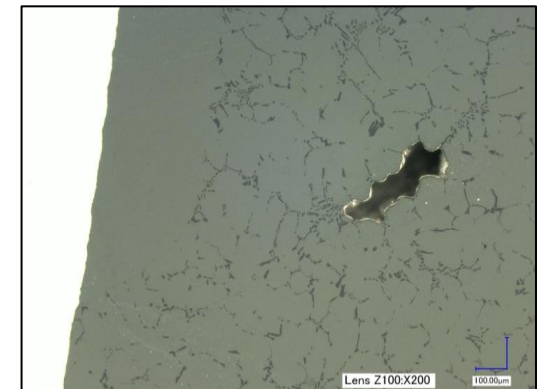
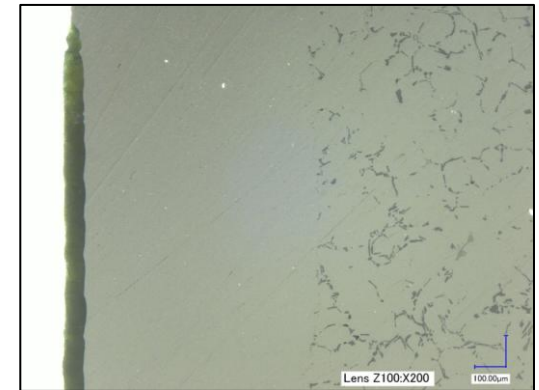
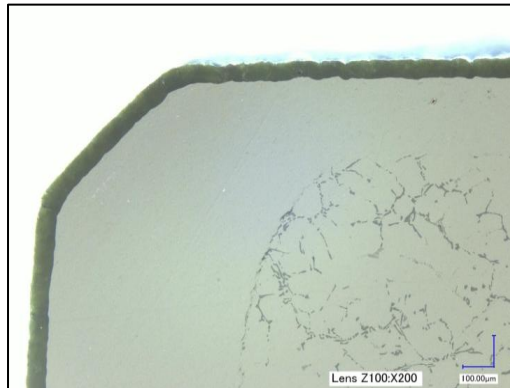
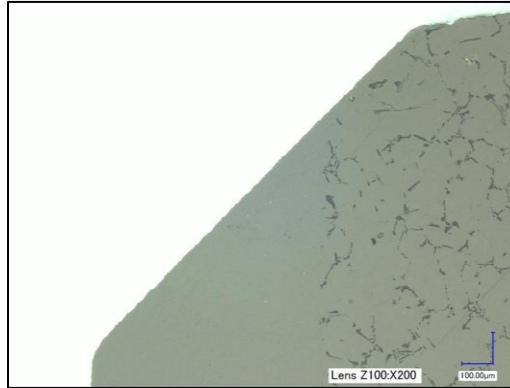
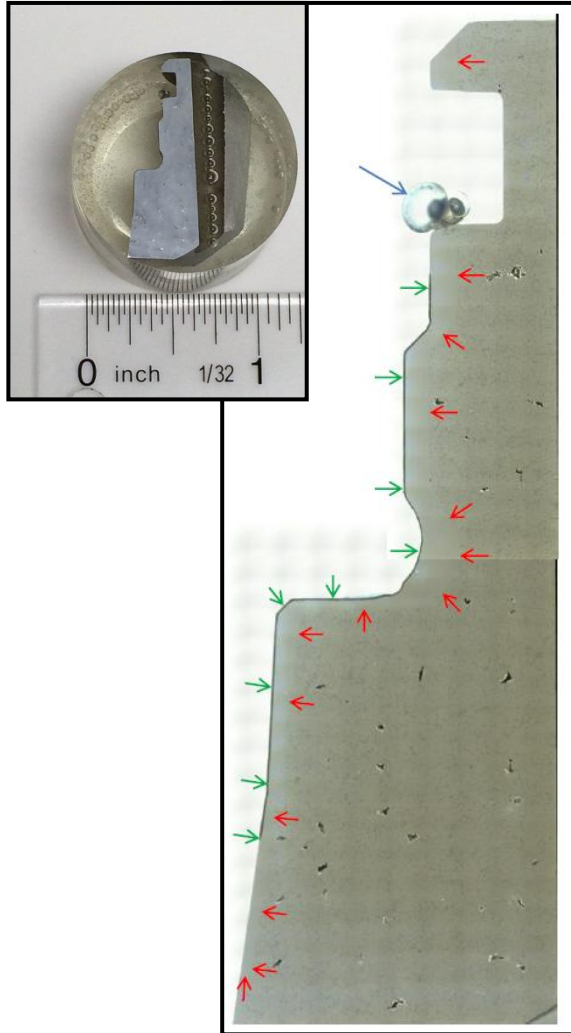
First Article Test Results

- 6061 Aluminum Alloy on C355 Aluminum Alloy
- Average Porosity: **0.188%**
- Minimum Adhesion Strength (ASTM C633-01): **8,856 psi**
- Average Hardness: **112.9 HV (0.2 kg)**
- Bend Test: **Passed without flaking or debonding**
- Microstructure: **No indications of cracks or anomalies**

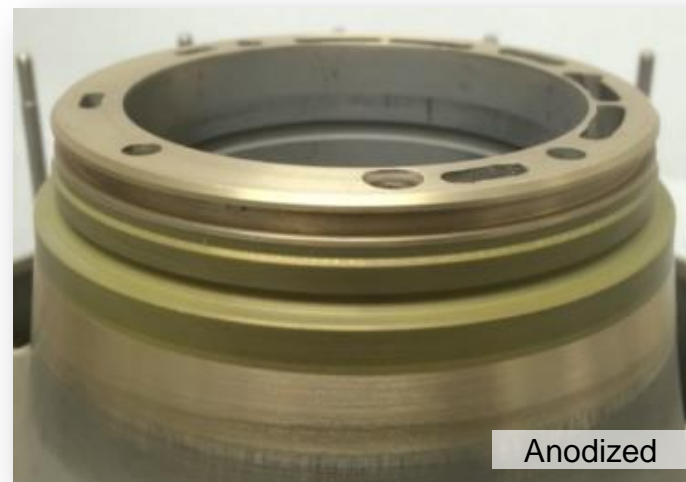
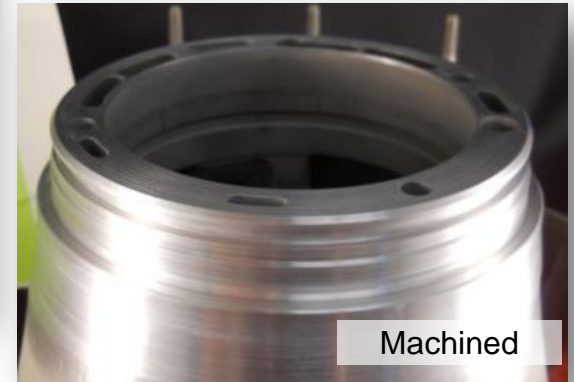
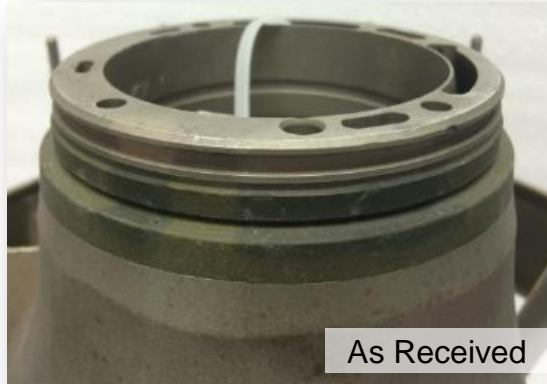


Above: bend test specimen
Right: microstructure specimen

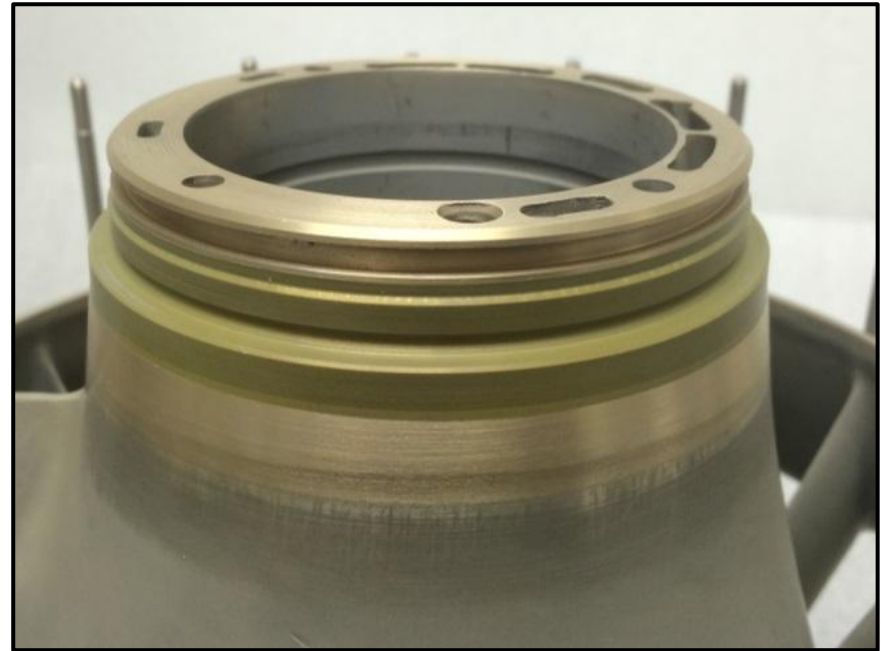
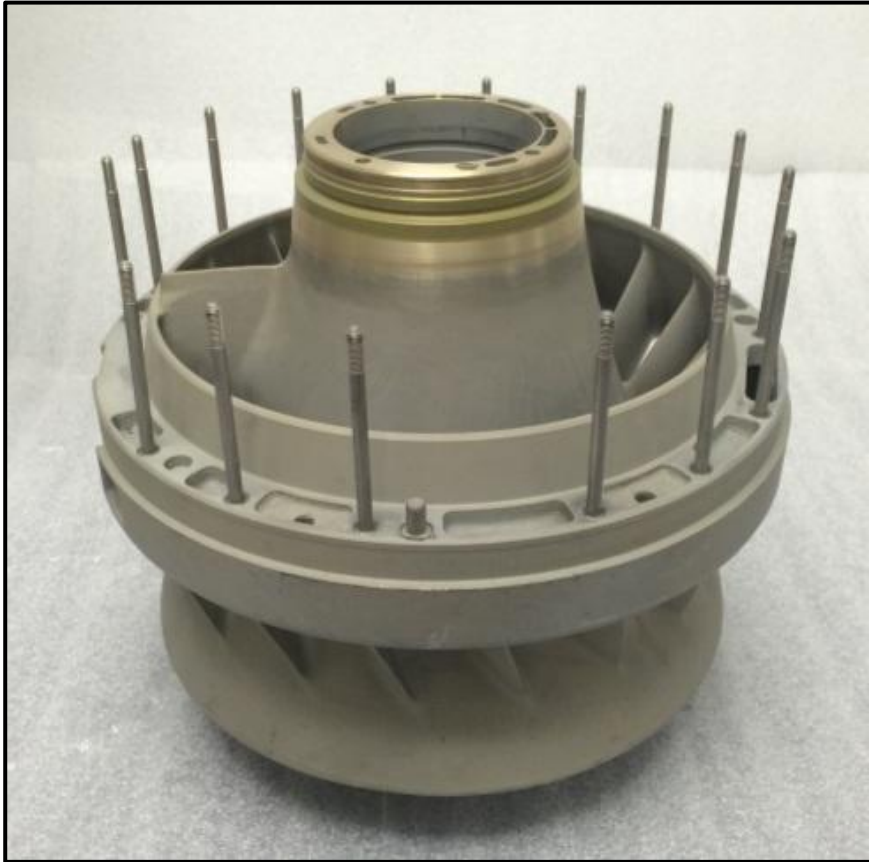
Microstructure Analysis



Cold Spray Repair Sequence



Cold Spray Repair of T700 Front Frame



- **MEO B1718 – Issued February 27, 2015**

Acknowledgements

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GE Aviation
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