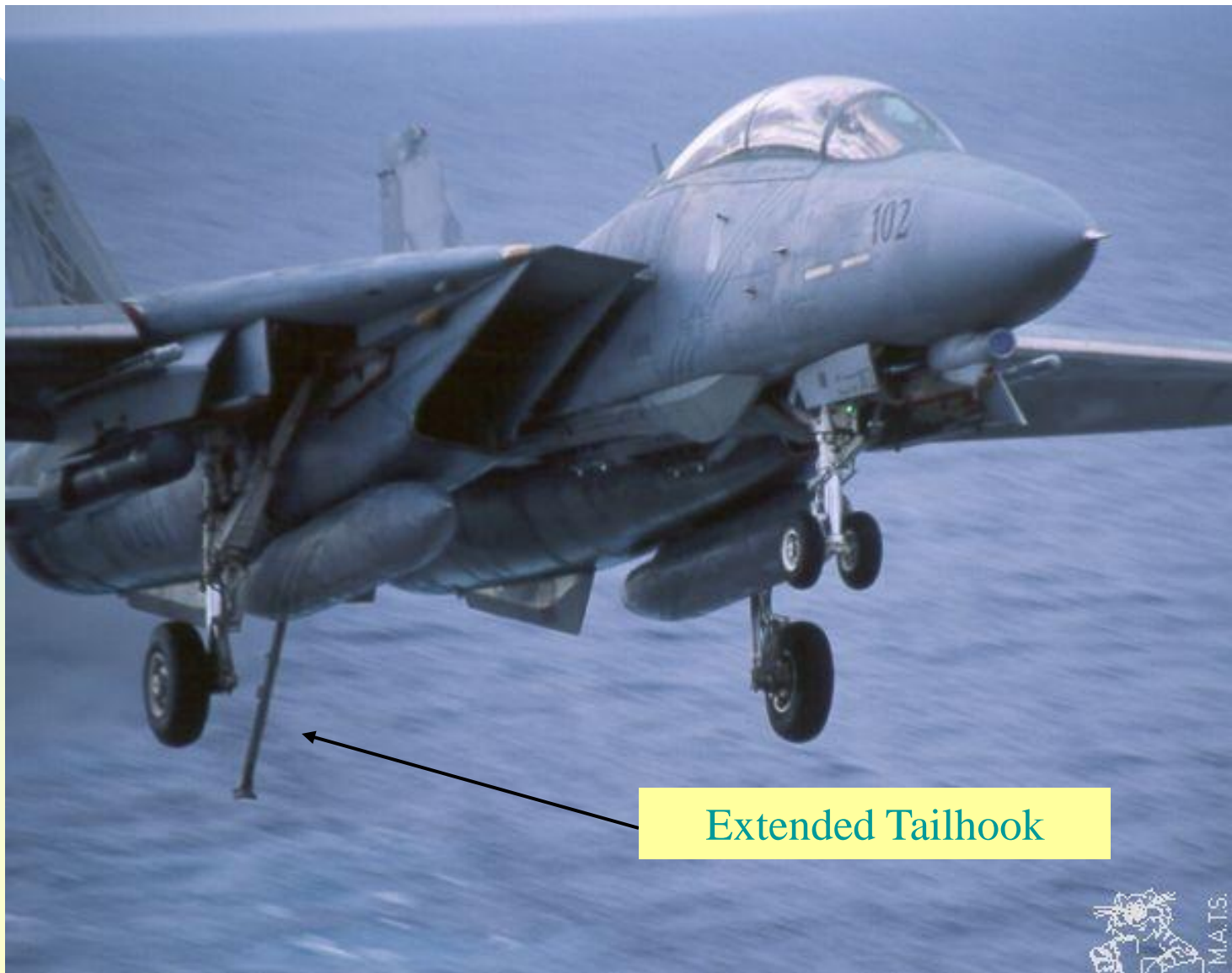


Tailhook Failure

Presented to University of Florida Engineering Students

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This analysis involved the work of a staff of 10+ metallurgists and engineers each addressing a different aspect of the failure including: fractography, rework procedures, fracture mechanics, electron microscopy, materials testing and non-destructive inspection.



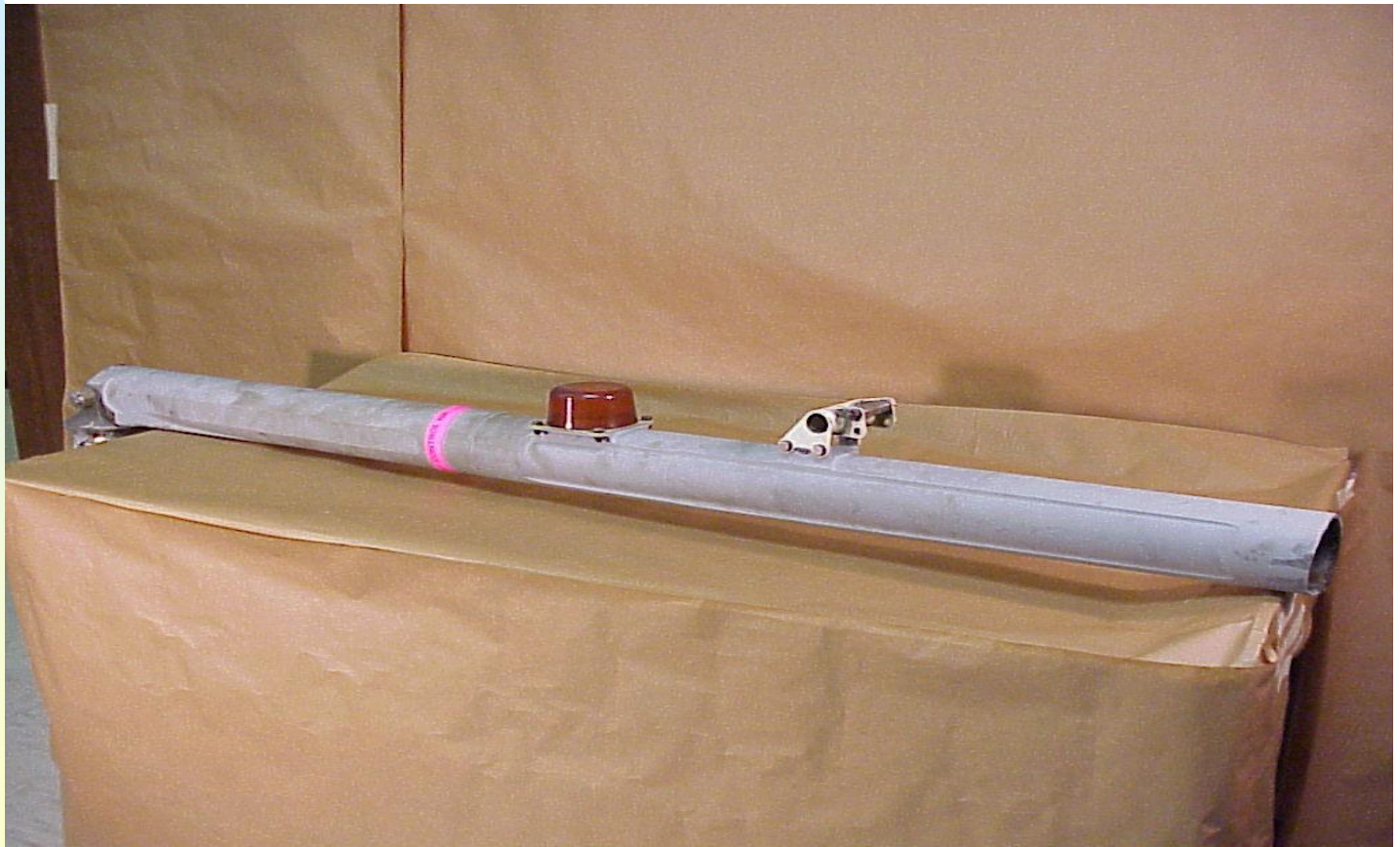
Extended Tailhook



Event

- One side of Tailhook delivered
- Injured pilot and backseater (RIO)
- Loss of Aircraft (captured by NBC News)
- Downed aircraft operations
- My task: fracture mechanics & fractography/testing consultation

Tailhook section, as received.



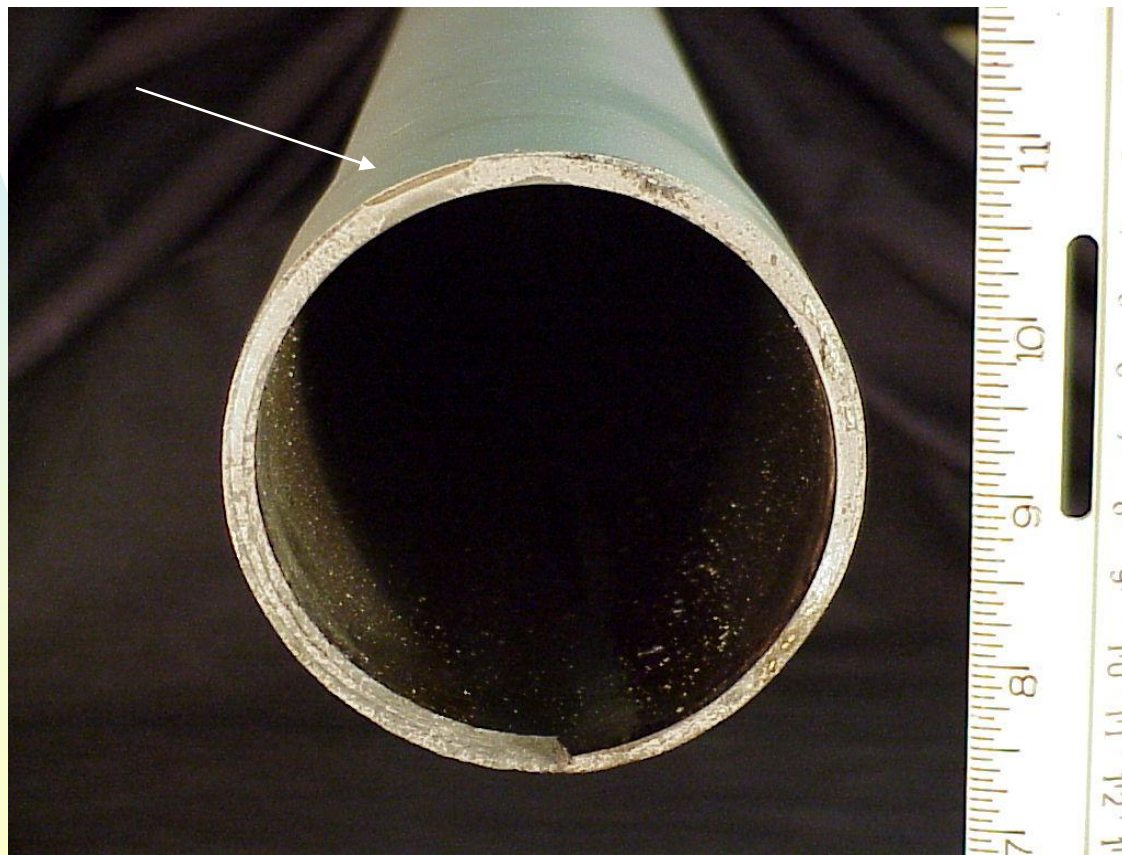
Material/Component Details

- 300 M steel.
- 280-300 Ksi UTS.
- 53-55 HRC
- Forged in 3 sections.
- “Flash” welded.
- Aluminum IVD or sprayed for corrosion protection on exterior.
- Primed and painted.

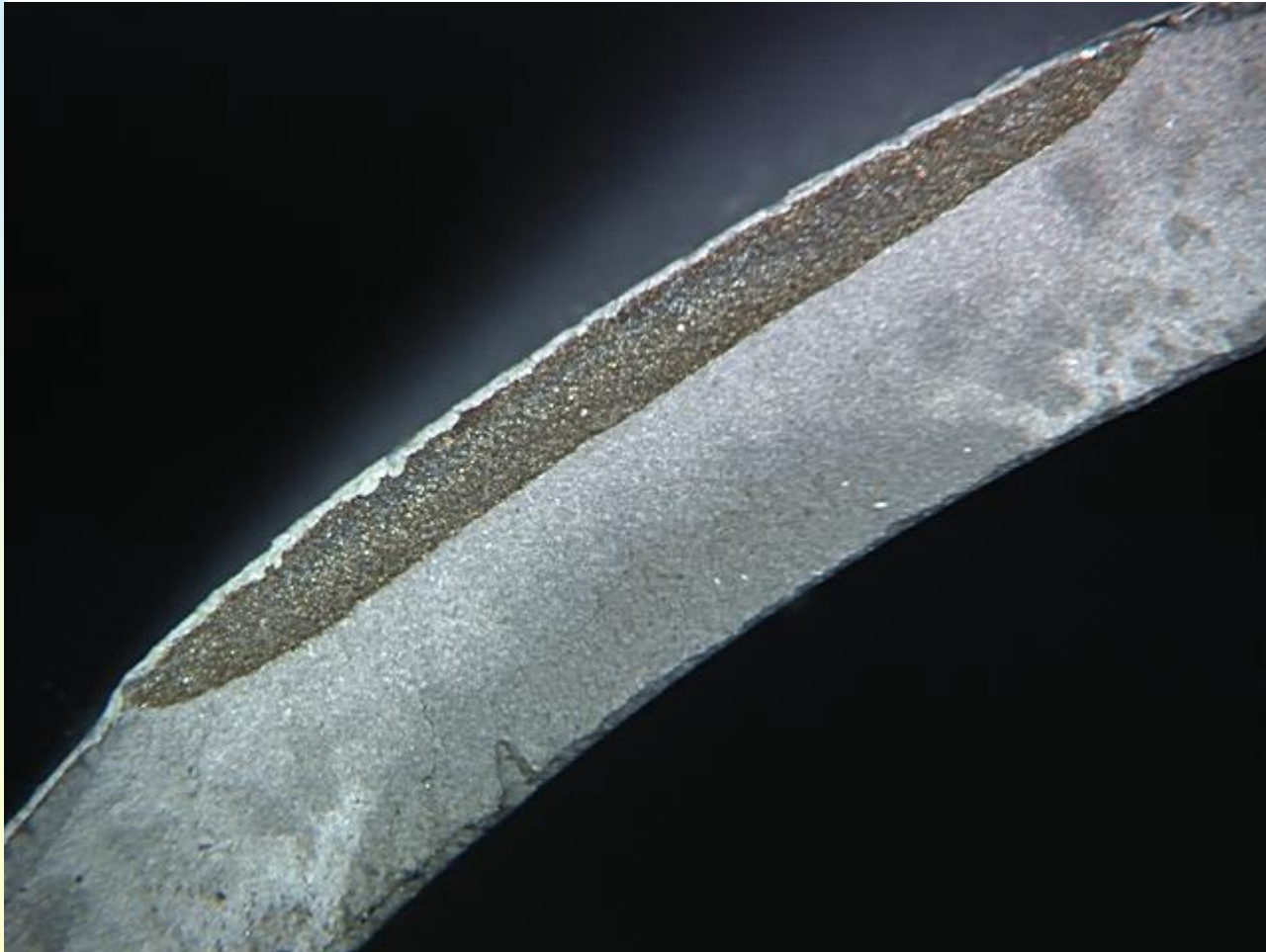
Inside of Tailhook Surface. Normal welded joint & flashing.



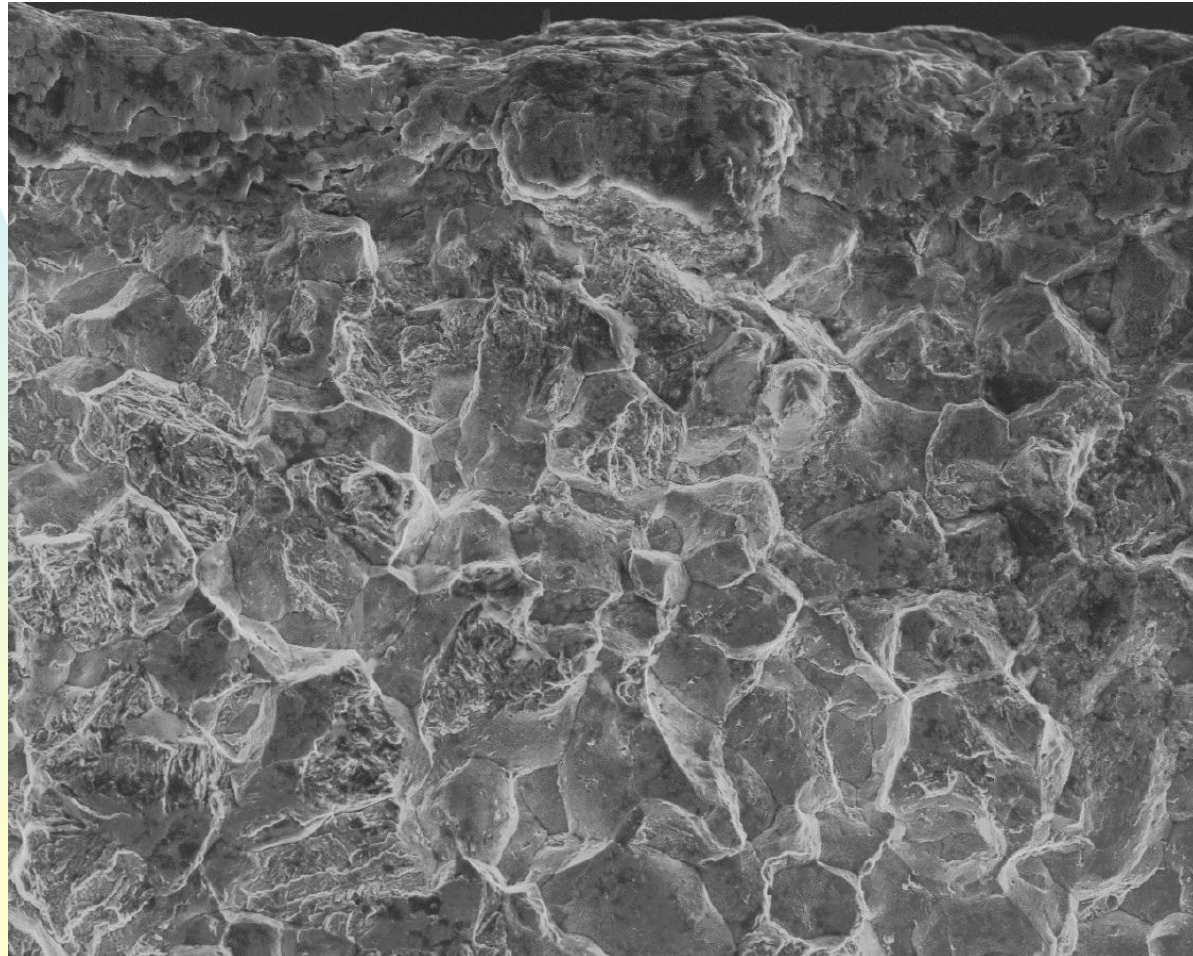
Fracture surface. Defect on O.D. noted



Crescent shaped fracture initiation site (dark). Overload beyond that region.



**Fracture surface under SEM:
Features show a blend of intergranular and
transgranular fracture path**



Failure Mode

- Fracture origin intergranular/transgranular.
- Surface characteristic of environment assisted cracking:
- Possibilities: Stress corrosion cracking (SCC), hydrogen embrittlement, liquid metal embrittlement, others ...
- SCC seemed most plausible until history was examined.

Component History

- History often hard to get.
- This stinger failed on second use after rework.
- Stingers are reworked after each 100 traps.
- Stingers sent to depot level for examination & complete rework.

Where did the flaw come from?

- Suspected hydrogen generated during Al stripping process.
- Suspected residual stresses from unintentional impact helped to absorb hydrogen into area.
- Tested this theory in the laboratory. Proven plausible
- Used samples of AISI4340 in reverse bending to simulate component loading—they failed early.

Conclusions

- Fracture attributed to hydrogen embrittlement during rework.
- Sodium hydroxide stripping of aluminum coating determined in the laboratory to produce sufficient hydrogen to initiate fracture.

Post Failure Analysis Actions

- Cryogenic testing instituted to find small cracks.
- New rework NDI procedures in place.
- NDI procedures developed for operating squadrons.
- All assets inspected.
- Baking for HE relief 375F/24 hr instituted.
- Monitoring continues.
- No additional failures in 8+ years