# Solid Particle Erosion

***Some Examples of Solid Particle Erosion in the Gas Turbine & Steam Turbine Industry***



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# Solid Particle Erosion in Gas Turbine Engines



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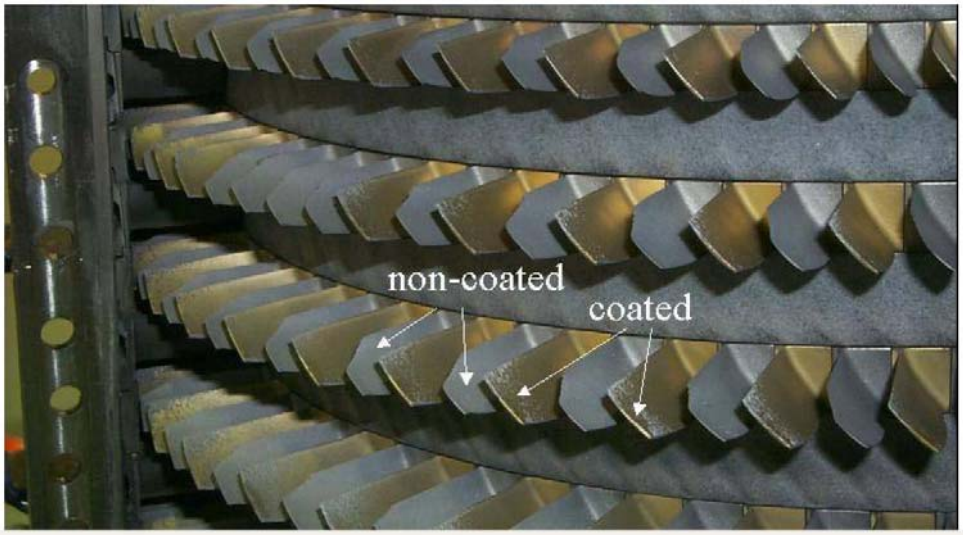
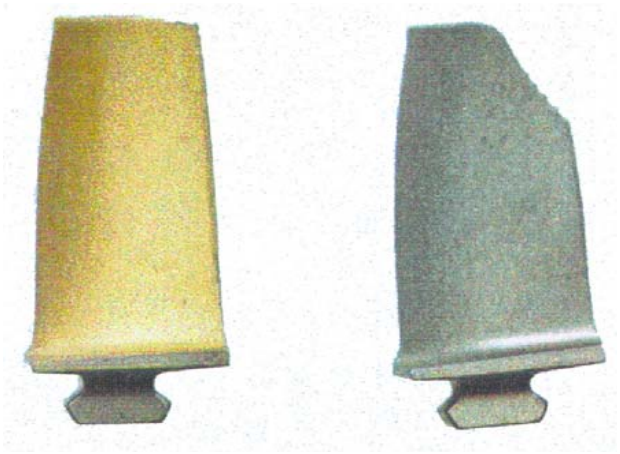
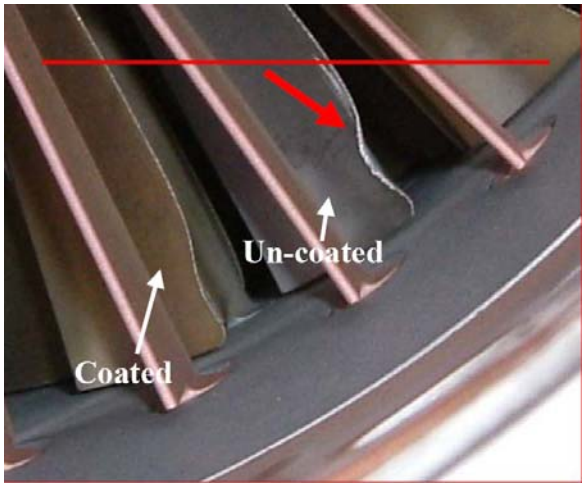
# Solid Particle Erosion in Gas Turbine Engines

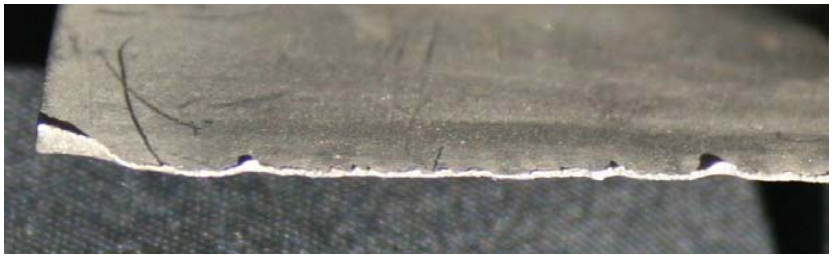
***Protective Coatings can Minimize Component Degradation***

## GT Compressor Section Erosion







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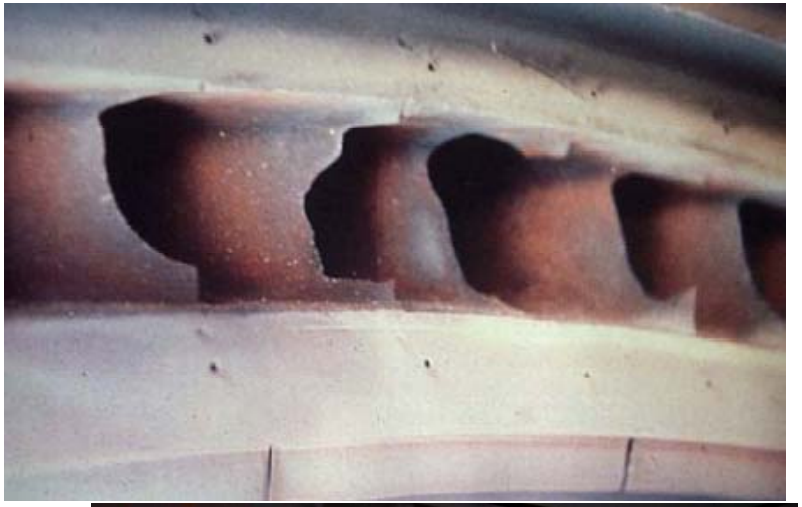
# Solid Particle Erosion in SteamTurbines

## High-Pressure Rotor Inlet Erosion




*(Photos Courtesy of Encotech)*



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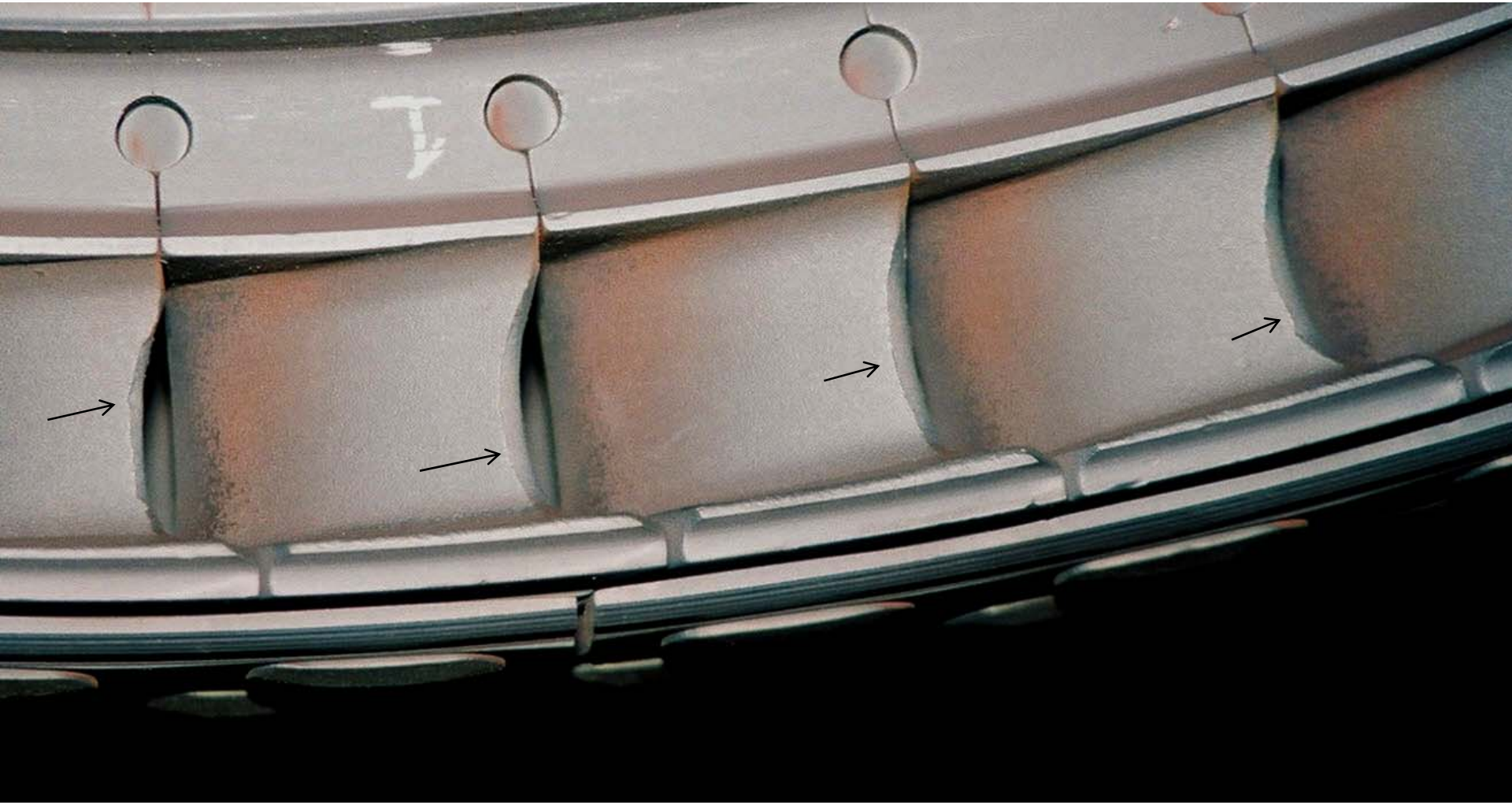
# Solid Particle Erosion in Steam Turbines –

## *Note Erosion Through Protective Coating*



*(Photo Courtesy of Encotech)*

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# Various Factors that Influence Erosion

- **Particle Characteristics**
  - Particle Size & Distribution
  - Morphology (blunt,, angular, sharp edges etc.)
  - Hardness
  - Resistance to Fragmentation
  - Particle Type (Alumina, Silica, Chromite, Magnetite or ARD)
  - Velocity
  - Concentration
- **Substrate Properties**
  - Ductility of material being eroded
  - Microstructure
  - Hardness
- **Impingement angle**
- **Temperature**



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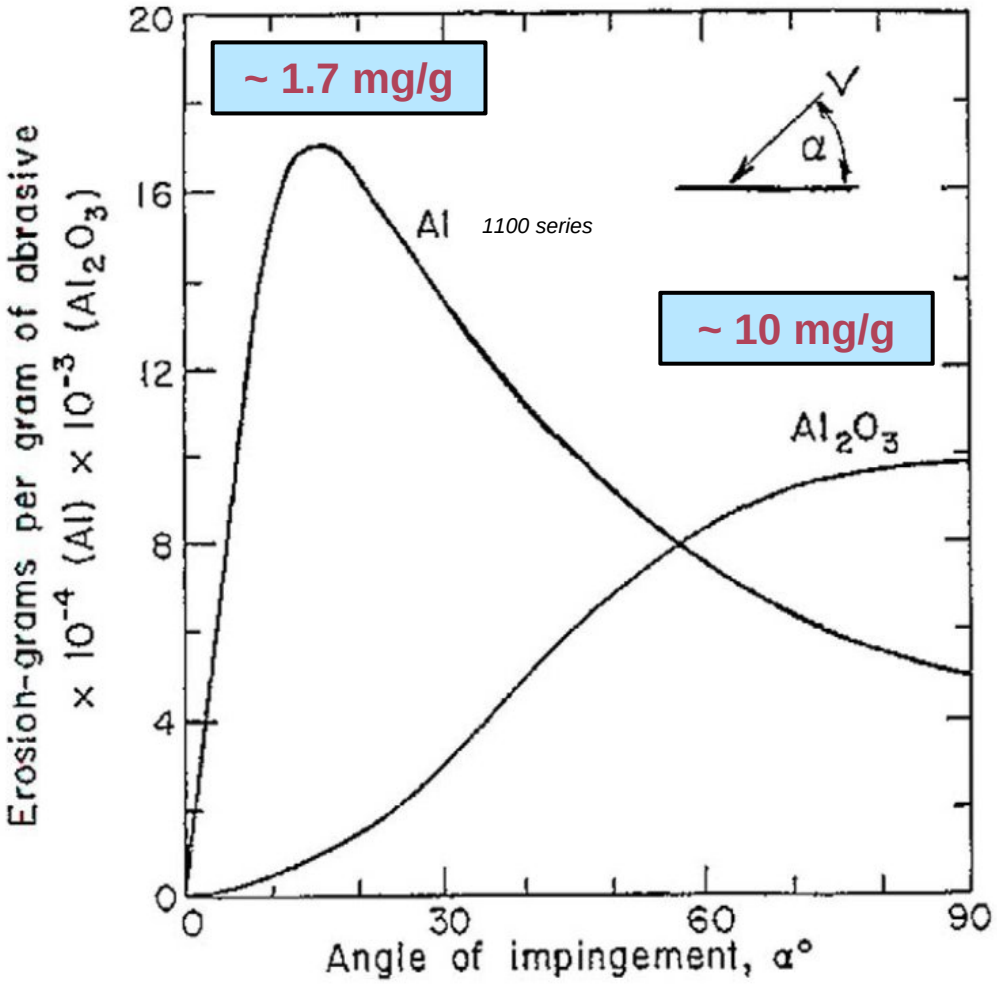
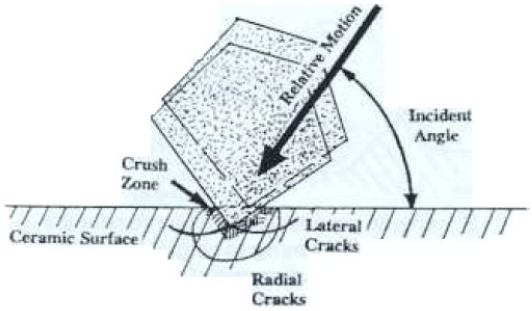
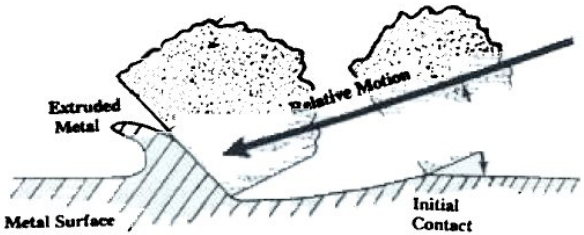
# Erosion Behavior- Ductile and Brittle Materials




*120 mesh SiC (127 micron) at 152 m/s*

*(Sheldon & Finnie 1966; Finnie 1995)*



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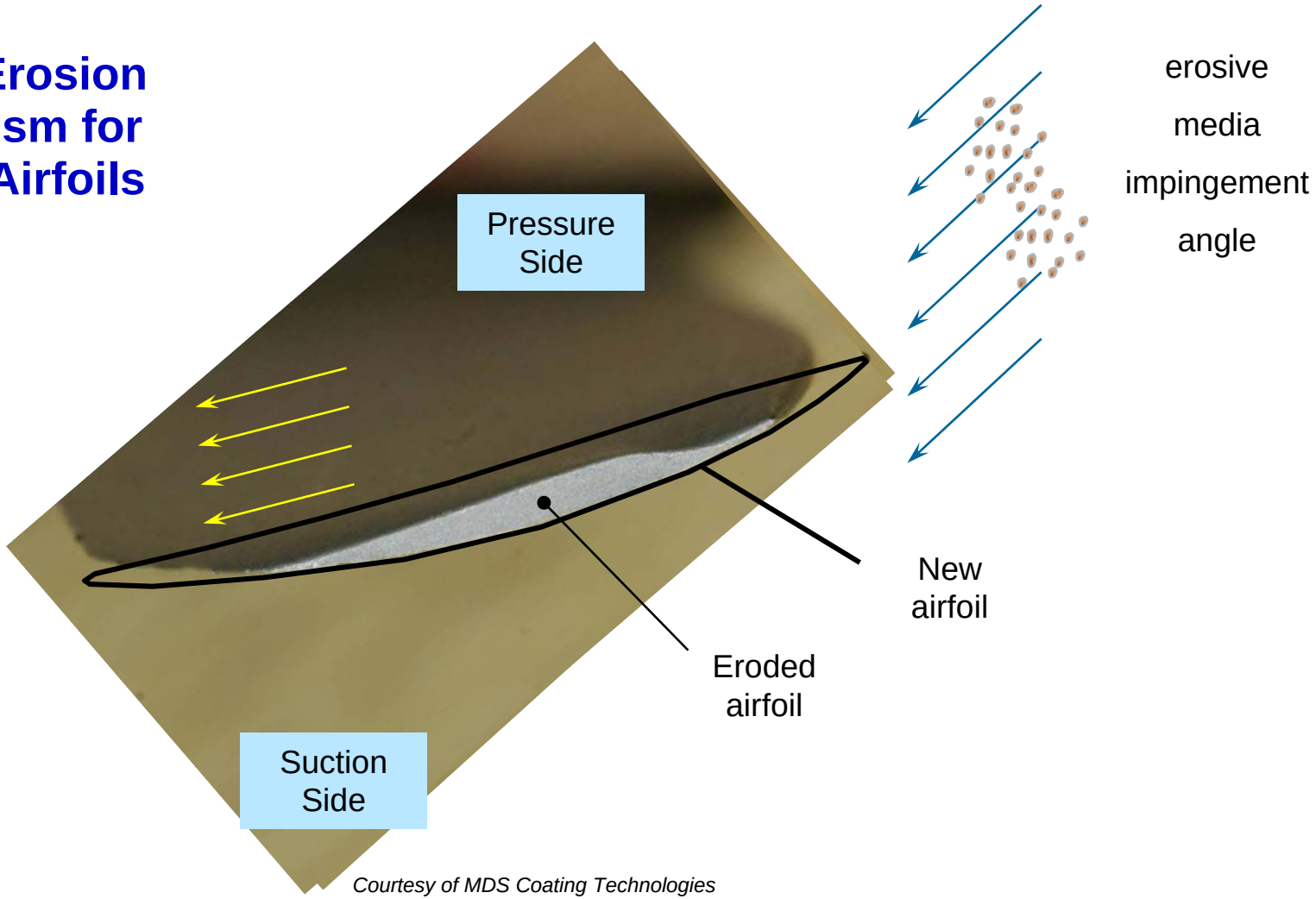
# Erosion Behavior and Characterization

## Typical Erosion Mechanism for Turbine Airfoils




*Courtesy of MDS Coating Technologies*



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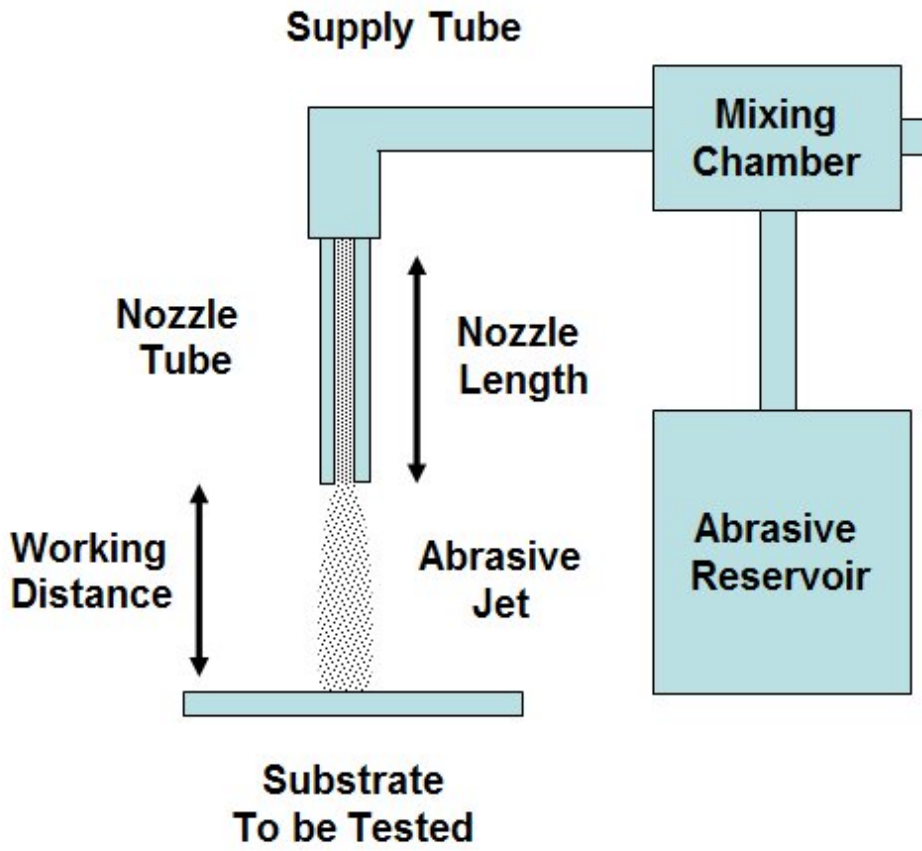
# G76 Gas Jet Particle Erosion Test Schematic




- 50 μ Alumina
- 30m/s particle velocity)
- 10 mm stand off distance
- 1.5 mm (0.060”) nozzle dia.
- 1020 Steel Substrates
- 2 grams/minute powder feed
- 10 minute min. test time
- Room Temperature Test
- 90 degree impingement angle
- $mm^3$/gram of erodent (*need to substrate density*)
- Only small area tested



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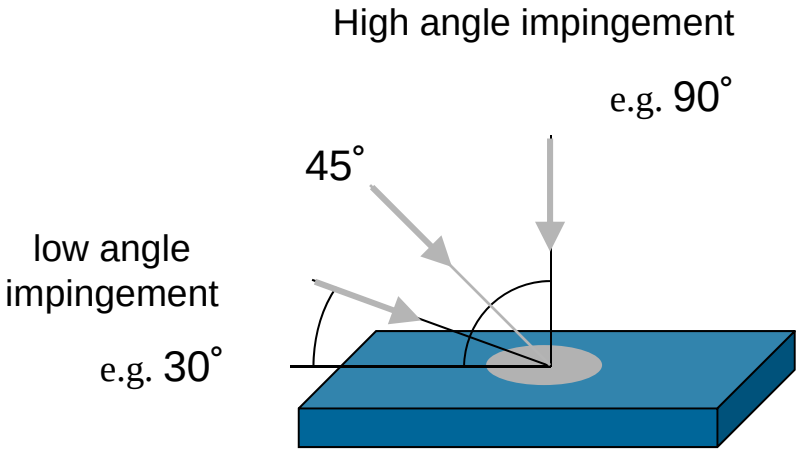
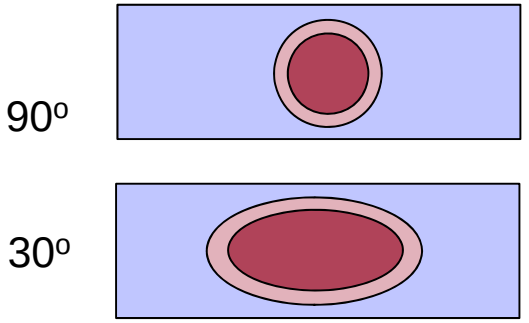
# Benchmarking Techniques

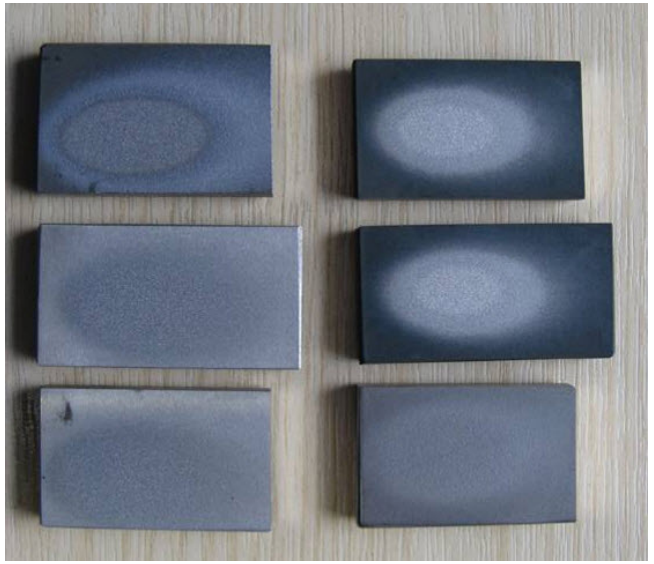
## Flat Coupon




- Coating coupon vs airfoil
- Multi test angle on coupons to evaluate performance

## Erosion Scars



*Courtesy of Cranfield Univ.*



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# ASTM G76 Standard Method for Erosion Testing

- Standard Test *Method* for Conducting Erosion Tests by Solid Particle Impingement Using Gas Jets
- This standard is under the jurisdiction of ASTM Committee G02 on *Wear and Erosion* and is the responsibility of Subcommittee G02.10 on *Erosion by Solids and Liquids*.
- Round Robin Conducted in 1982 formed Basis for Current Standard Test Method
  - Five Labs Participated
    - National Bureau of Standards, Univ of Kentucky, Univ of California, Bureau of Mines-Albany, Union Carbide - Linde
- Standard is Cited by Labs Doing SPE Testing, but has Some Limitations
- New Erosion Testing Standard under Development



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