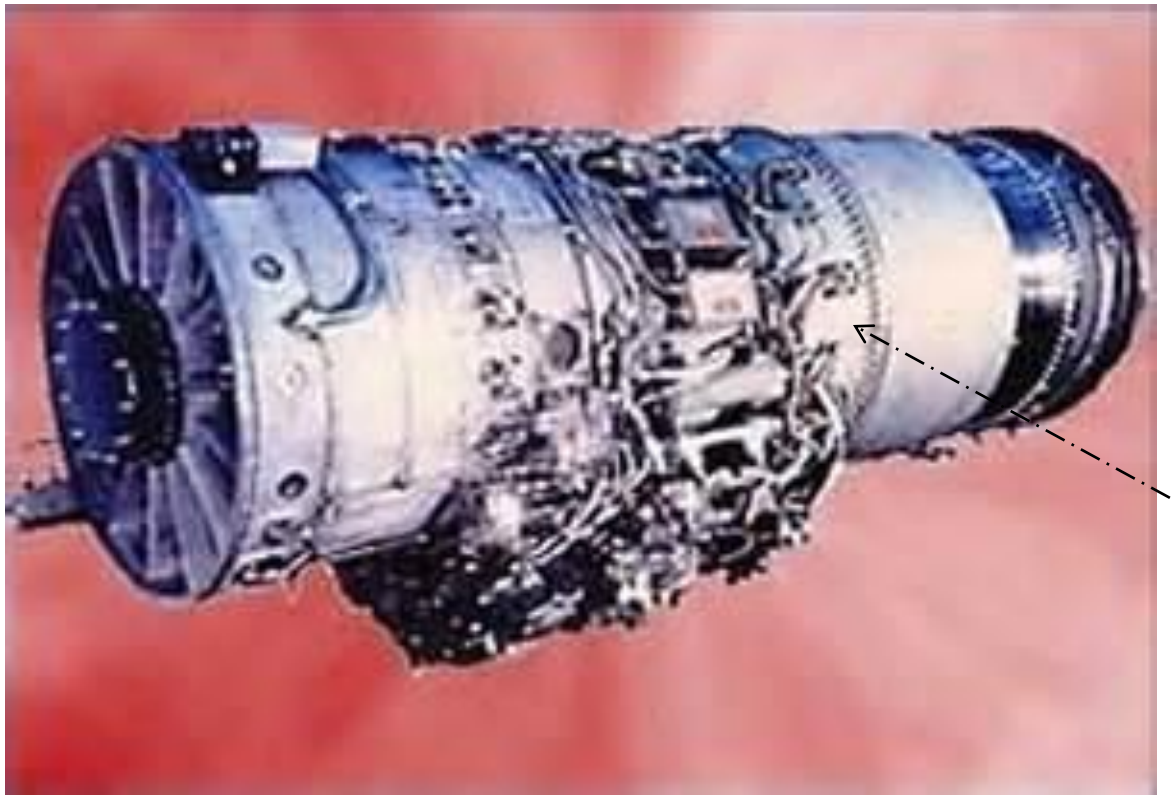
Failure Analysis of Turbine Engine In-flight Failure

Luis R. Carney, P.E.
Materials Engineer
Jacksonville, Fl.

AEROMET CONFERENCE

Outward view of Turbine Engine



Background

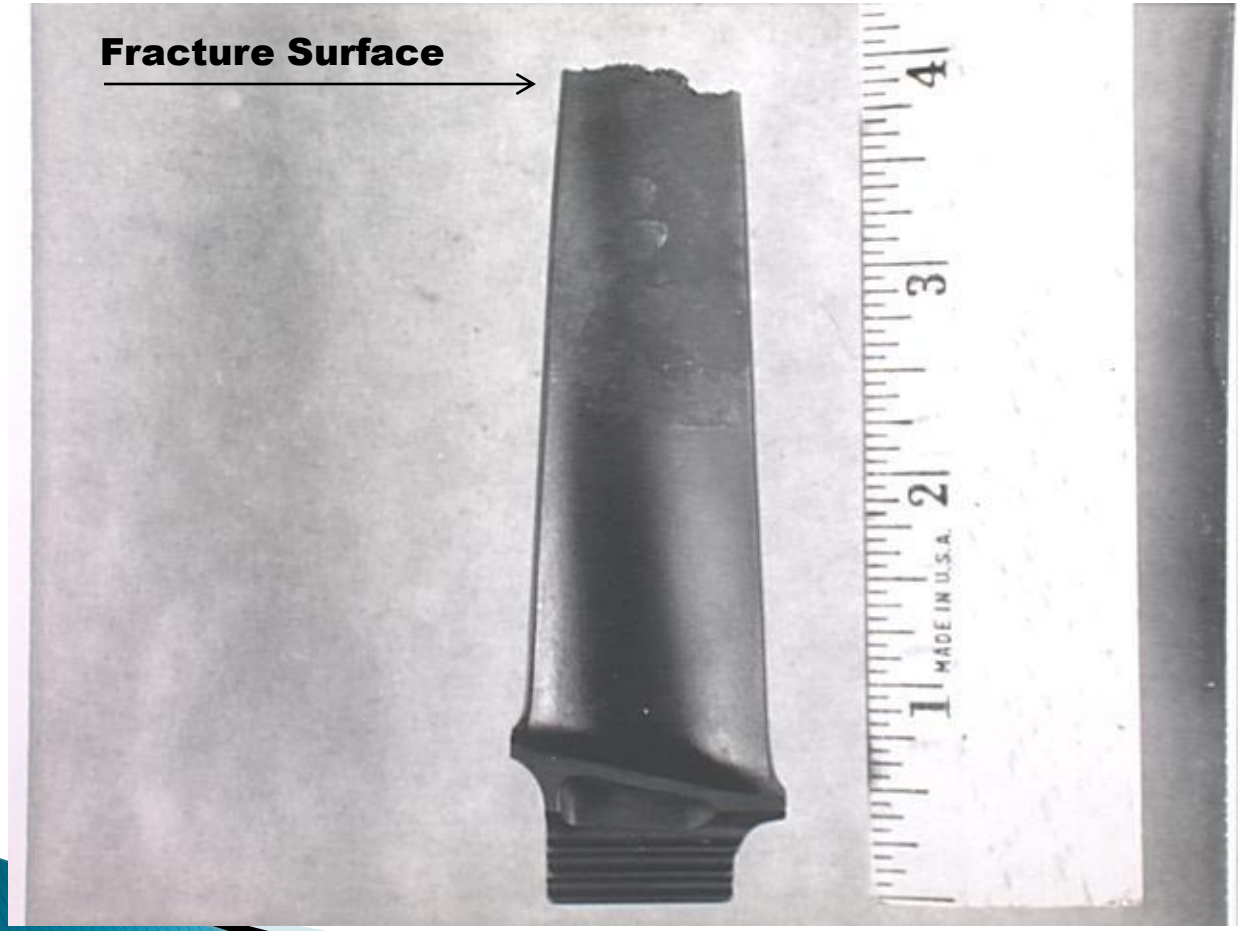
- Engine used in military service. High performance version of three available (higher turbine temperature) .
- Engine failed 40 minutes after take off during routine flight. (one of two).
- Indications of on-board fire.
- Engine shut down. Second O.K.
- Time Since Overhaul: 599 hours
- Time on Components : Unknown.

Background

Disassembly revealed:

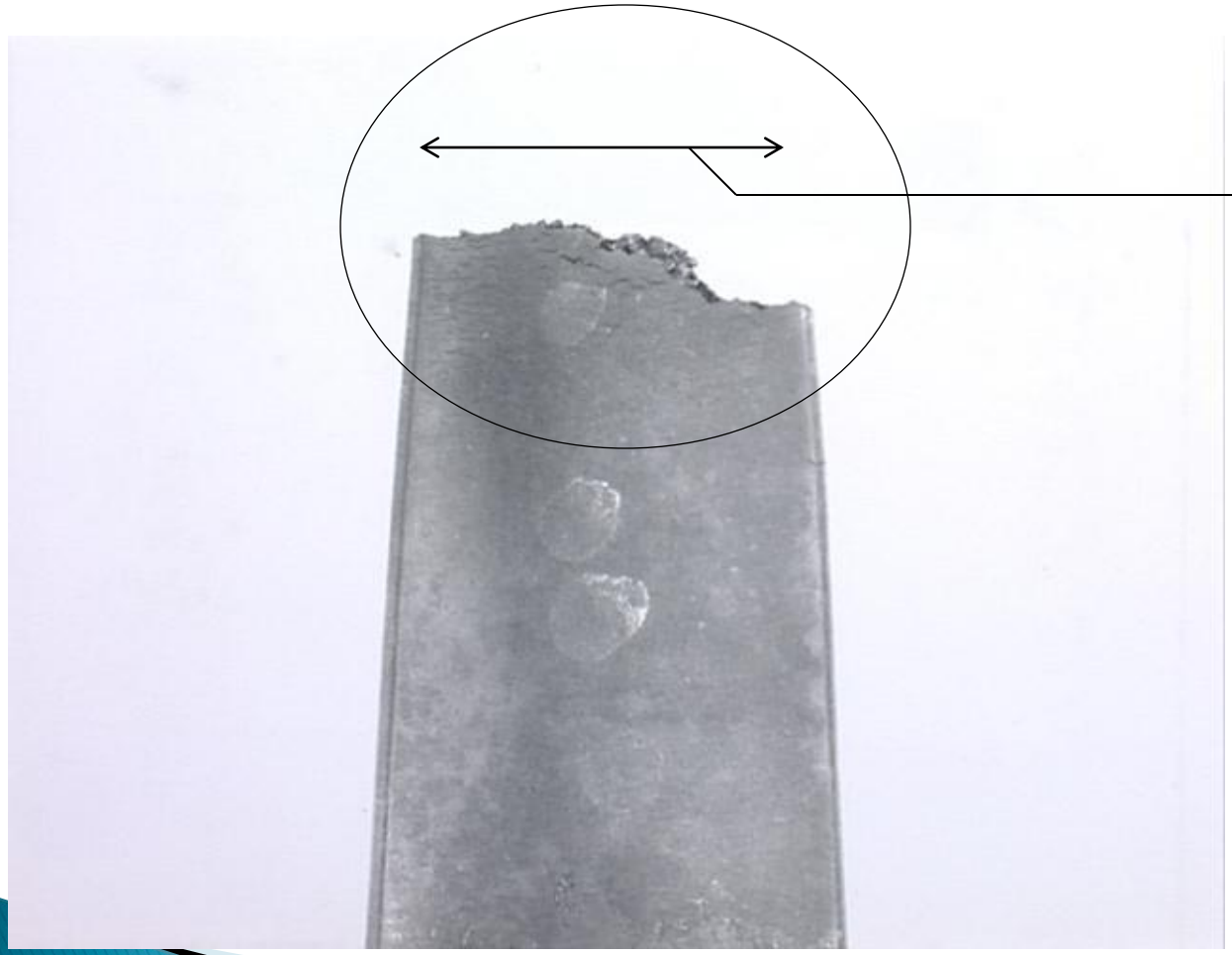
- 2 fractured burner can lugs.
- One separated 2nd Stage blade.
- Fractured #6 brng housing strut.
- Damaged #6 brng housing and carbon seals.
- Bulge in exhaust case and tailpipe

Visual Observations



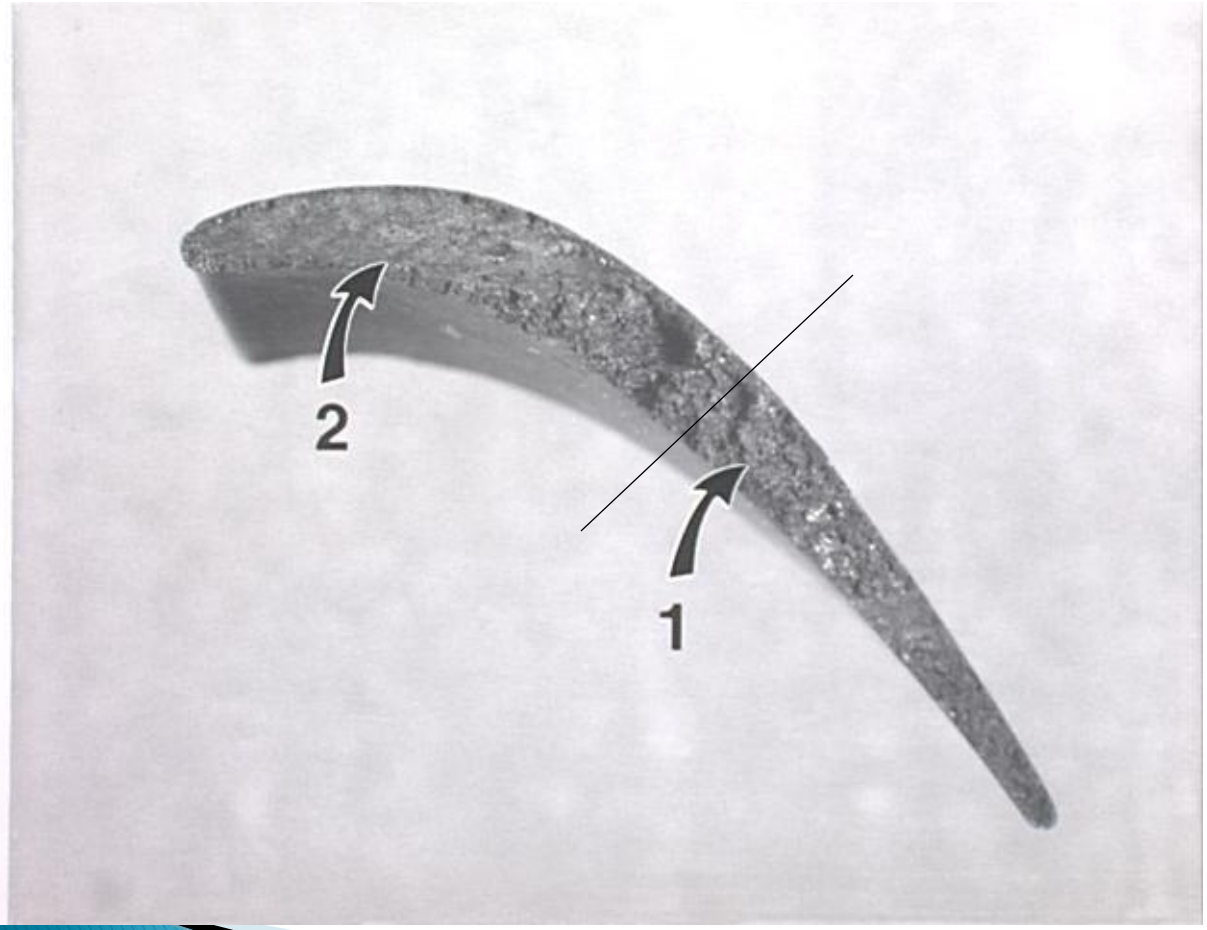
- Stage 2 turbine blade, as received.

Visual Observations



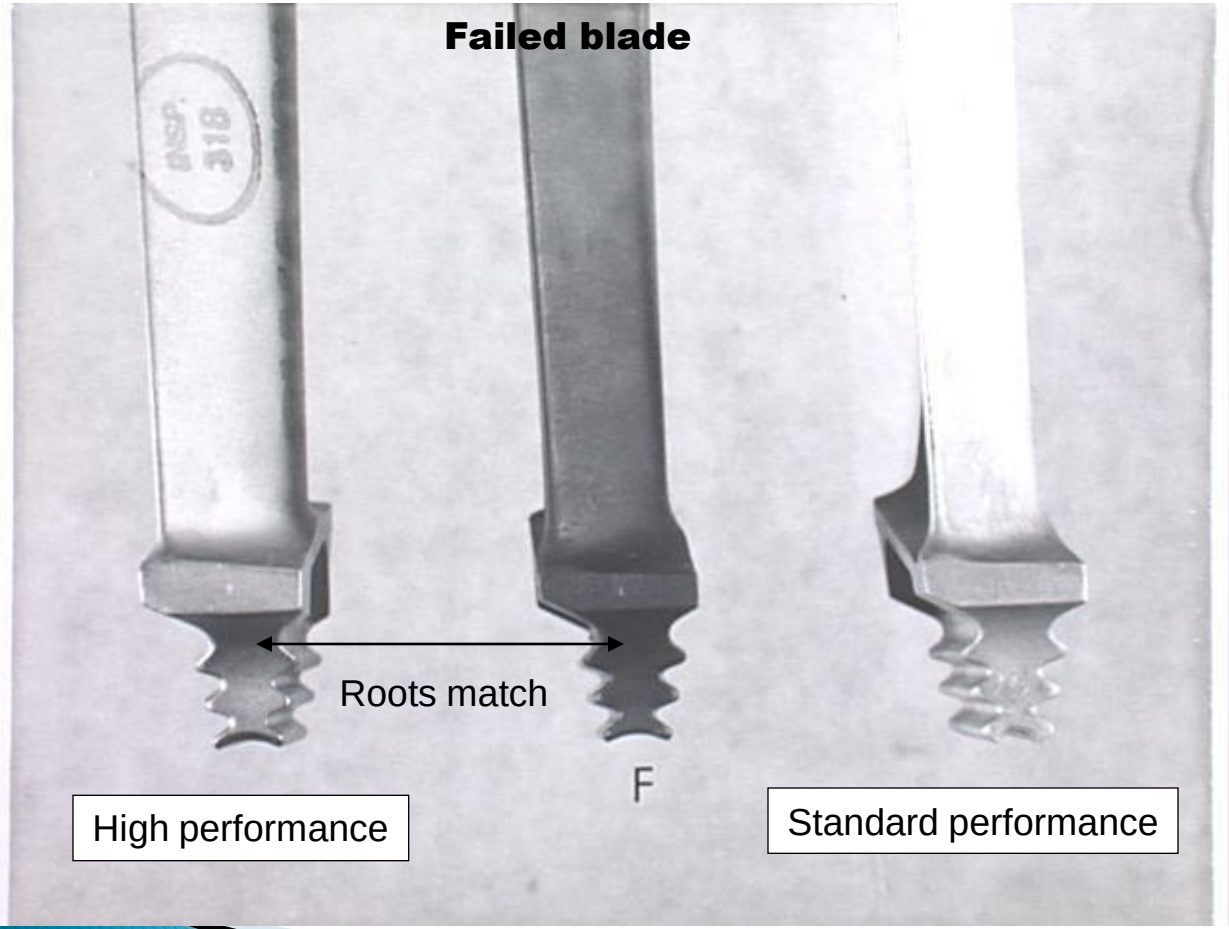
- Stage 2 fracture.
- Area surrounding fracture surface exhibited many cracks and slight necking.

Visual Observations



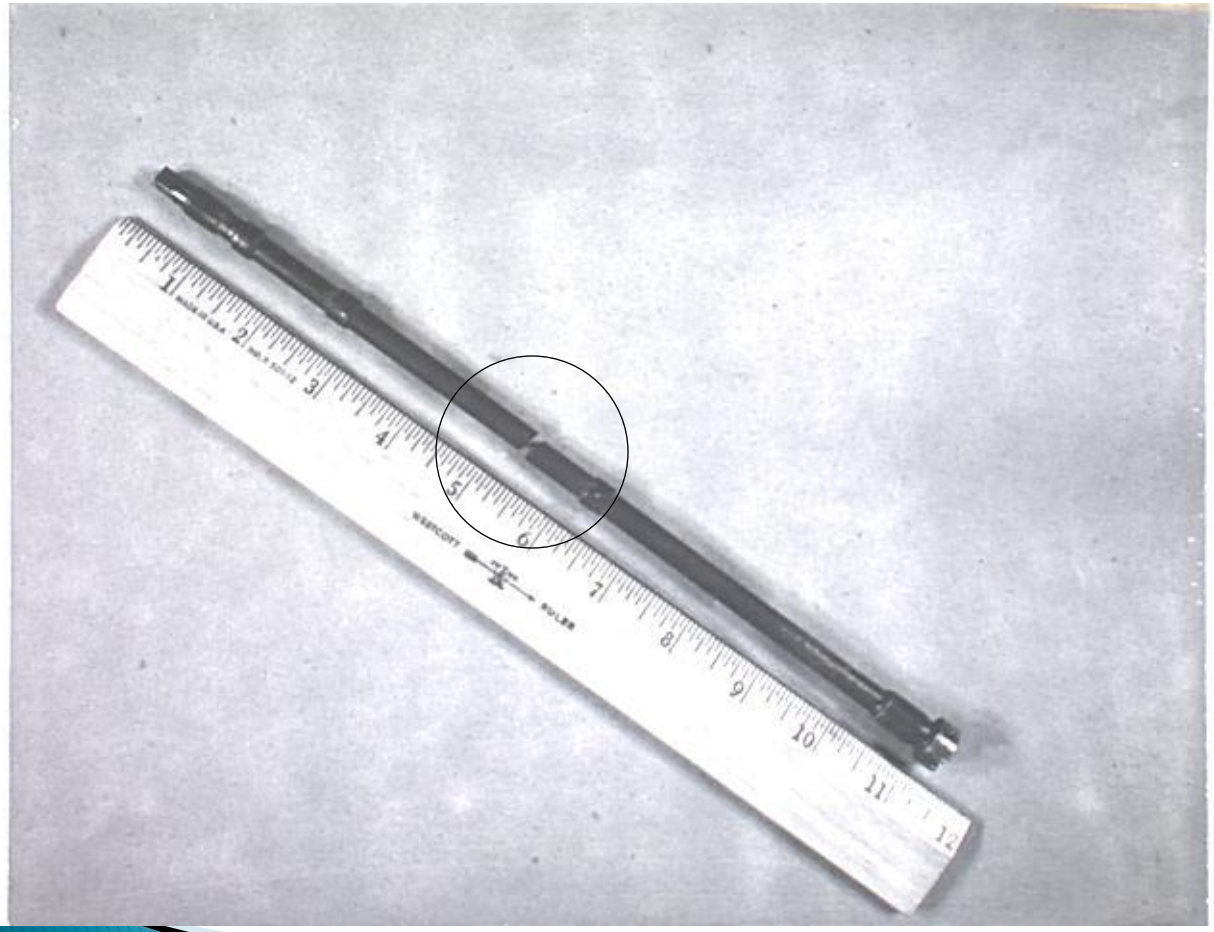
- Fracture surface of 2nd Stg blade.
- Area 1 flat & perpendicular to long axis
- Area 2 at 45 deg to long axis

Visual Observations



- Root section (F) appropriate for & fits high performance engine version
- P/N stamped on (F) inconsistent with high performance requirements
- P/N (F) matches standard performance (cooler running) engine

Visual Observations

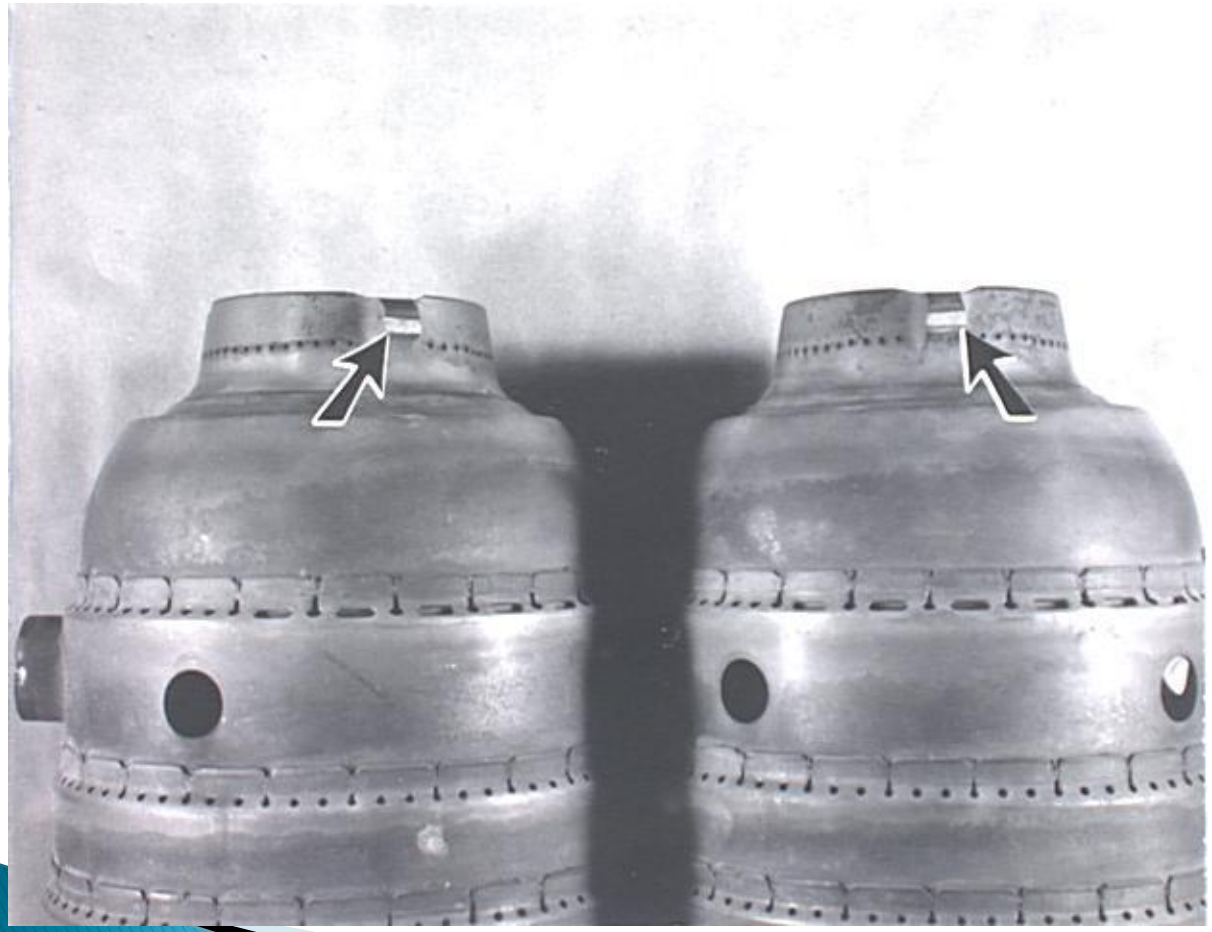


- #6 bearing strut.
- Fracture zone circled.

Visual Observations

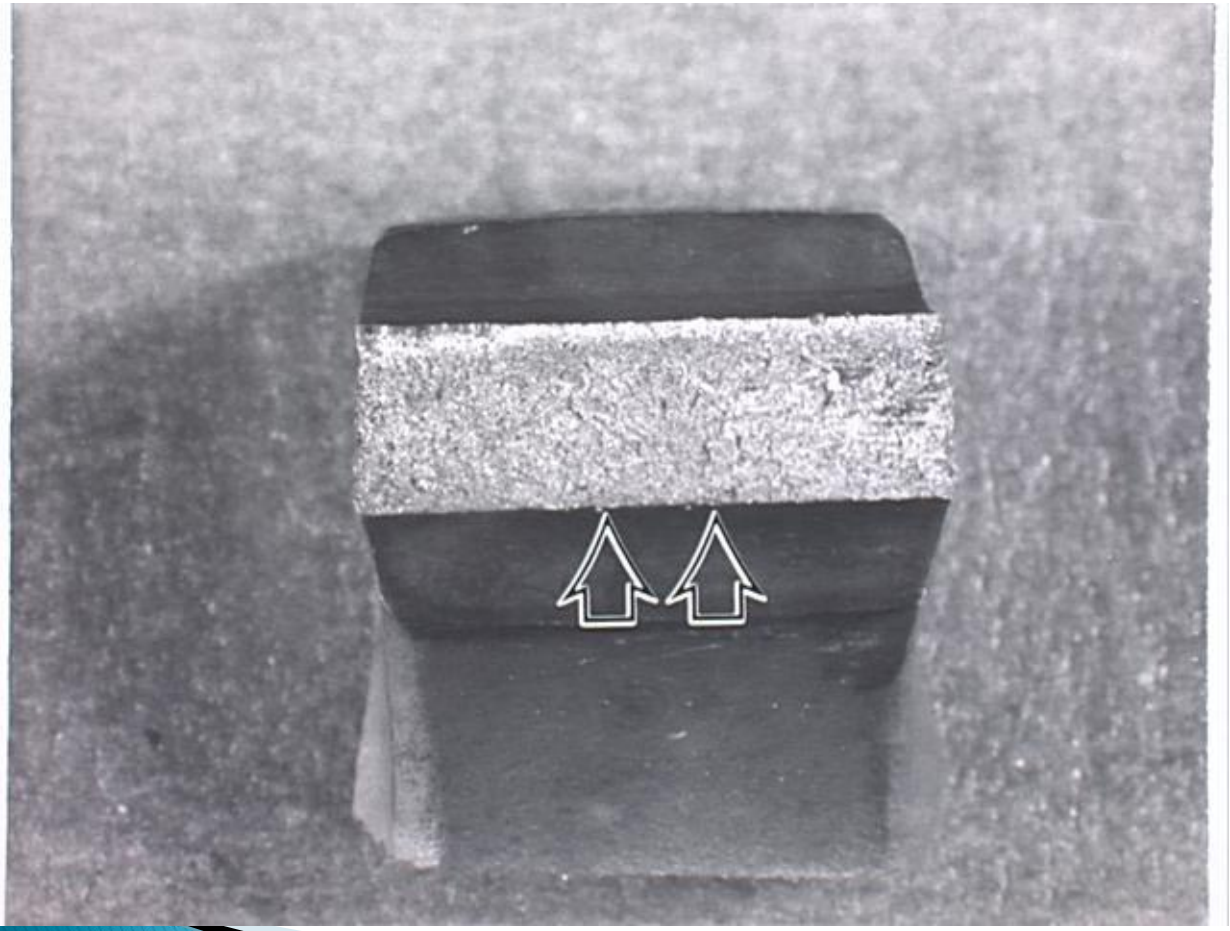
- Fracture surface of #6 bearing strut.
- Fracture initiation region and propagation direction noted

Visual Observations



- Fractured burner can lugs, as received.

Visual Observations

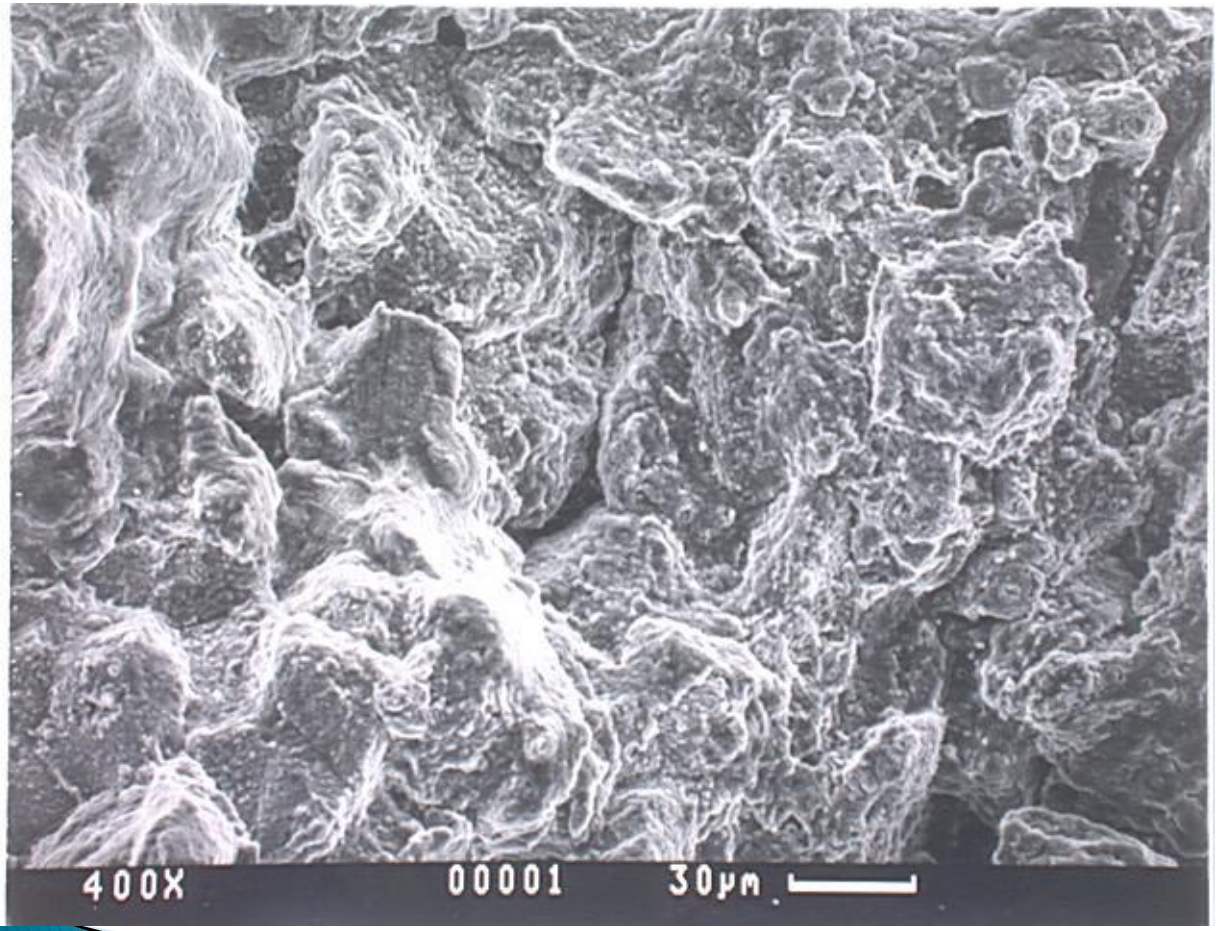


- Burner can lug fracture surface.
- Initiation region noted
- Bands typical of progressive fracture observed.

Metallography

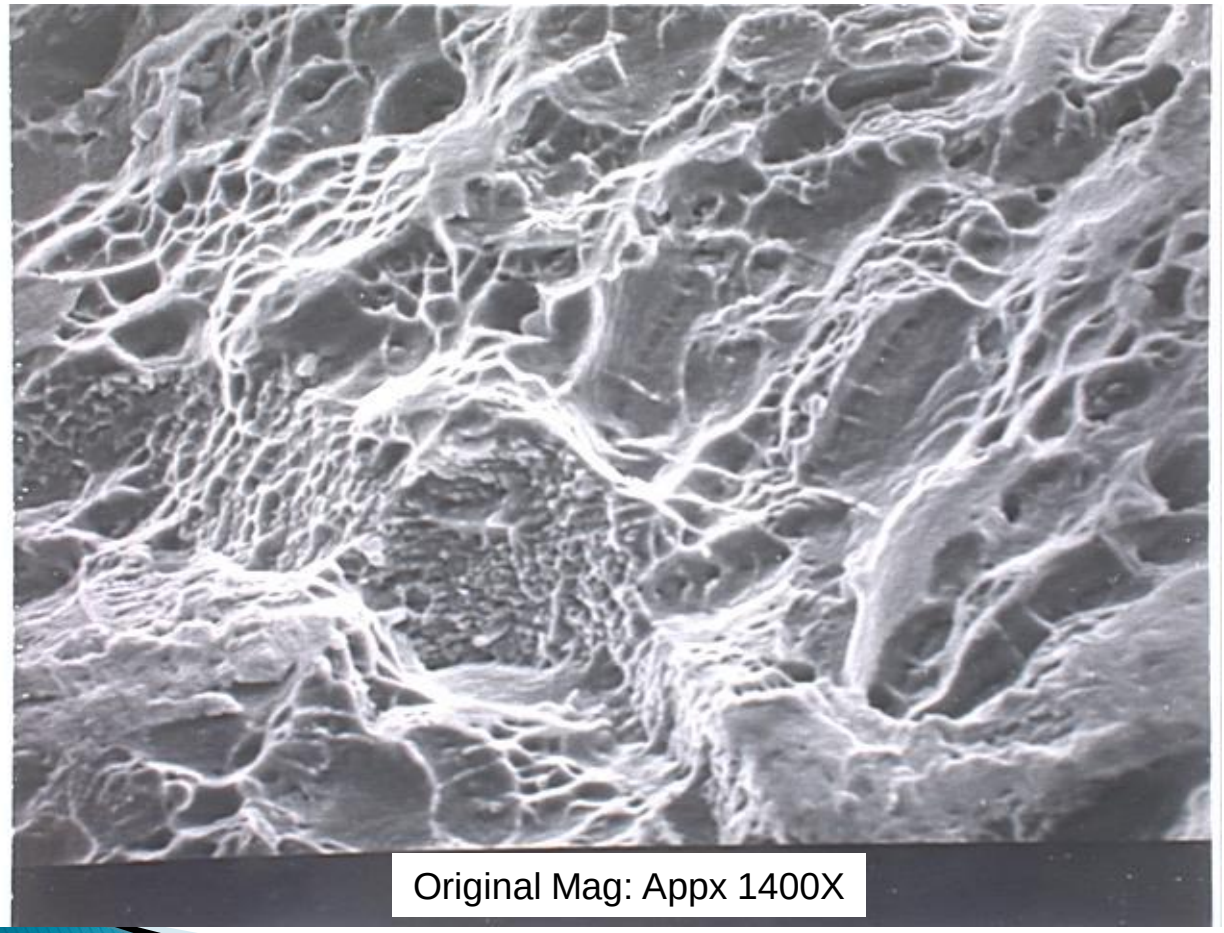
- Metallographic inspection of 1st stg blade used to determine if engine overtemped.
- No microstructural degradation was noted.
- Engine not overtemped

Electron Microscopy



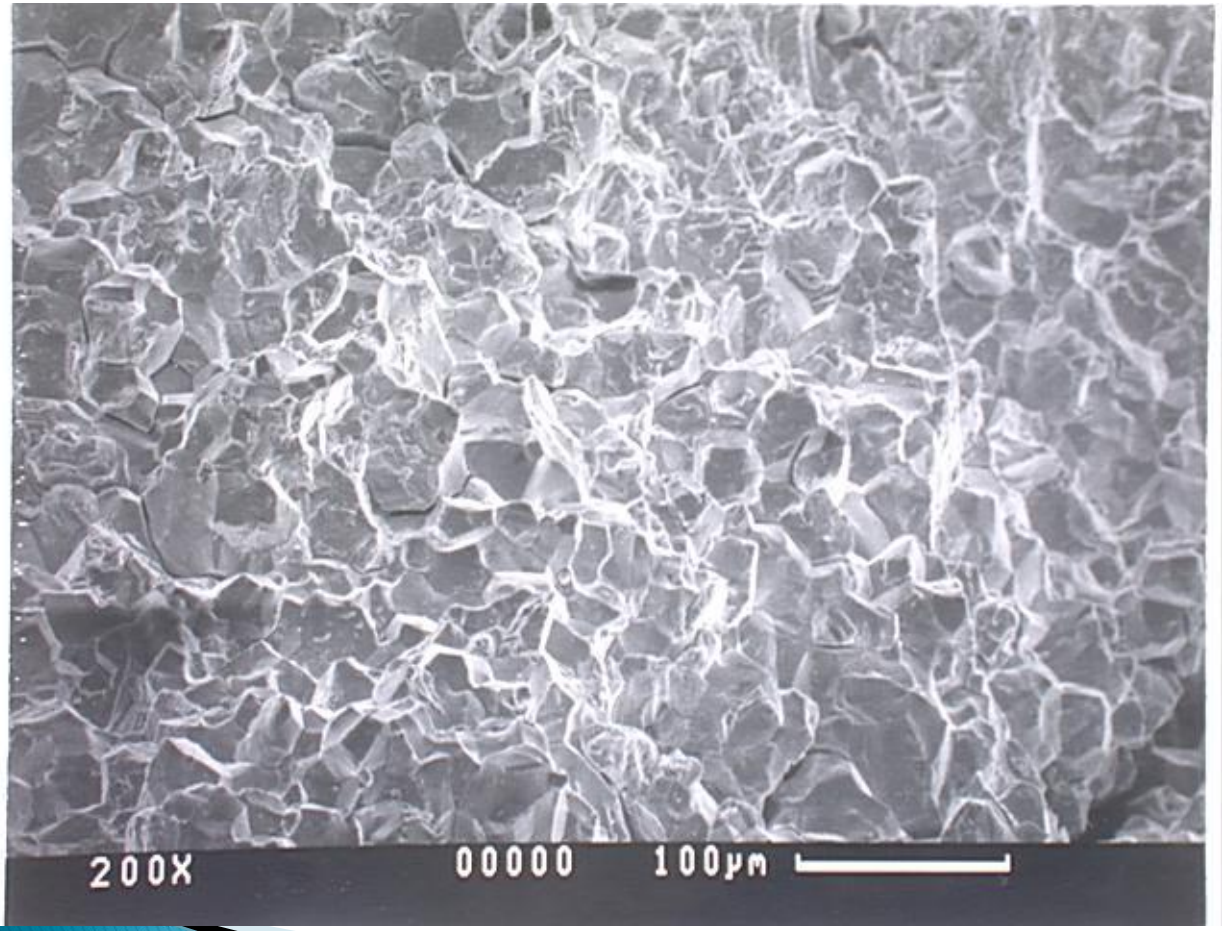
- Scanning Electron Microscope view of Stg 2 blade in area #1.
- Intergranular fracture features noted—creep suspected.
- Surface somewhat oxidized due to normal high temp exposure.

Electron Microscopy



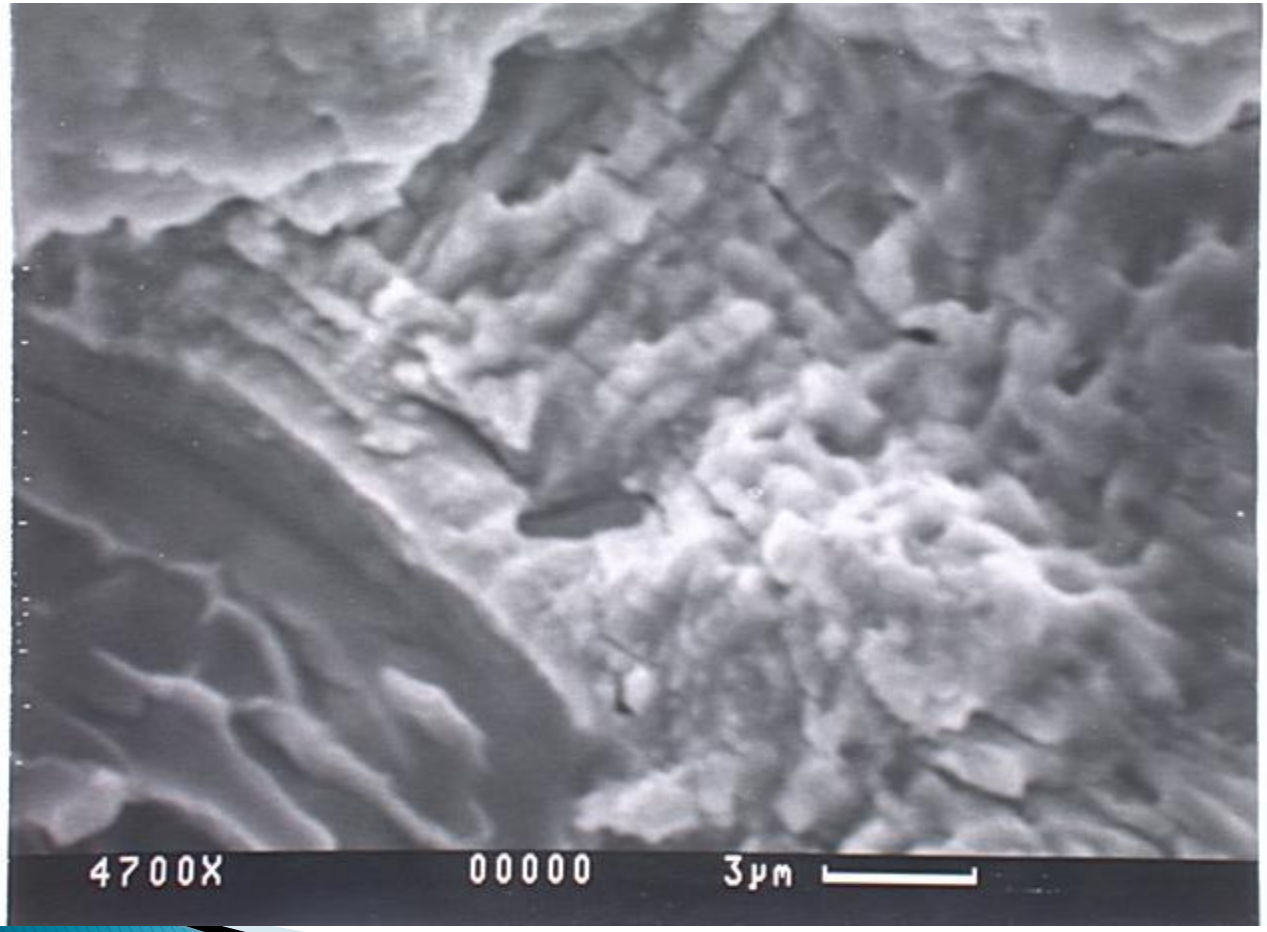
- SEM view of Stg 2 blade in area #2.
- Microvoid coalescence noted—typical of terminal stage overload.
- Surface relatively clean and free of oxidation.

Electron Microscopy



- Fracture surface of support strut.
- Clean intergranular fracture noted.
- Features found to be typical of overload in Waspalloy.

Electron Microscopy



- Image typical of burner can lugs.
- Striations typical of fatigue.
- Fatigue suggests engine vibratioins above normal.

Chemistry and Heat Treatment

- Second stage blade did not meet compositional requirements. Hardness acceptable.
- Second stage blade shape fits high performance engine but has composition of cooler running engine.
- Lugs and struts met compositional and heat treat requirements.

Conclusions

- Second Stg. blade initiated failure sequence. Blade chemistry suitable for standard performance engine but not high performance version.
- Blade failed due to creep/stress rupture.
- Burner can lugs failed due to fatigue resulting from turbine imbalance and vibrations.
- Strut overloaded due to turbine imbalance.
- Damage to other components also consistent with excessive turbine wheel vibrations.
- Failed blade later found to have been experimental and should have been destroyed. Component entered service through non-traditional supply channels.

Story behind the story:

- Failed blade used in failed engine was experimental. The composition was the same as standard performance engine blades. Root was changed to fit high performance engine.
- The composition turned out to be unsuitable for high performance (hotter) engine version. The experiment failed and the blades should have been destroyed. Instead, they were saved. Somehow they entered the supply system much later in time through unknown channels. Standard performance blades failed in service after a few hundred hours.
- This was a supply system malfunction.
- Discovery of this problem saved 7+ engines