



Introduction to Materials Science and Engineering

Chapter 8. Failure



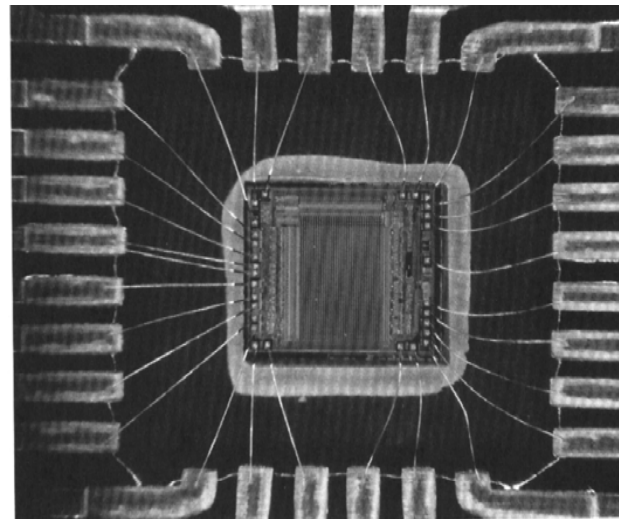
Failure --- Issues



Ship-cyclic loading
from waves



Hip implant-cyclic
loading from walking



Computer chip-cyclic
thermal loading

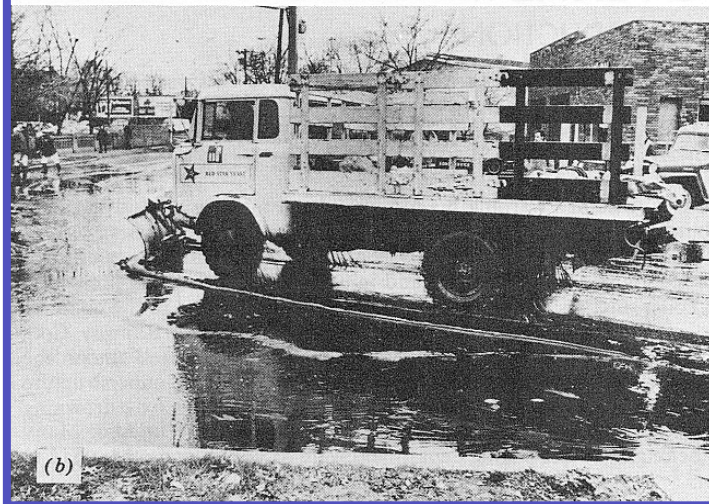




Failure: examples

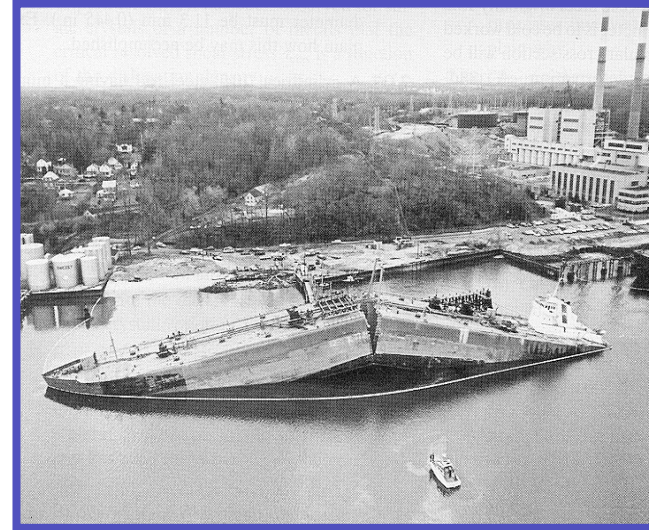


(a)

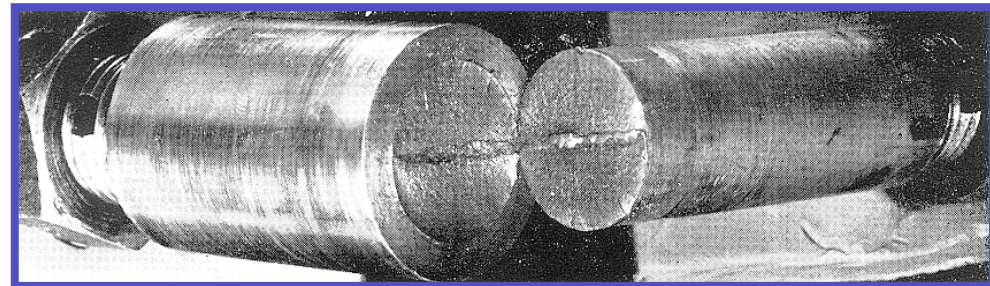


(b)

Fractured T-2 tanker, the S.S. Schenectady, which failed in 1941. Brittle fracture & crack propagated around its girth.



Sudden rupture of molasses tank (Bellview, N.J.) 03/22/73



Broken cabin bolt from an elevator.

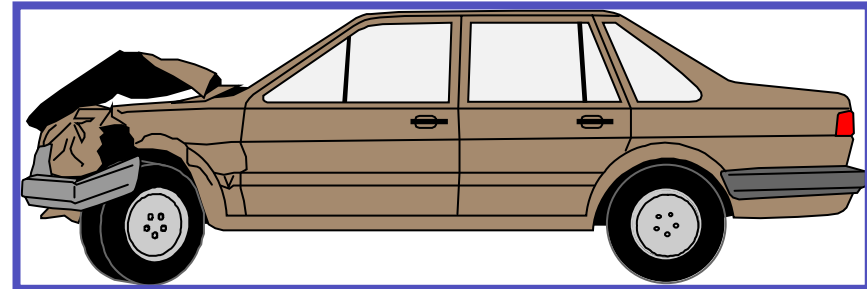
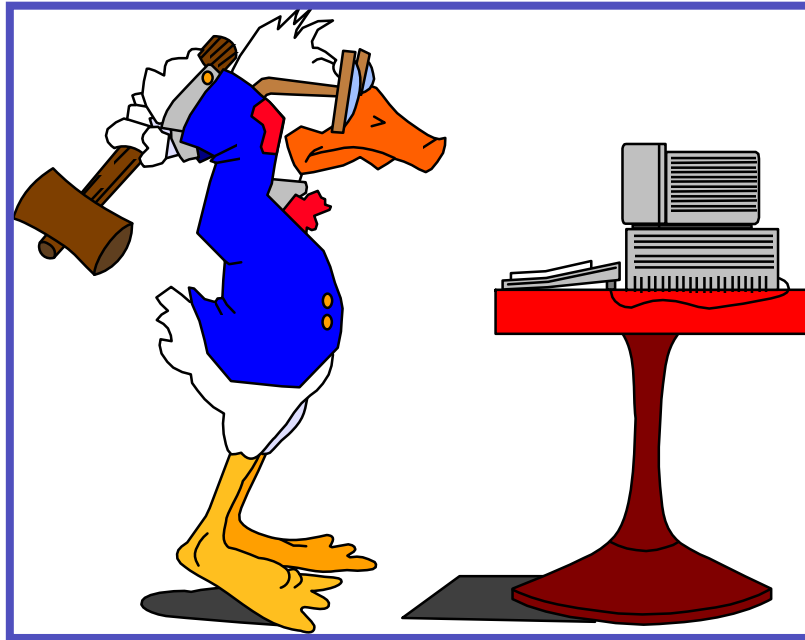




Failure Modes



- ❑ Need to understand various failure modes and mechanisms, e.g., **fracture, fatigue, and creep.**



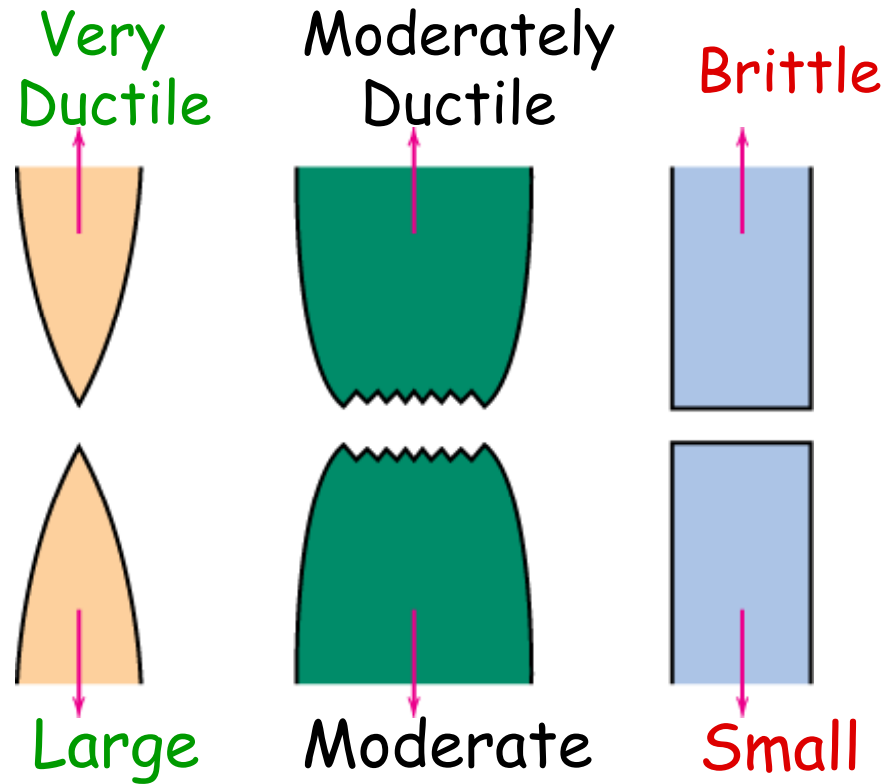


Classification



Fracture behavior:

Ductile fracture is usually desirable!



Ductile: Warning before fracture (occurs with plastic deformation)

Brittle: No warning (Little or no plastic deformation, catastrophic)



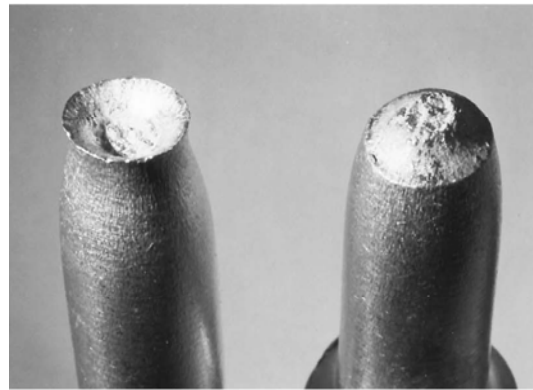


Ductile vs. Brittle Failure



- **Ductile** failure:
 - one piece
 - large deformation

- **Brittle** failure:
 - many pieces
 - small deformation



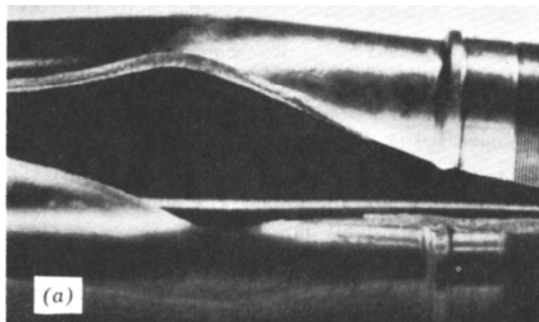
(a)

cup-and-cone fracture



(b)

brittle fracture



(a)



(b)

Failure of a Pipe





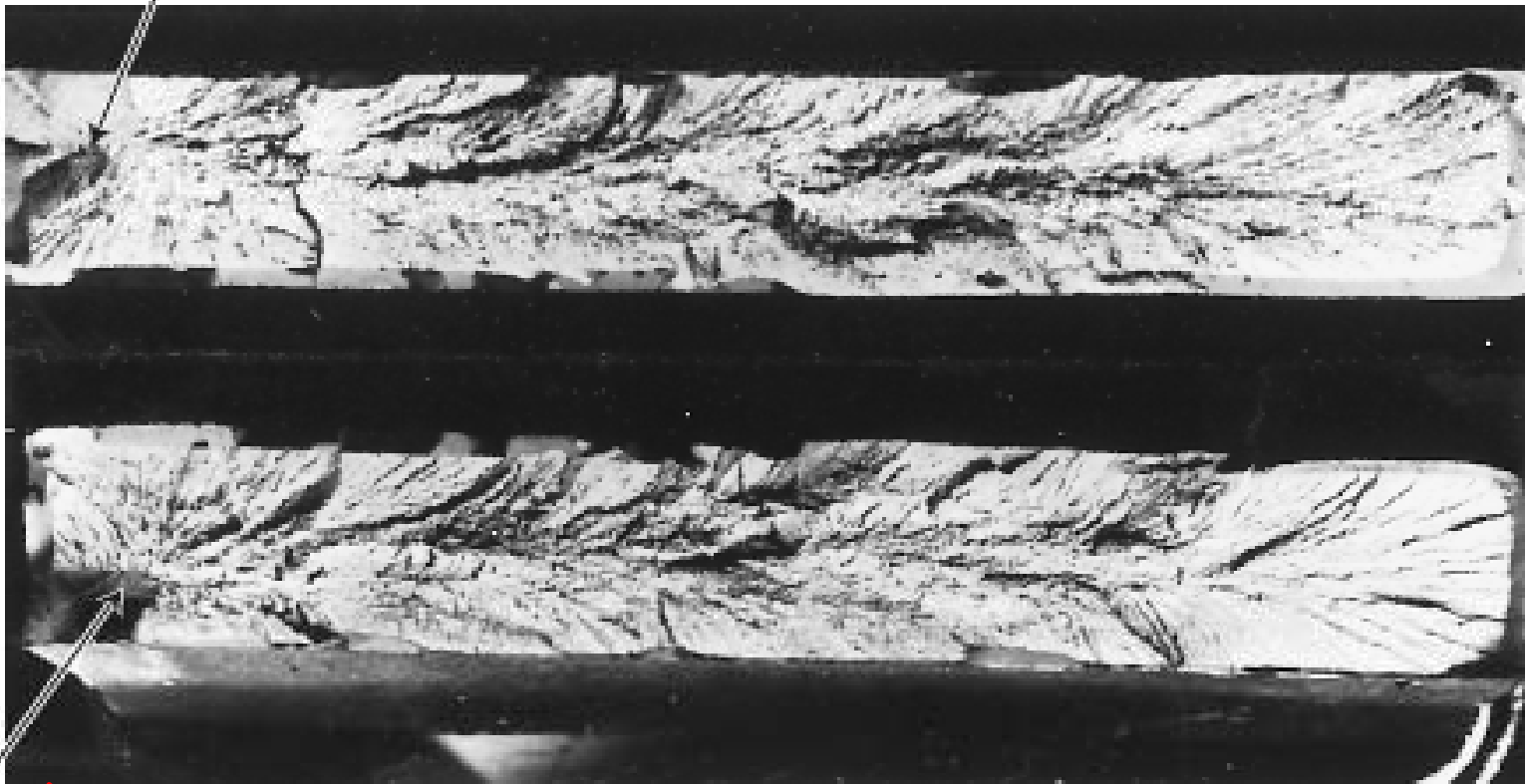
Brittle Failure



- Relatively flat fracture surface.



Arrows indicate point at which failure originated.



(Fig. 8-5)

(a)

(approximately actual size)

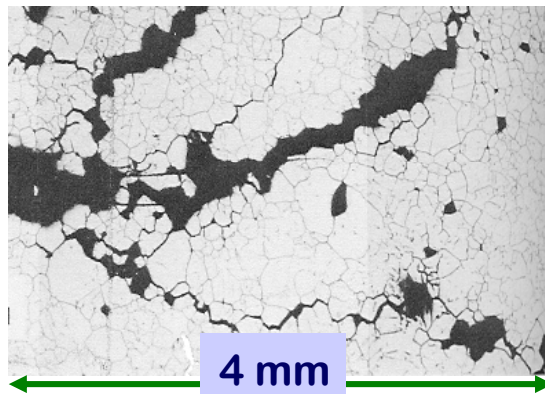




Brittle Fracture Surfaces

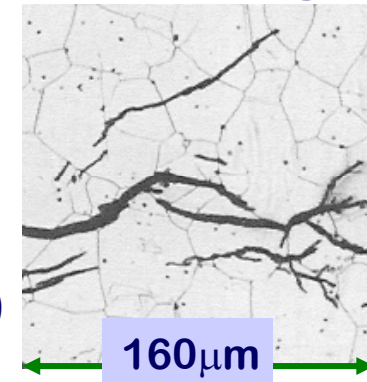


Intergranular
(between grains)

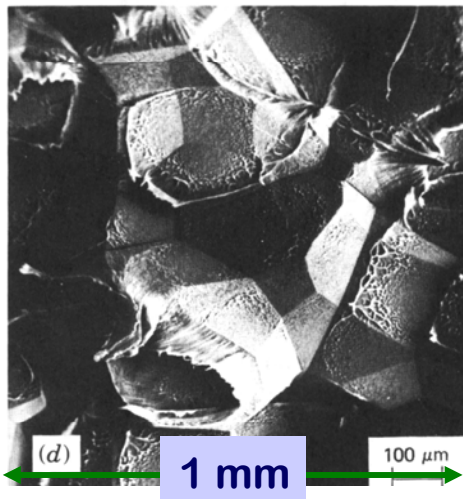


304 S. Steel
(metal)

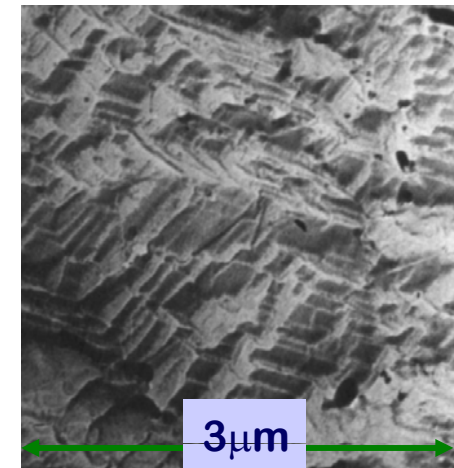
Intragranular
(transgranular, within grains)



316 S. Steel
(metal)



Polypropylene
(polymer)



Al Oxide
(ceramic)

