

How did it break? A technophobes guide to failure mechanisms

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Catastrophic Failure



What Constitutes Failure

A general term used to imply that a part in service:

- (a) has become completely inoperable
- (b) is still operable but incapable of satisfactorily performing its intended function
- (c) has deteriorated seriously, to a point that it has become unreliable or unsafe for continued use.

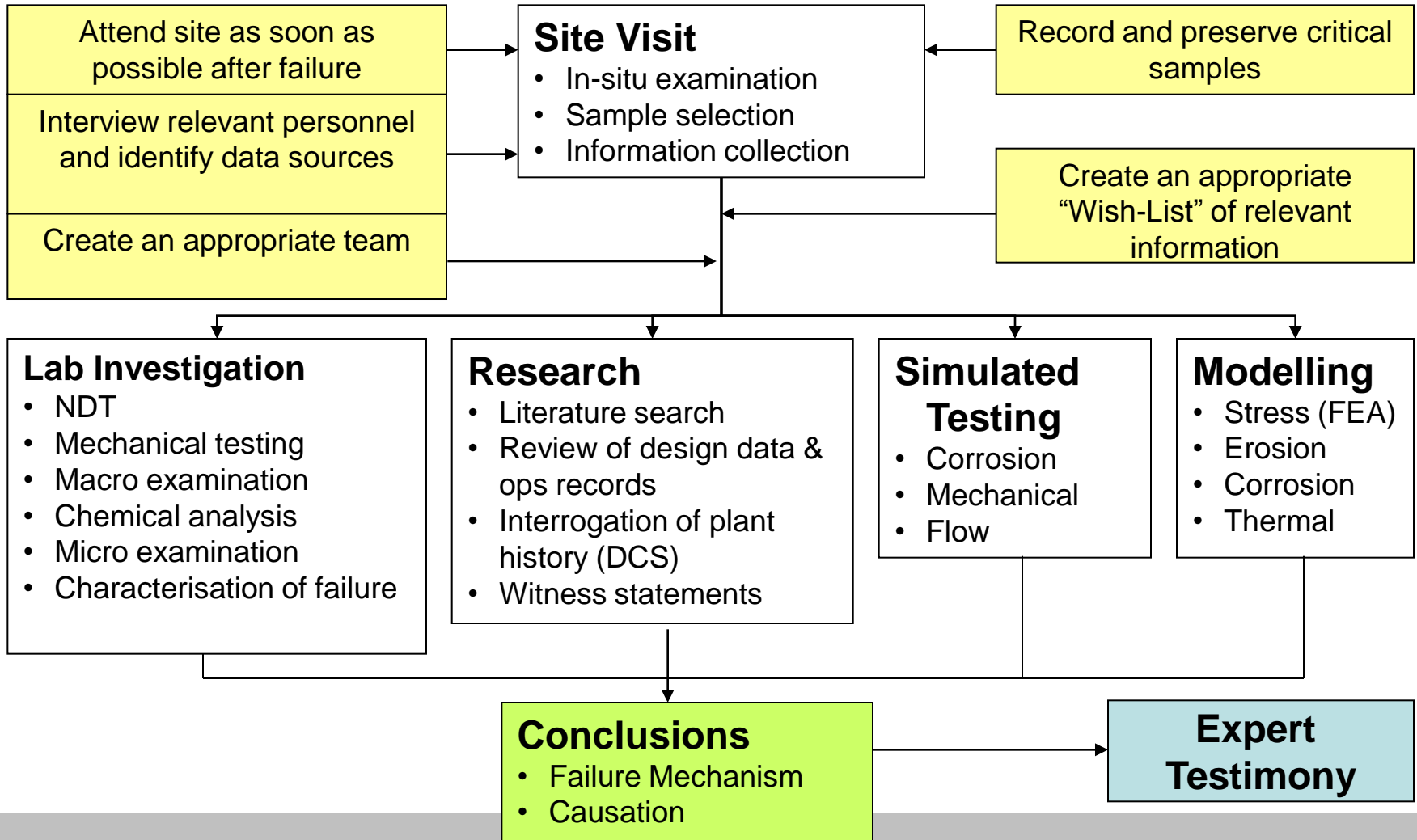
Failure Investigation

Mechanism and Cause?

Mechanism How a metal or component has physically come apart.

Cause What made the metal come apart in the way it has.

Stages of a Failure Investigation



Sudden and Unforeseen v Progressive

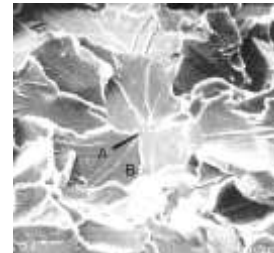
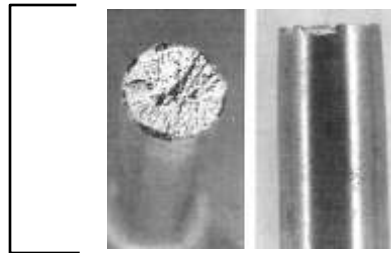
- Sudden and unforeseen are instantaneous fractures that have occurred without any warning e.g. an overload
- A progressive fracture is one which occurs over a period of time before final failure occurs usually related to problems such as wear, corrosion or fatigue

Mechanical Failures

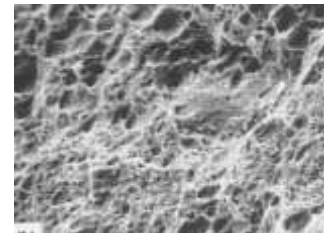
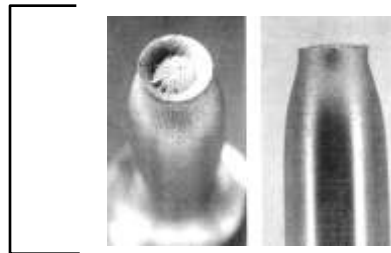
Macro

Micro

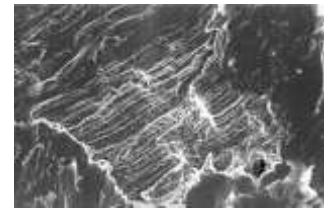
Brittle



Ductile

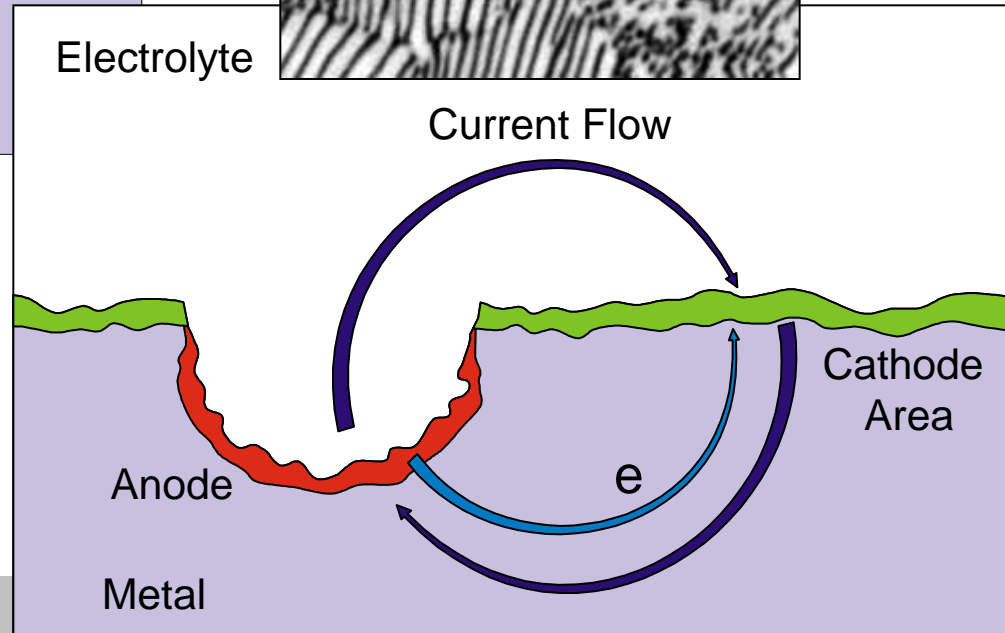
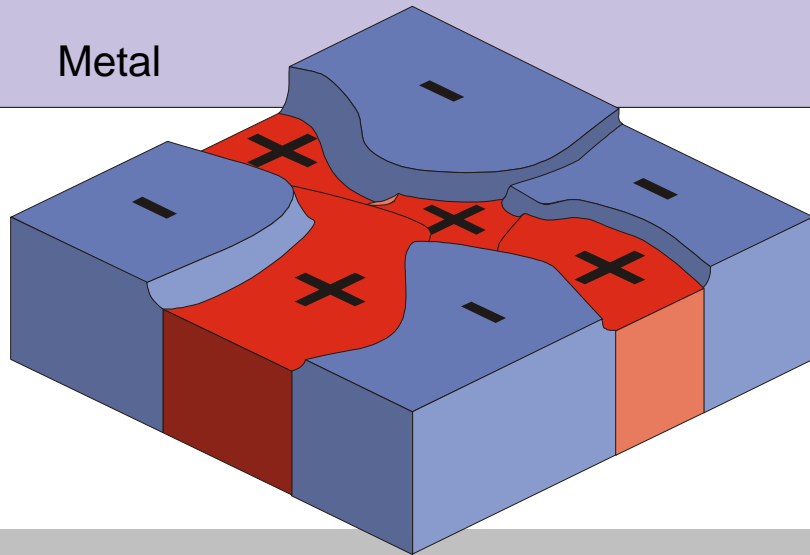
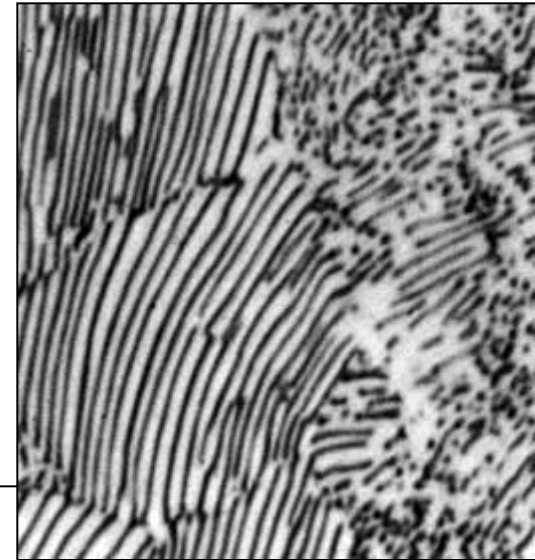
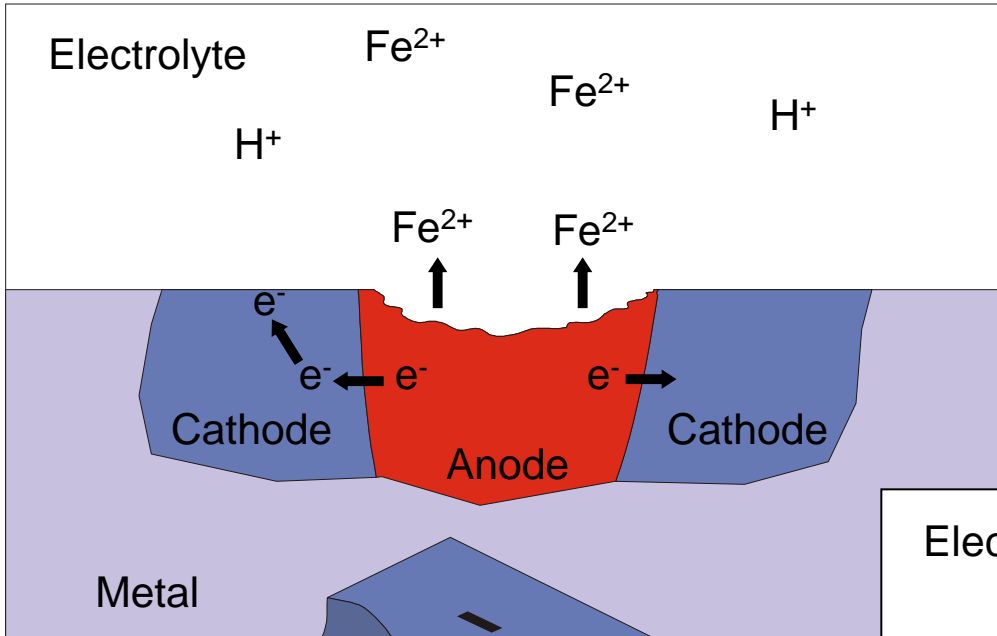


Fatigue

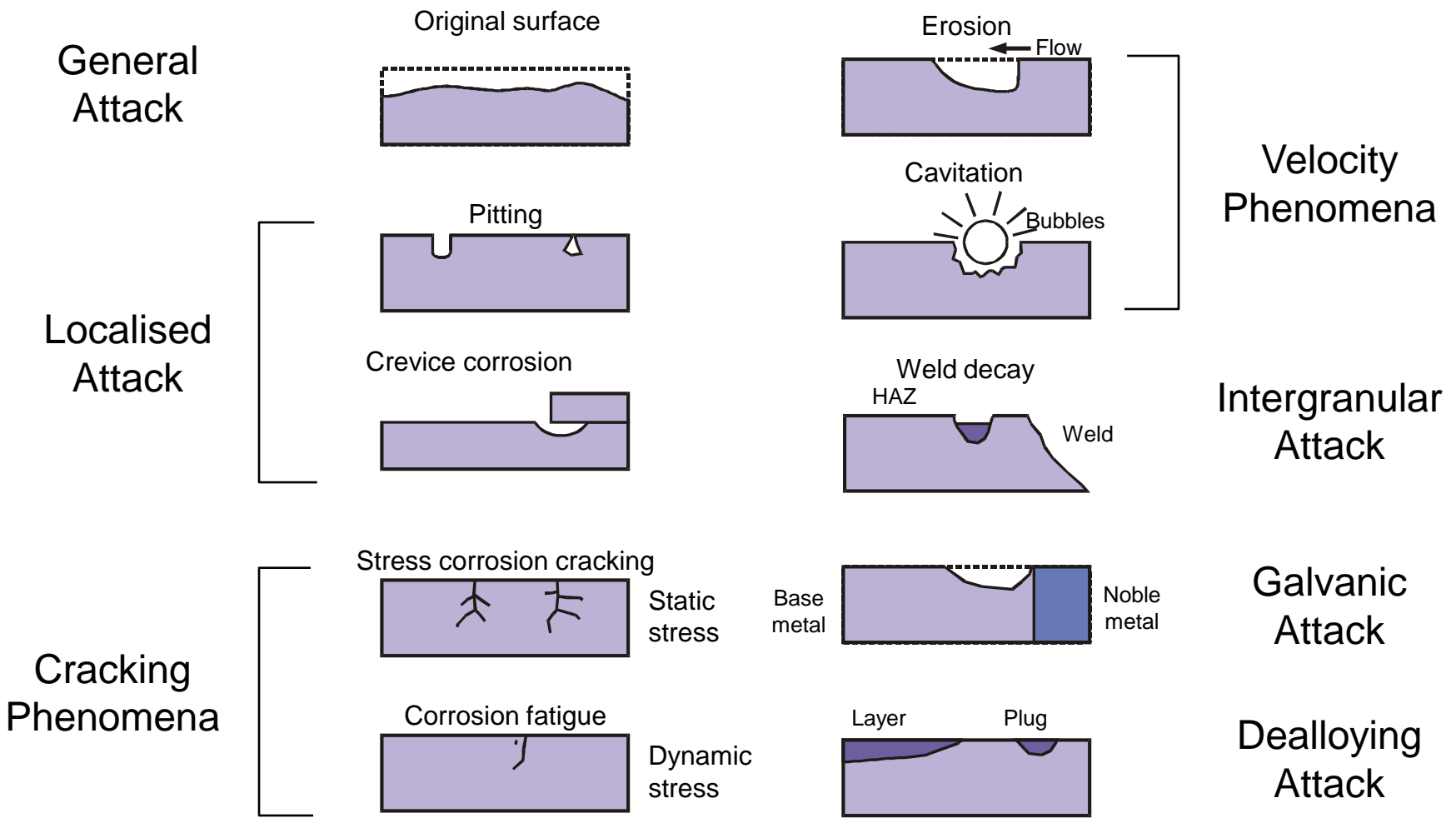


Others: Wear, Creep, Embrittlement

Uniform/General Corrosion



Forms of Material Degradation Corrosion

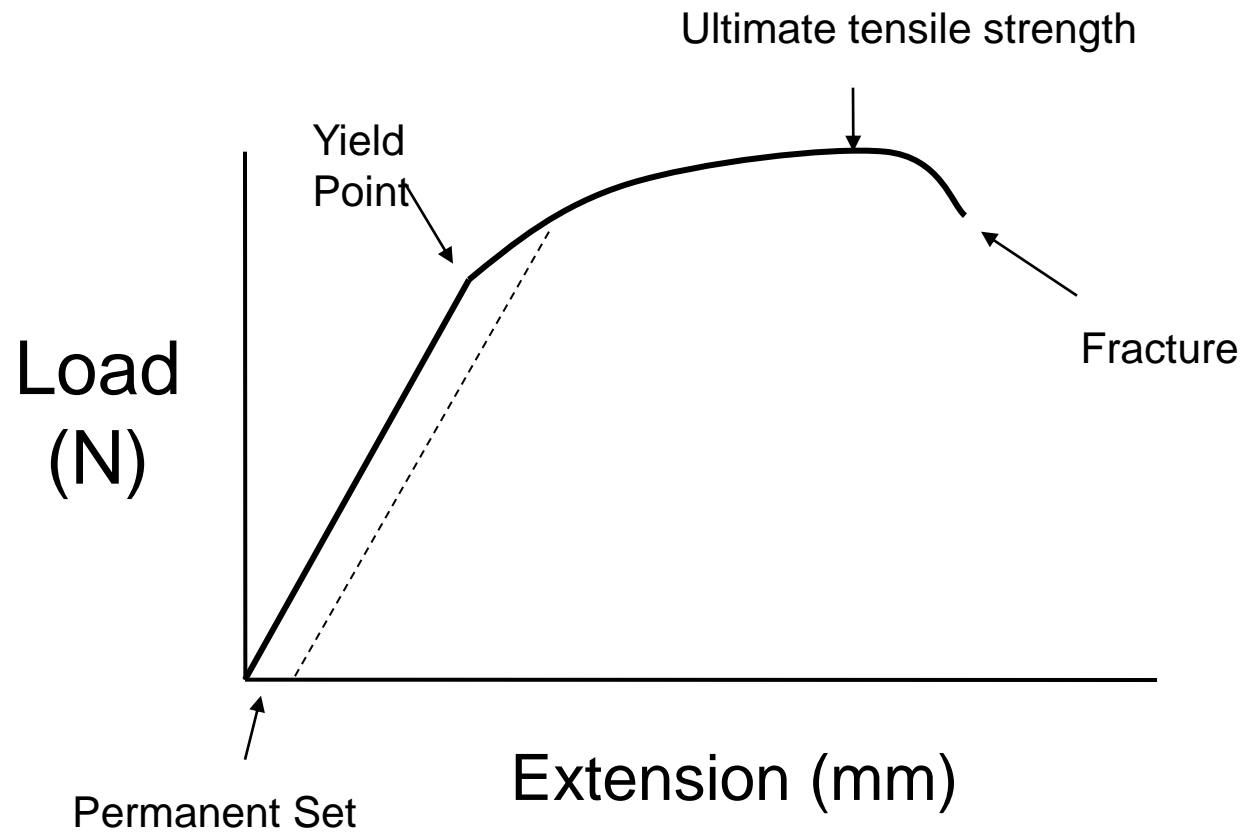


What is Stress

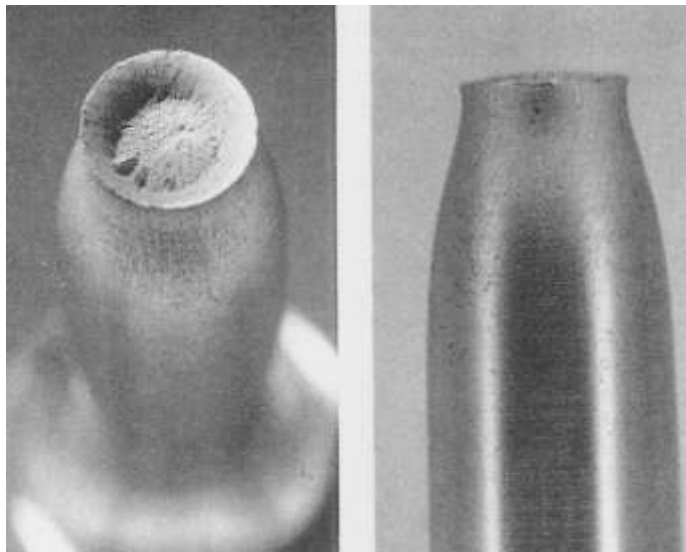
- The intensity of the internally distributed forces or components of forces that resist a change in the volume or shape of a material that is or has been subjected to external forces.

$$\text{Stress } (\sigma) = \frac{\text{Load or Force (N)}}{\text{Area (mm}^2\text{)}}$$

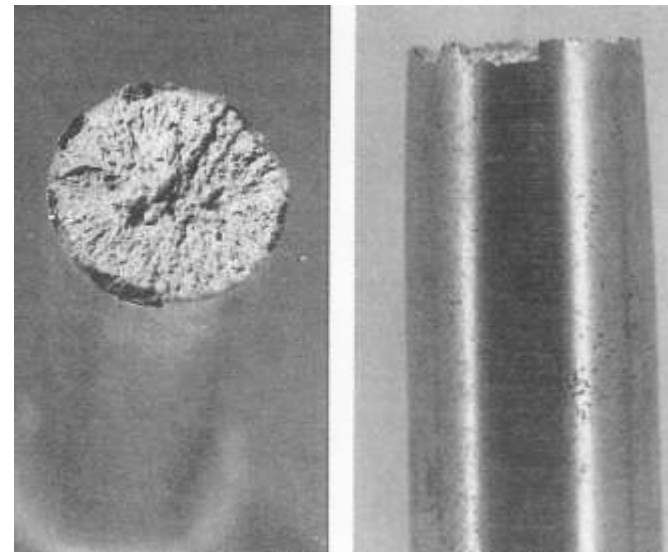
What is Overload?



Overload – Ductile/Brittle

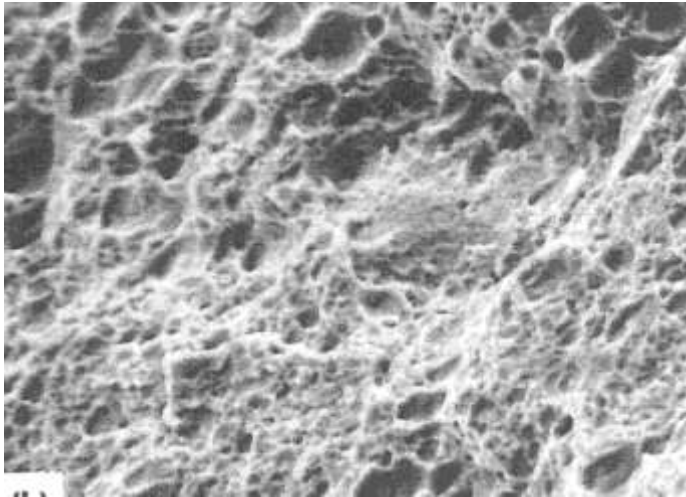


Ductile

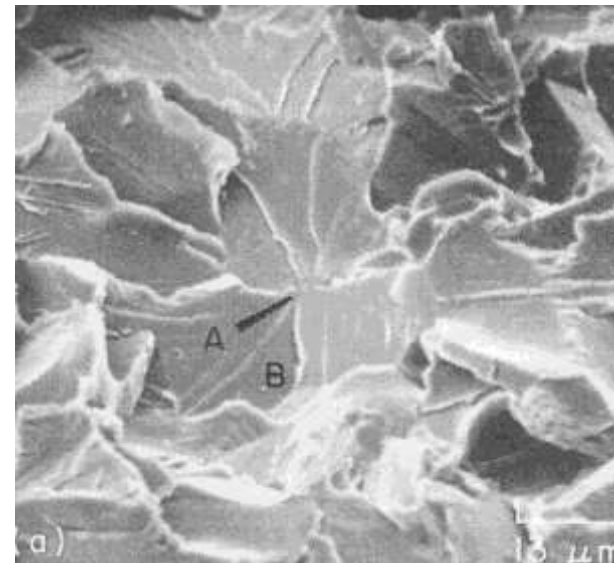


Brittle

Overload – Ductile/Brittle



Ductile

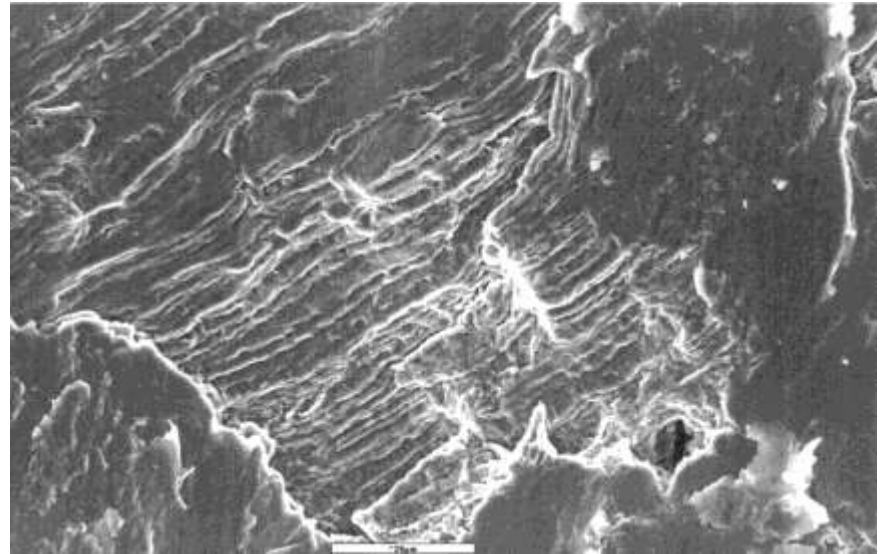


Brittle

Fatigue – Typical Fracture Faces

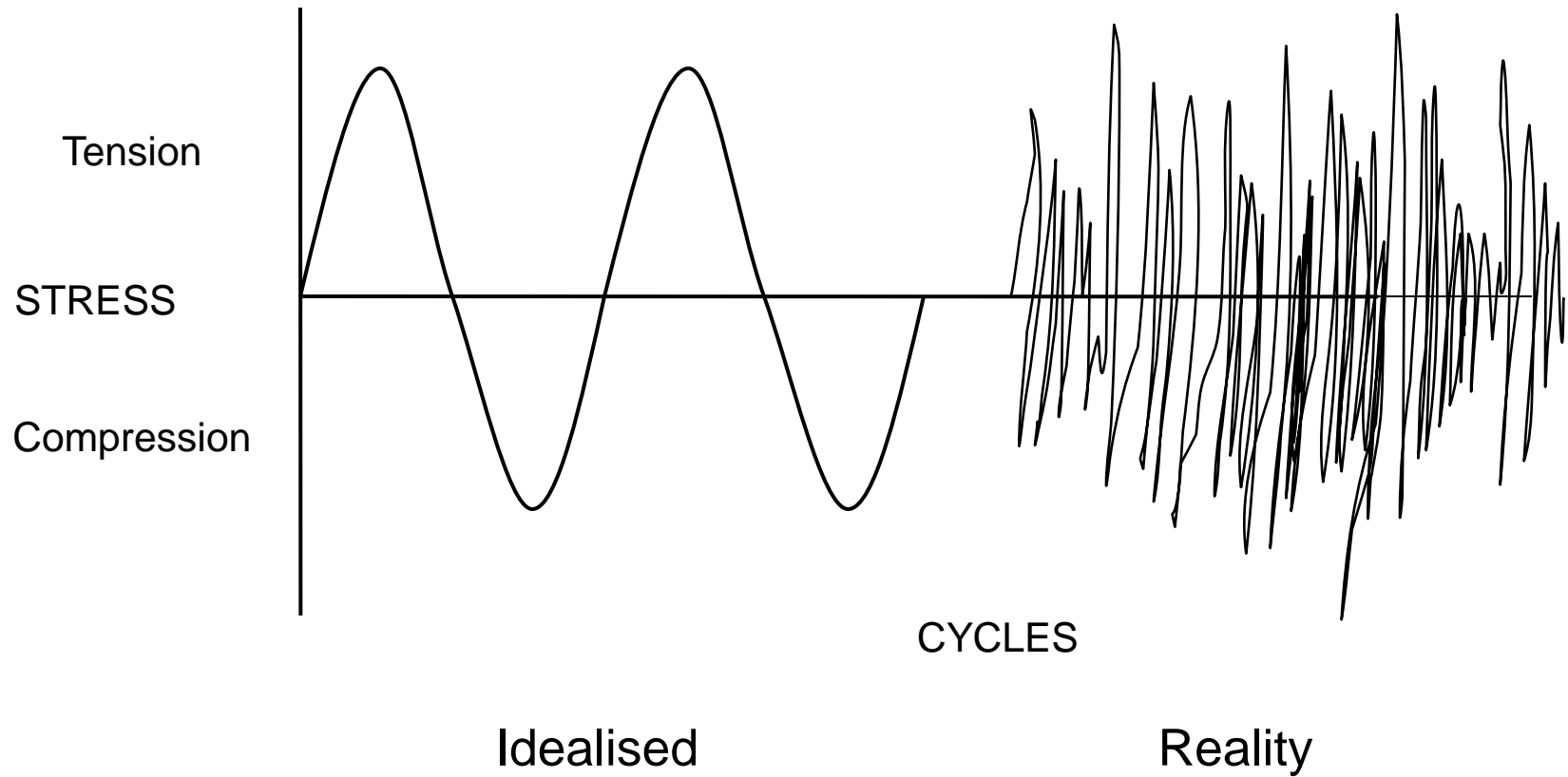


Beach Marks

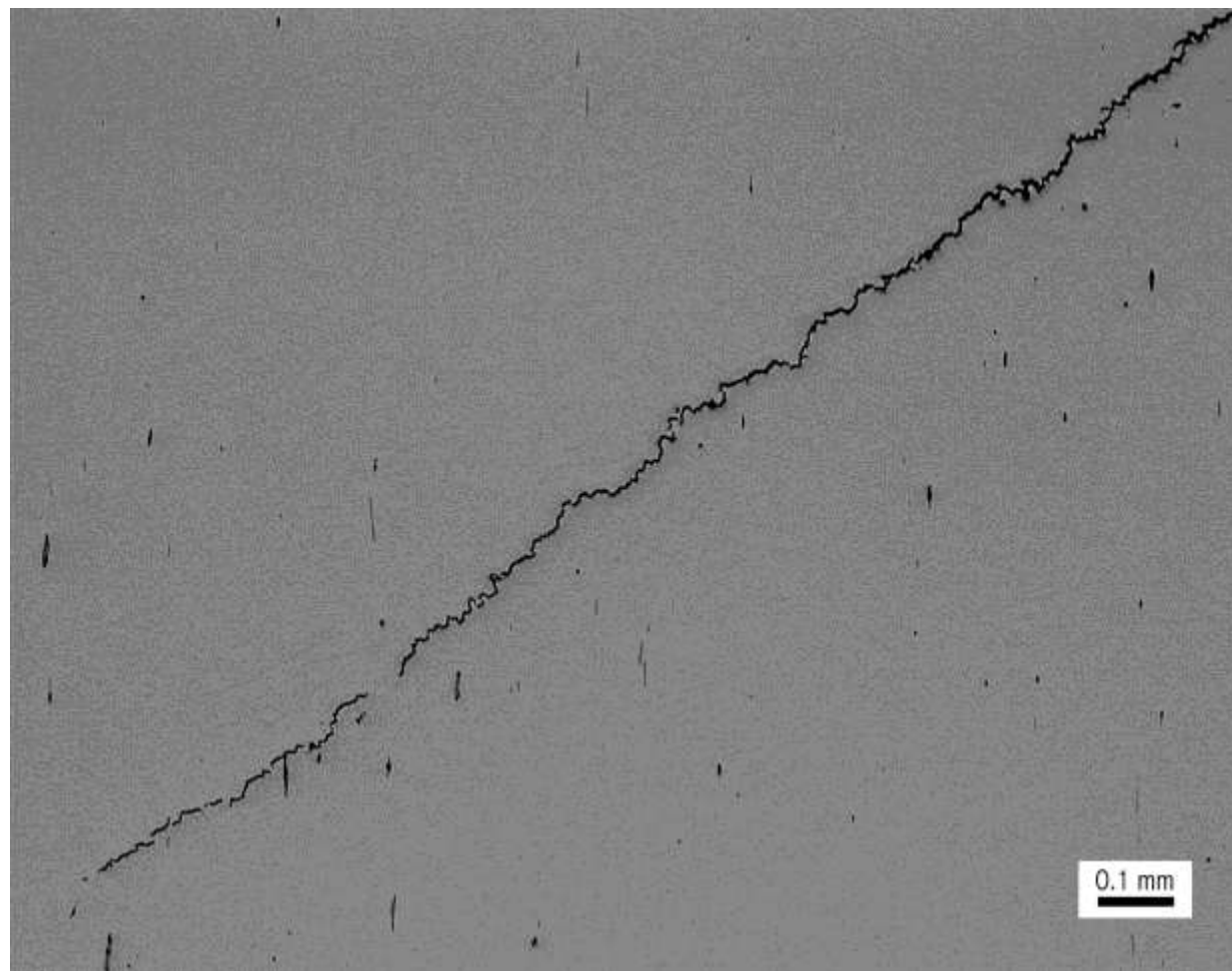


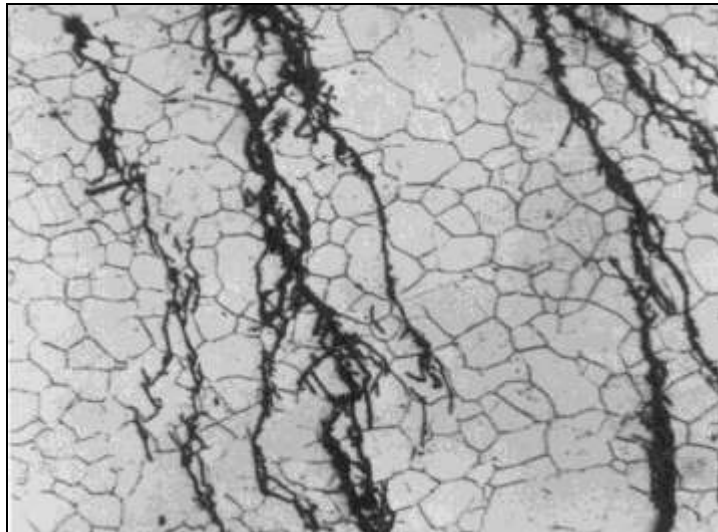
Striations

Fatigue – Cyclic Stress?





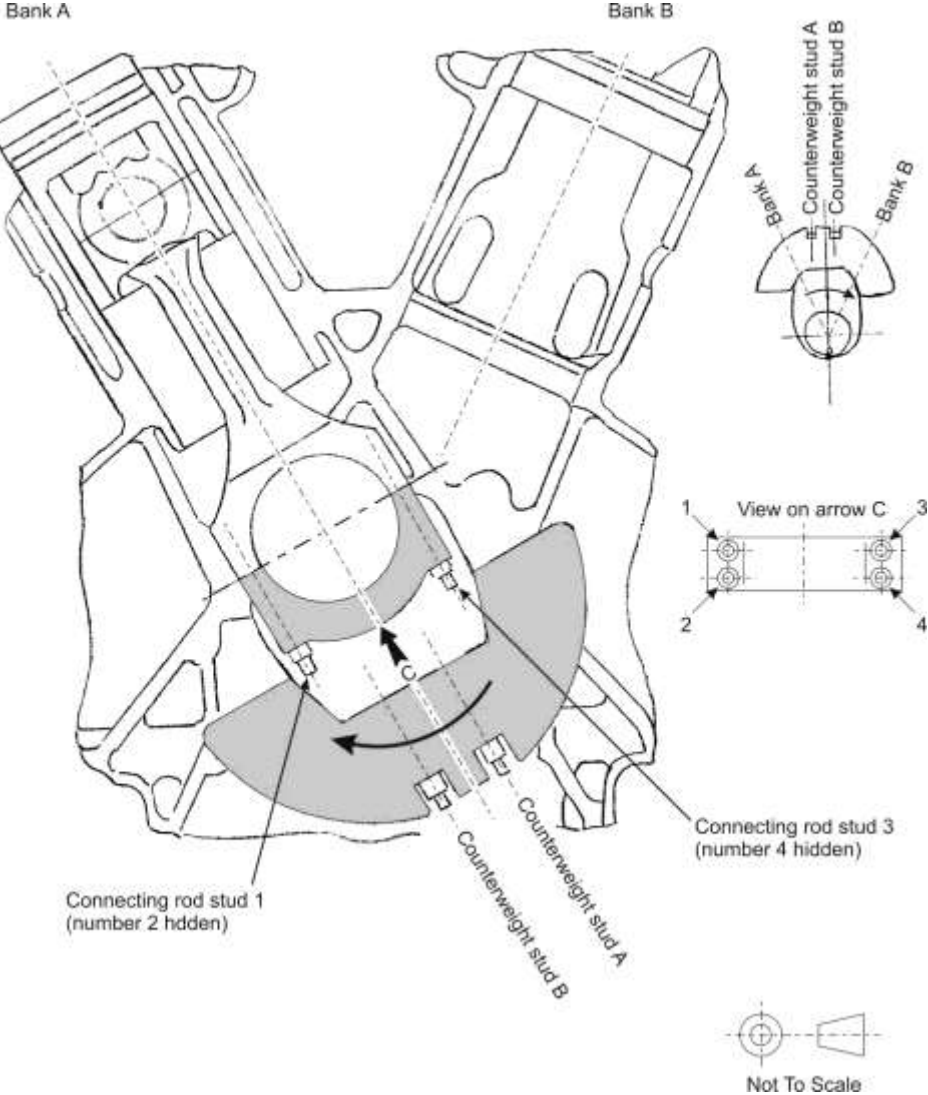




- Cracking caused by the joint action of corrosion and a tensile stress
- Damage is in the form of fine crack networks extending through the wall of the material
- Difficult to detect visually
- Stress can be residual from fabrication or applied
- SCC is promoted only in the presence of specific corrodents for individual materials

Diesel Engine - Power Generation

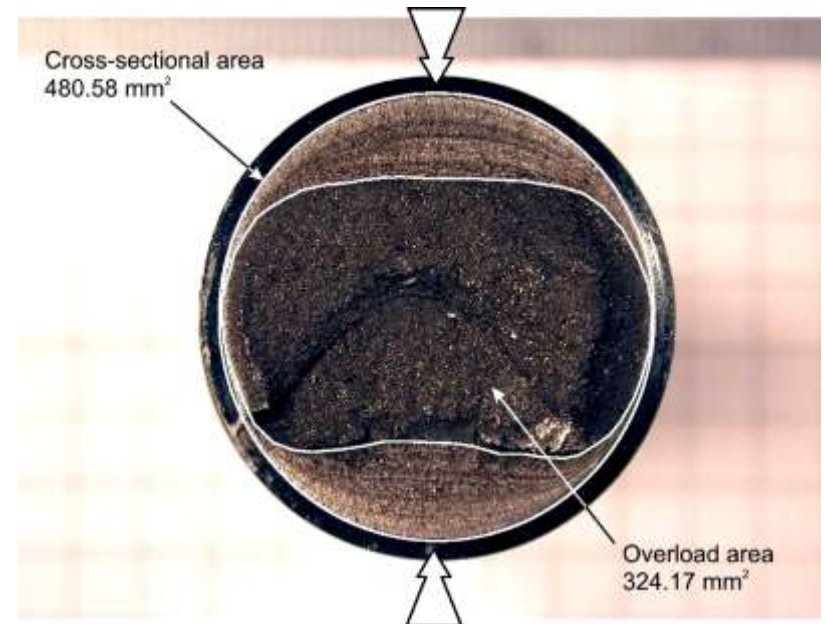
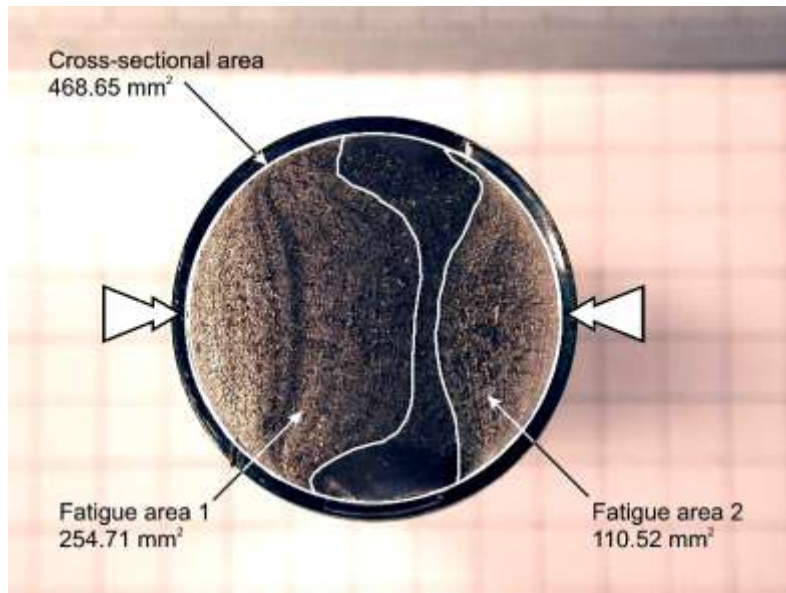




Con Rod & Counterweight Studs



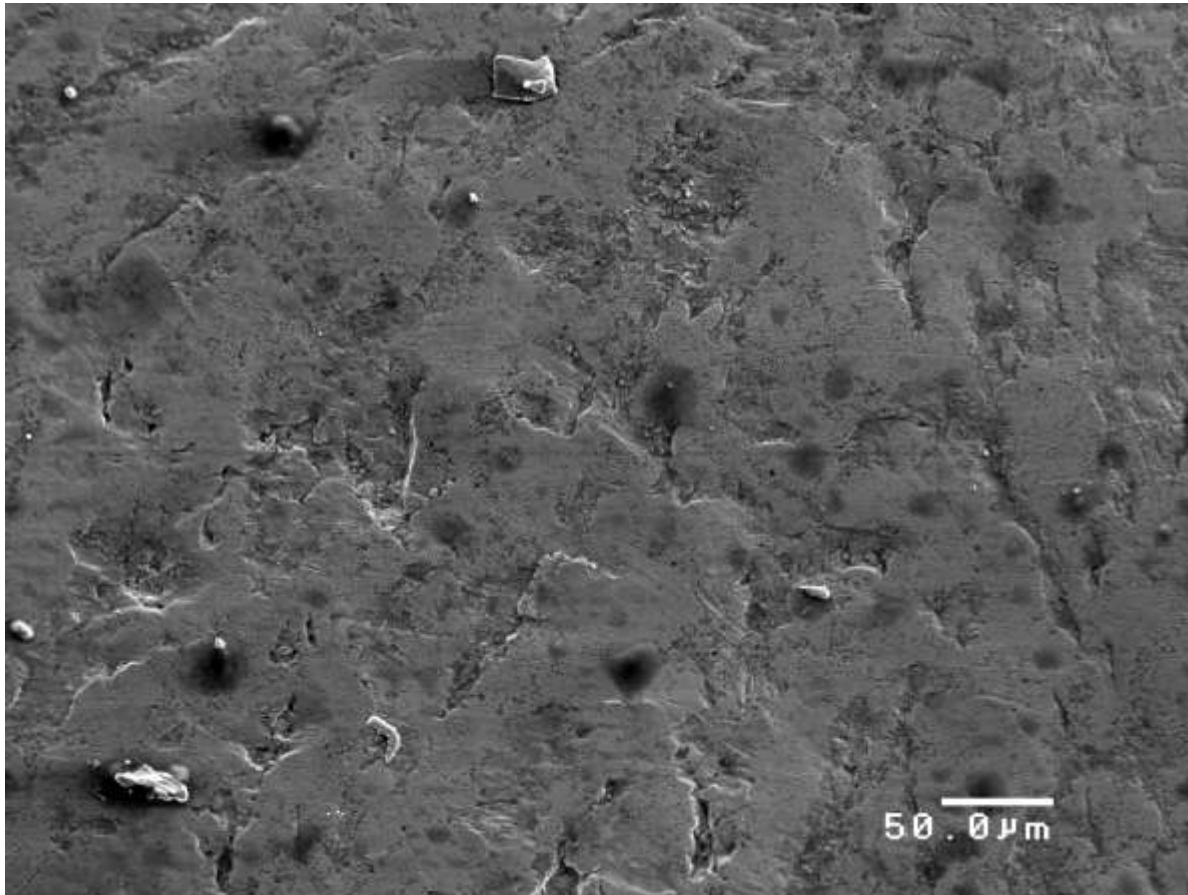
Fatigue (reversed bending)

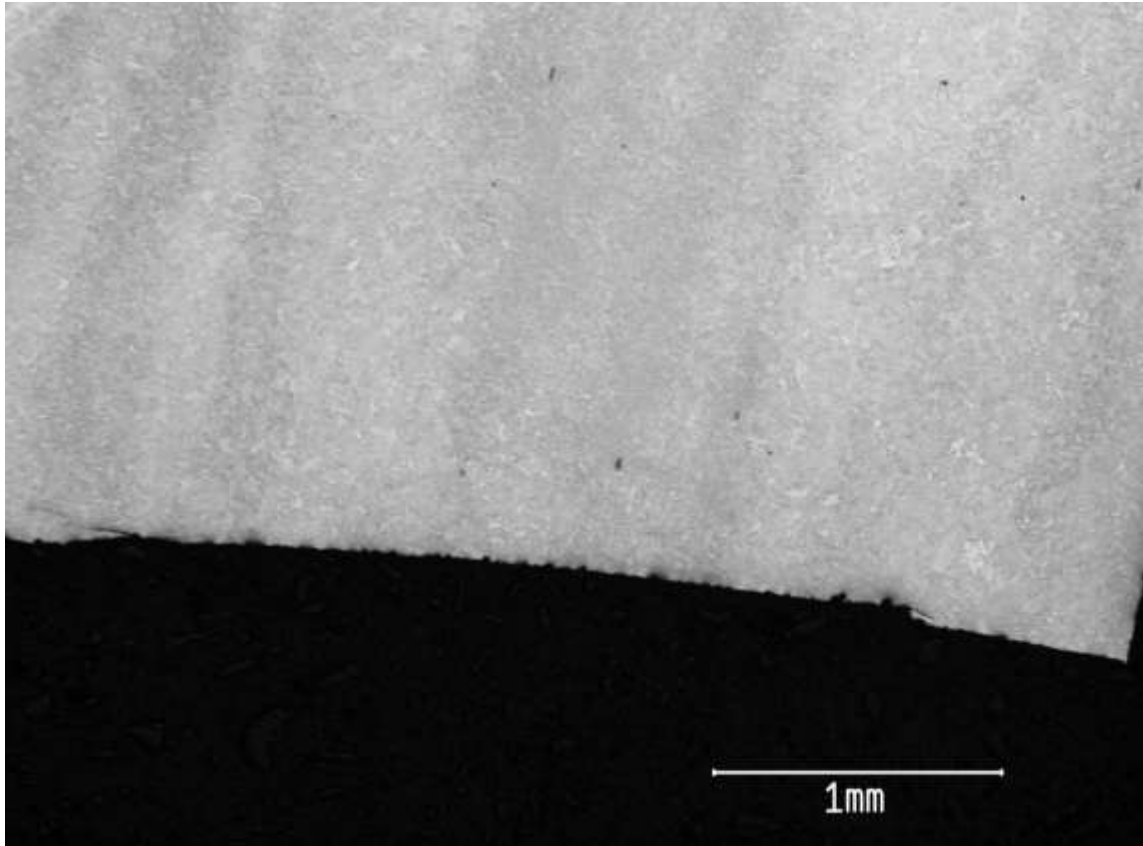


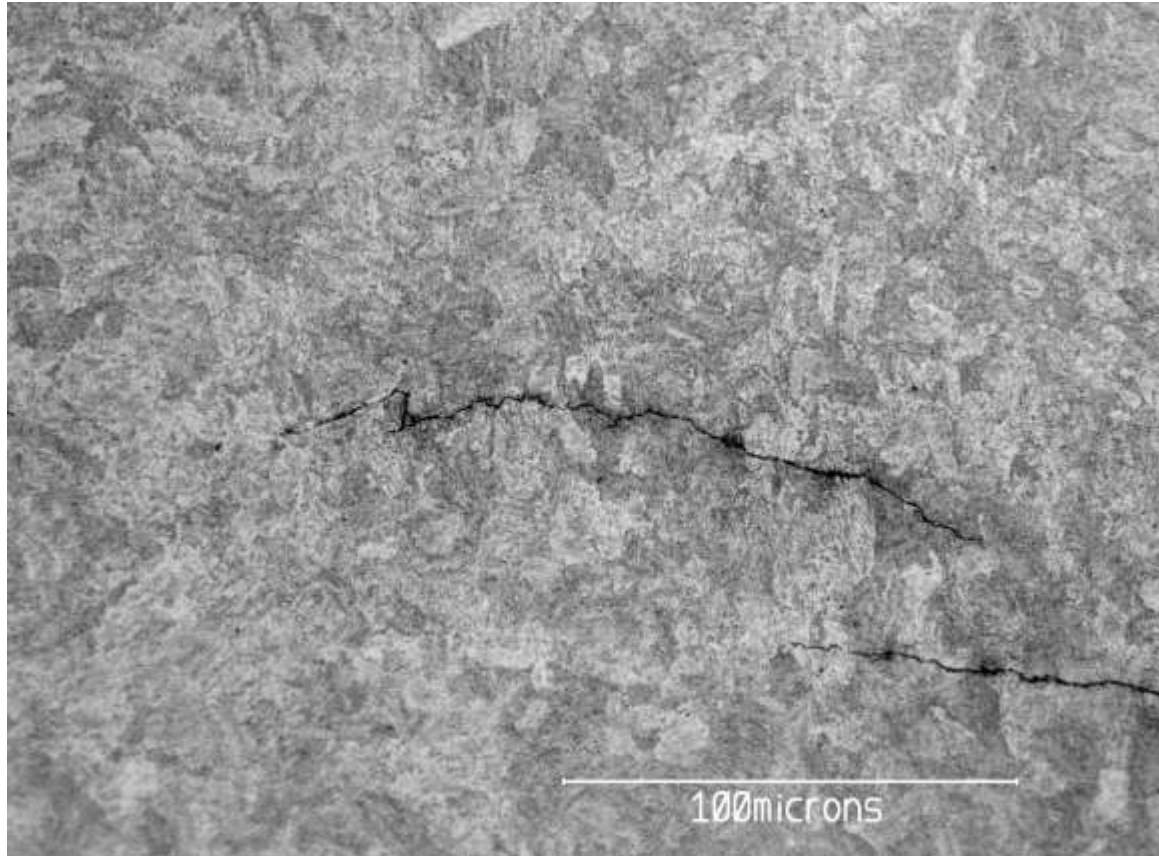




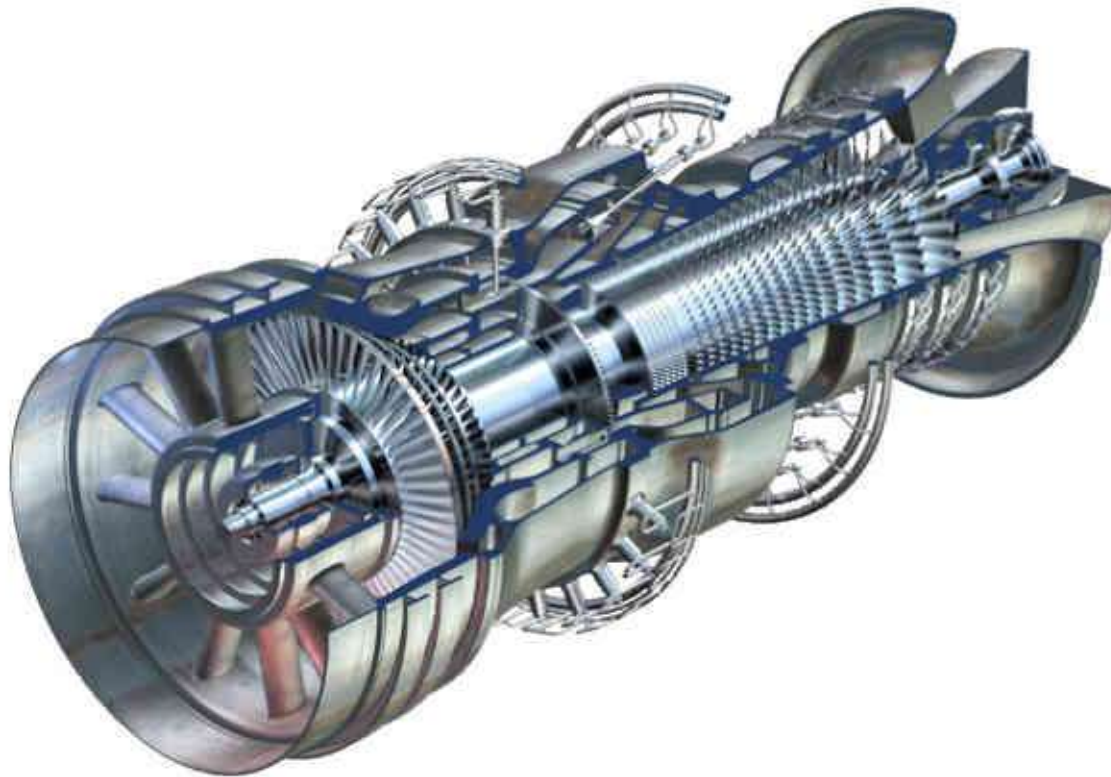








Gas Turbine Power Generation



Metal Loss from Compressor Blade



Associated damage



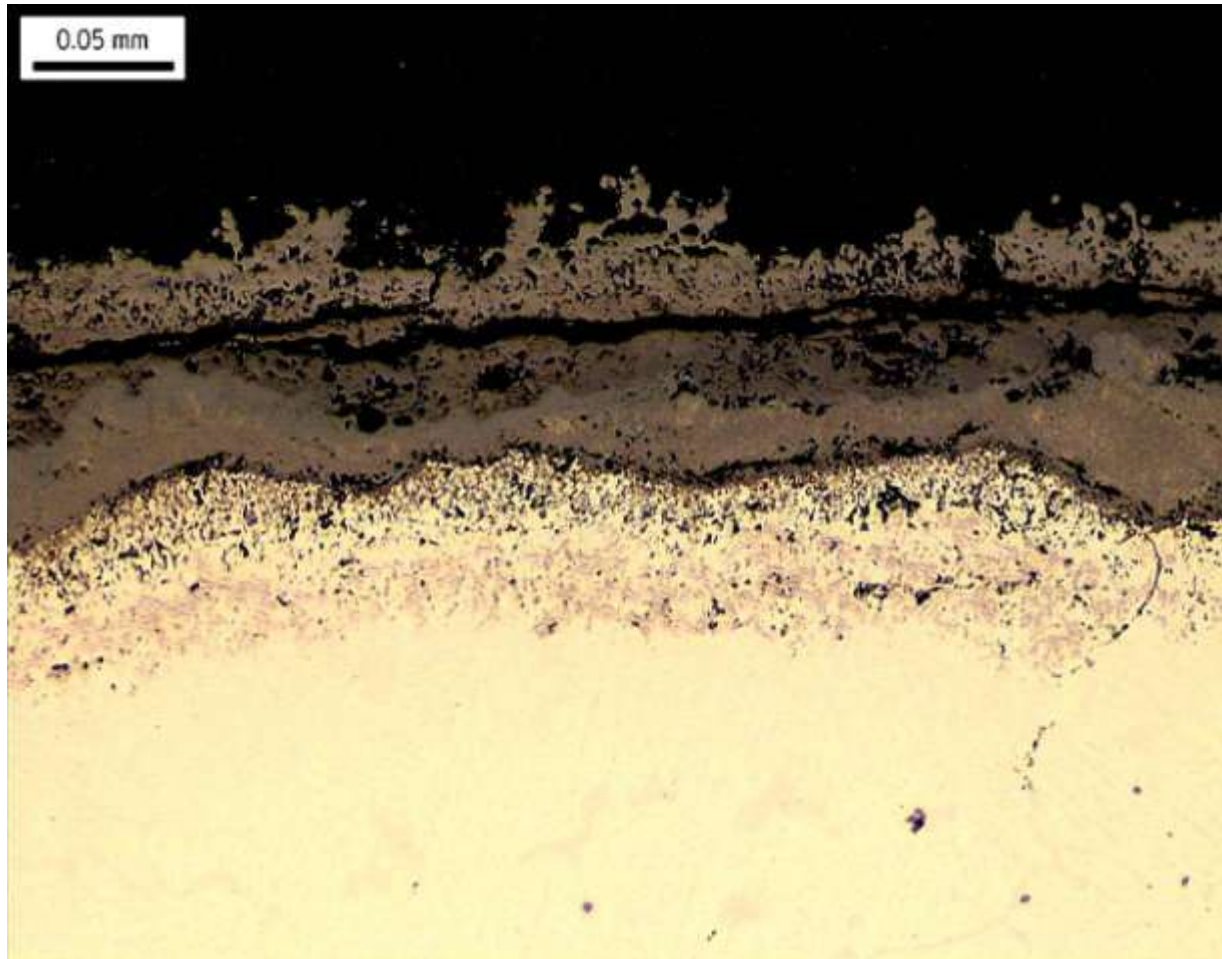
Subsequent damage?



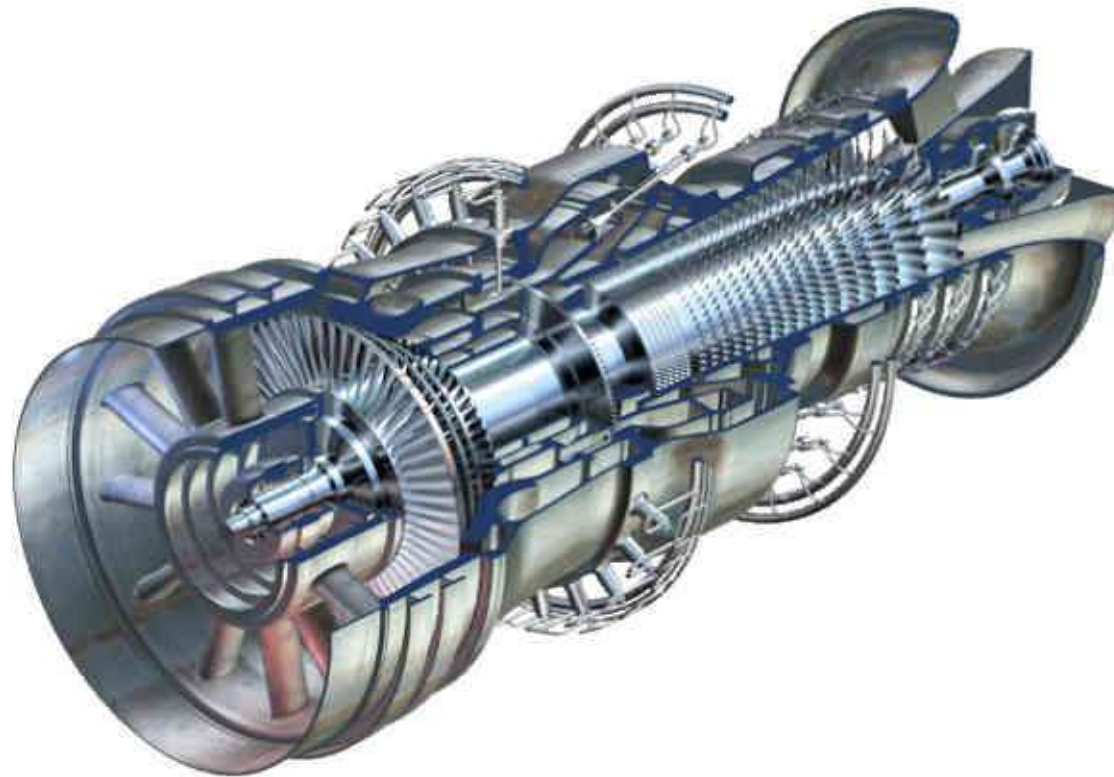
Gas Turbine Power Generation



Type I Hot Corrosion

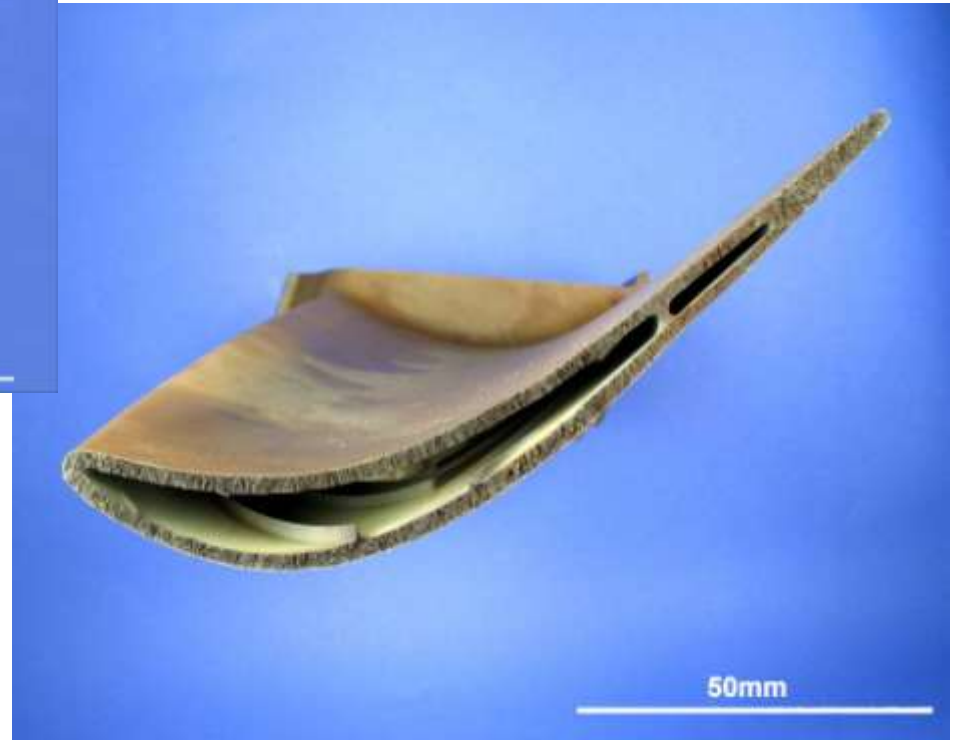


Gas Turbine Power Generation

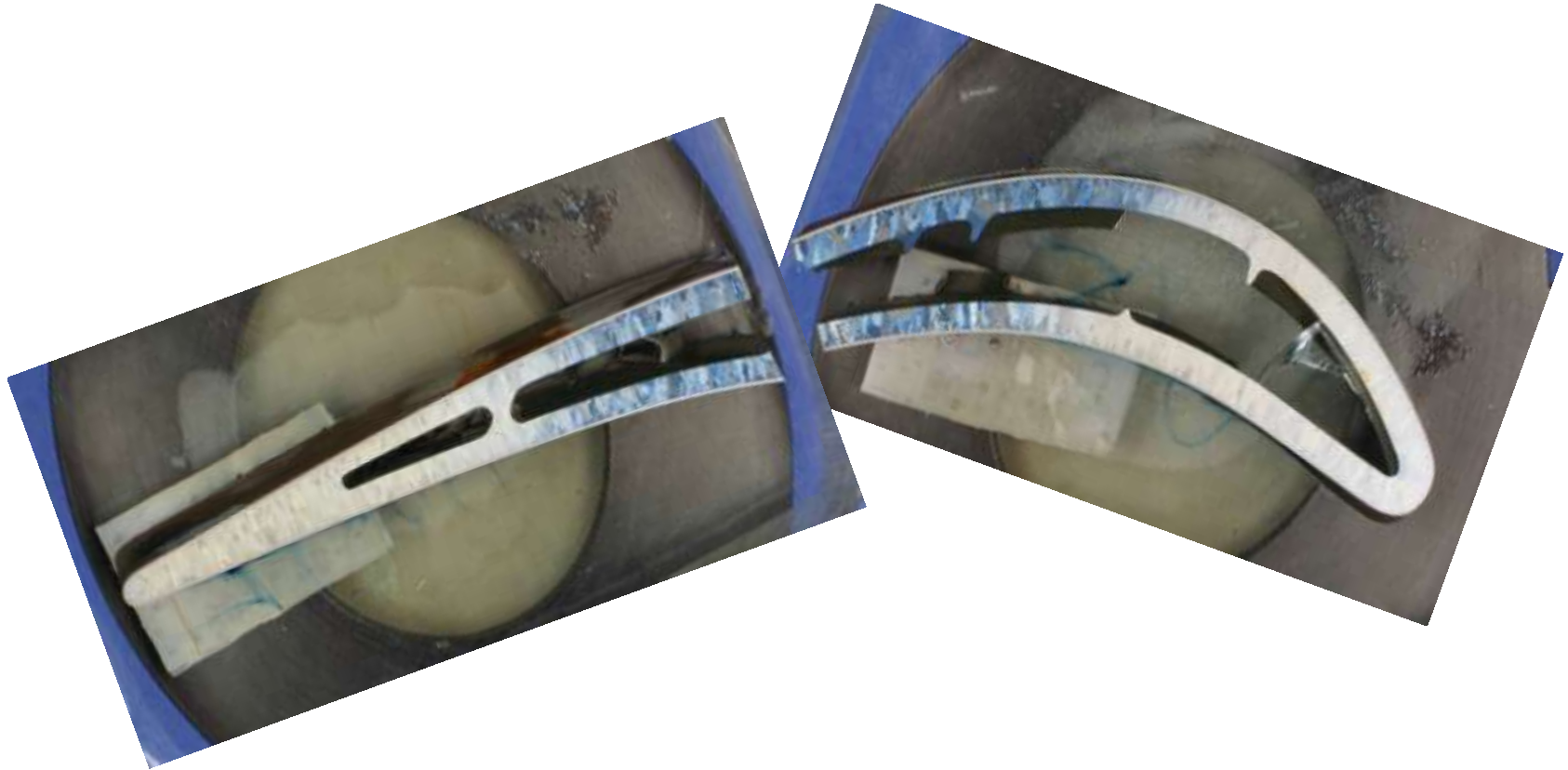




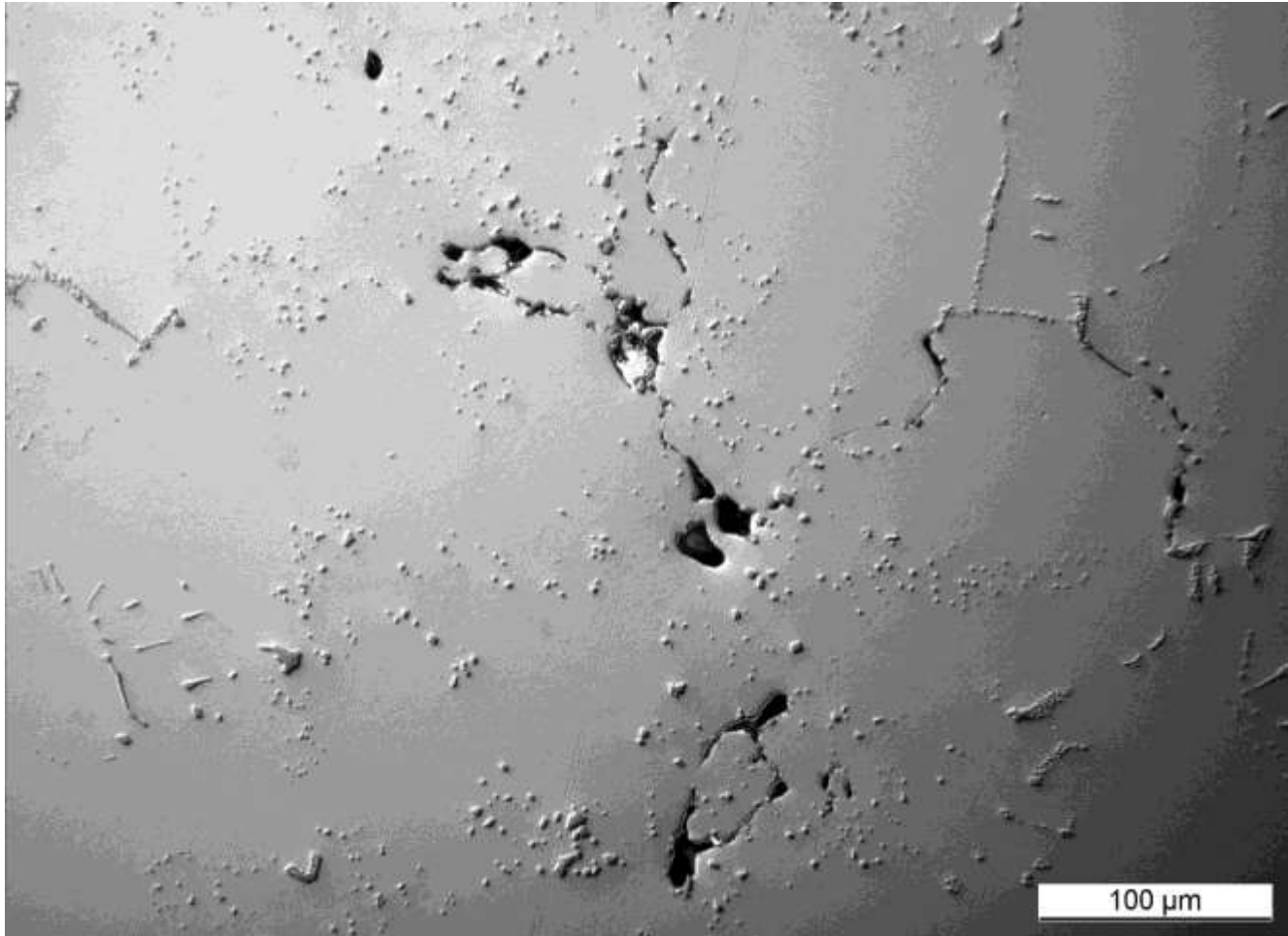
Low Pressure Turbine Blade



Turbine Blade Microstructure



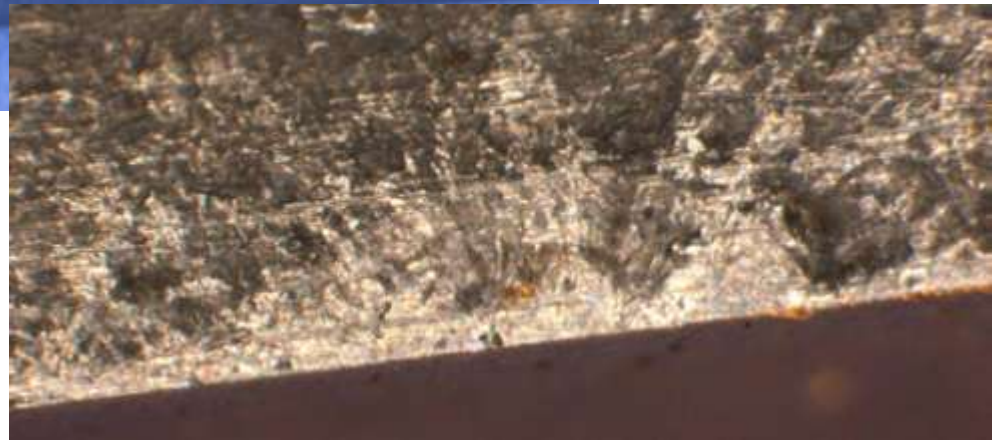
Turbine Blade Microstructure



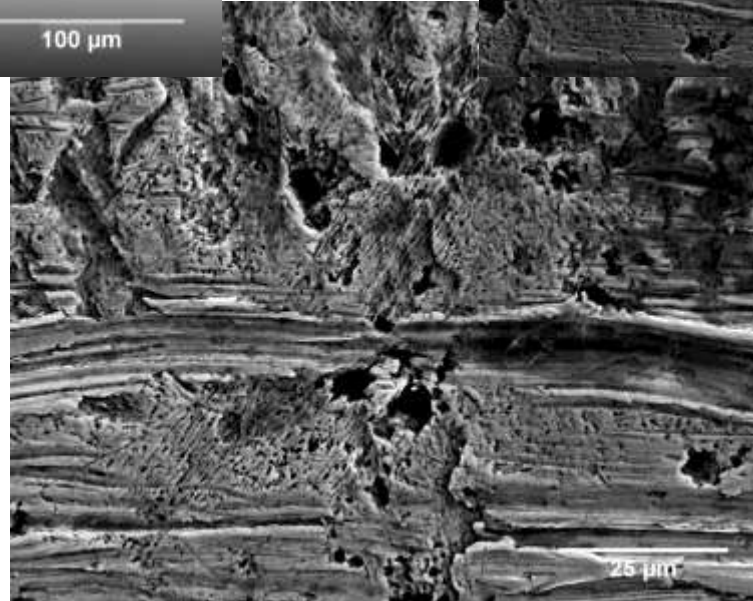
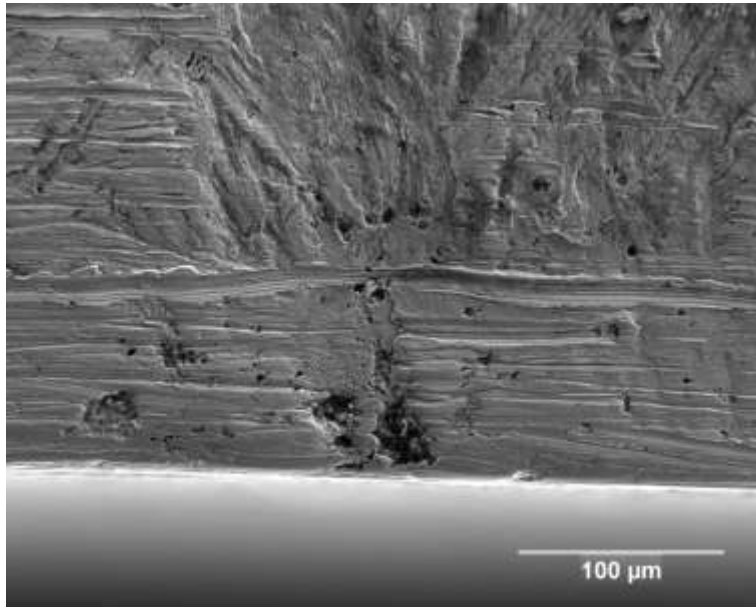
Low Pressure Compressor Blade



Fracture Surface

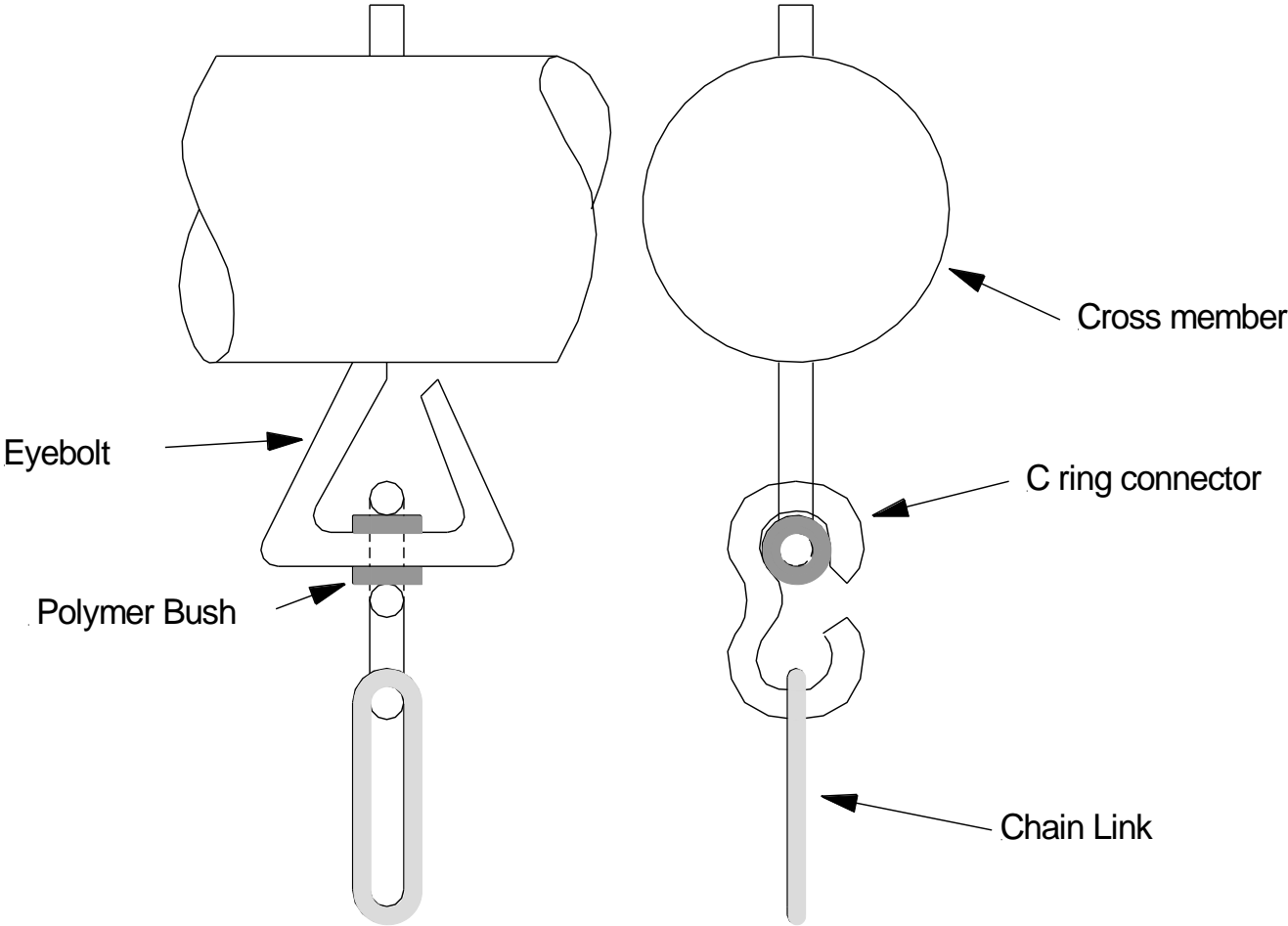


Fatigue Fracture Origin





Chain Failure







Chain Failure

