The University of Tennessee at Martin

MARTIN School of Engineering

Mechanical Properties of Ductile Metallic Materials

Lecture 1

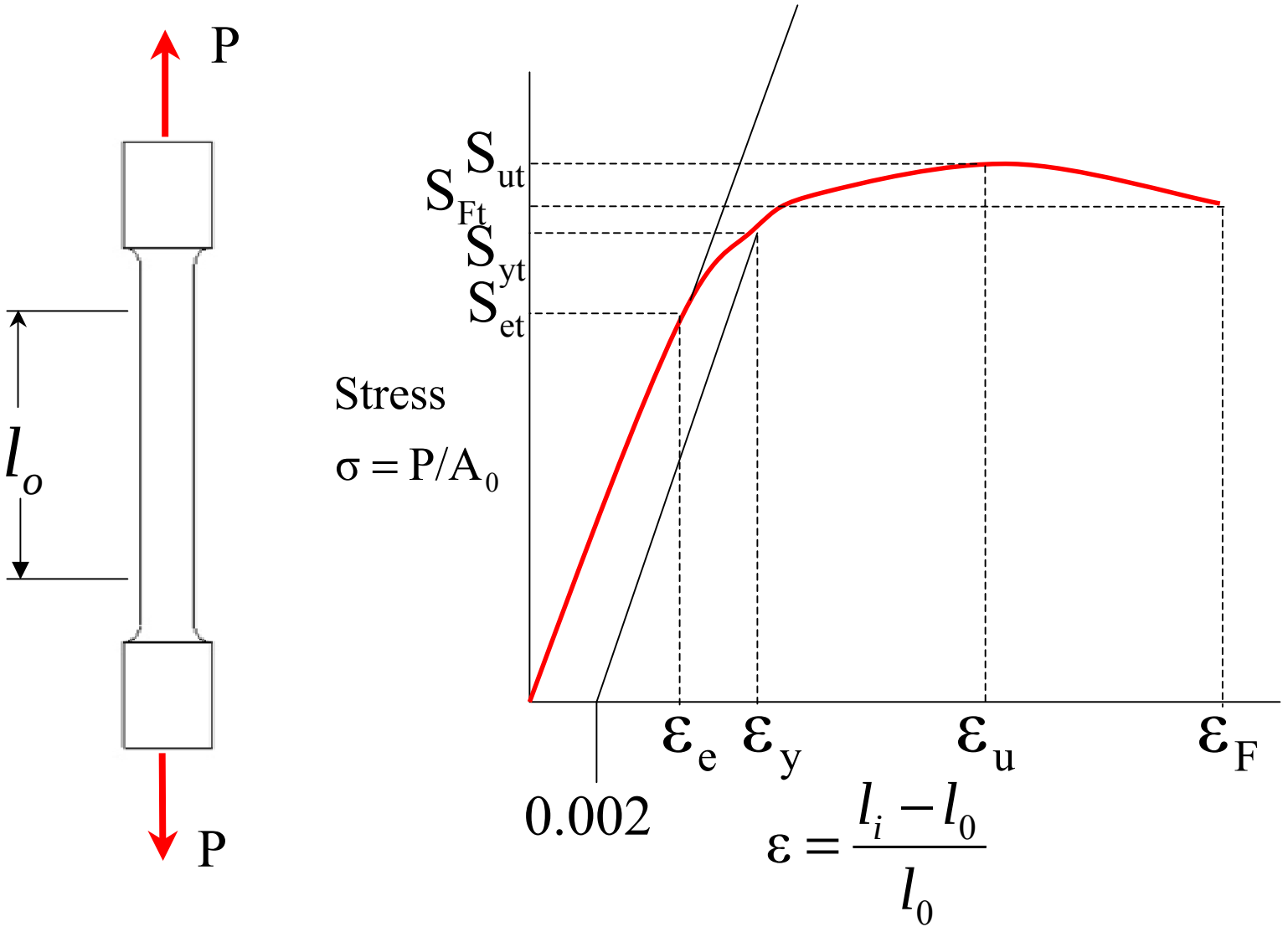
Engineering 473

Machine Design

MARTIN

Mechanical Properties

(Static Strength – Monotonic Elongation)



Mechanical Properties

(Static Strength Nomenclature)

Subscripts

y ≡ 0.2% offset yield

u ≡ ultimate

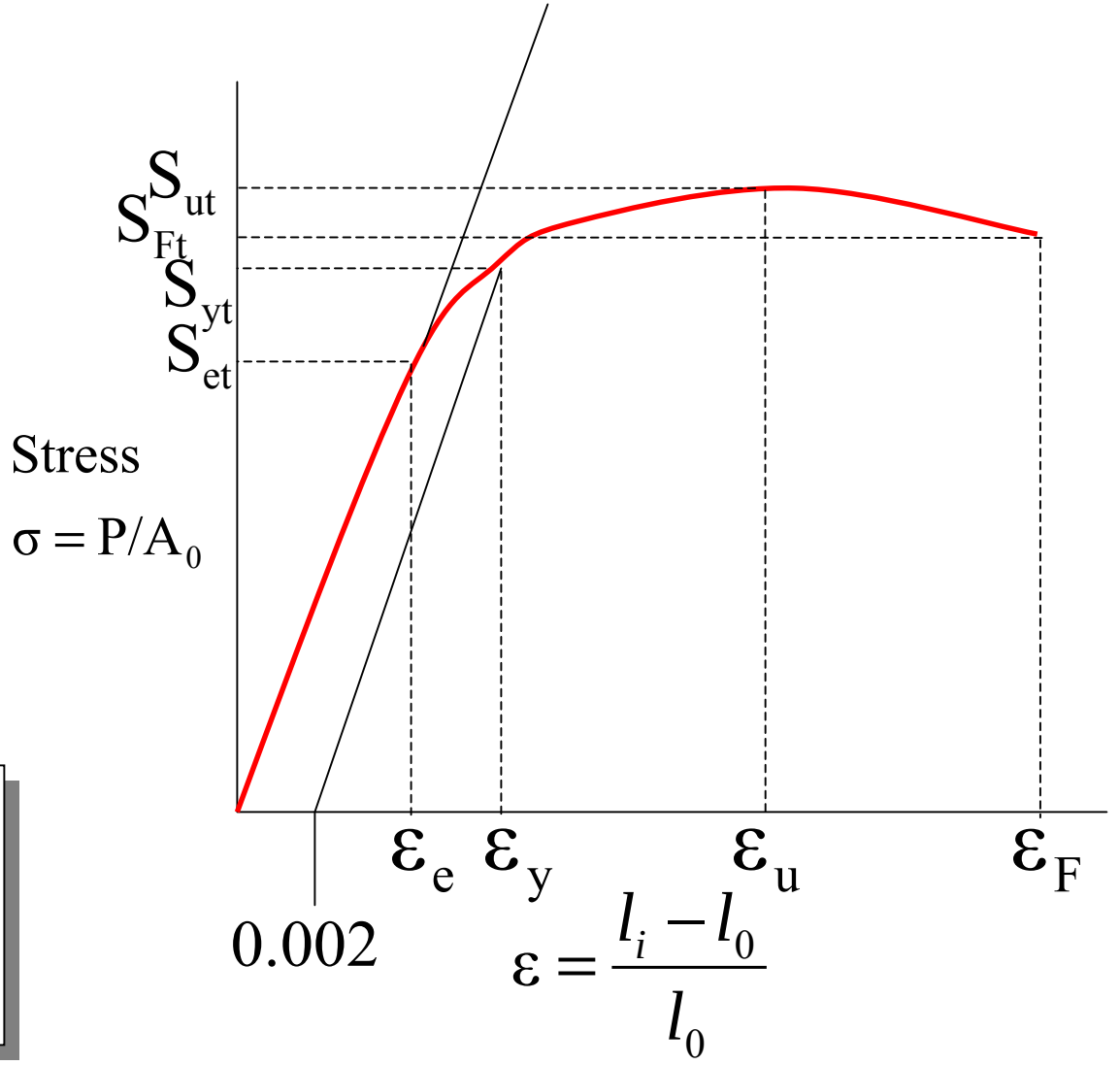
e ≡ elastic

F ≡ fracture

t ≡ tension

c ≡ compression

S_{yt} & S_{ut} are generally given in handbooks.



Mechanical Properties
(True Stress & True Strain)

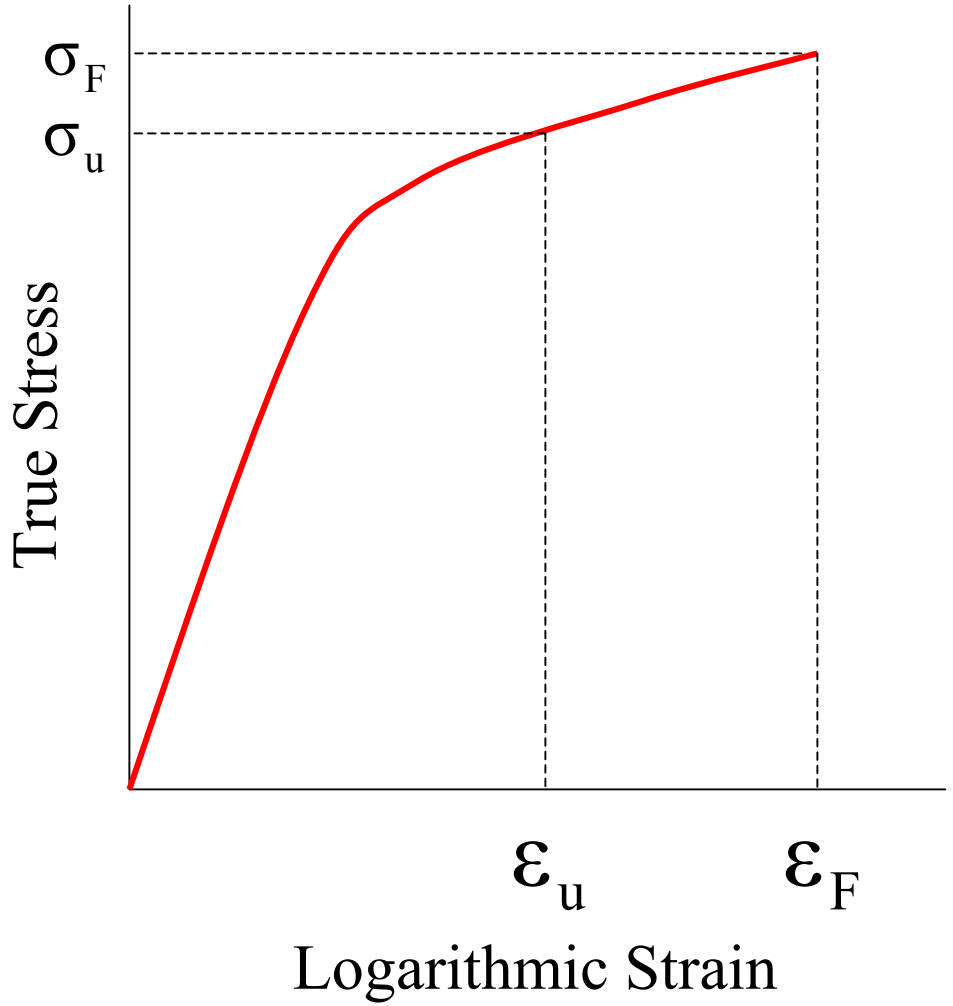
Logarithmic Strain

$$d\varepsilon = \frac{dl}{l}$$

$$\varepsilon = \int_{l_o}^{l_i} \frac{dl}{l} = \ln \frac{l_i}{l_o}$$

True Stress

$$\sigma = \frac{P}{A_i}$$



Mechanical Properties
(Example Data)

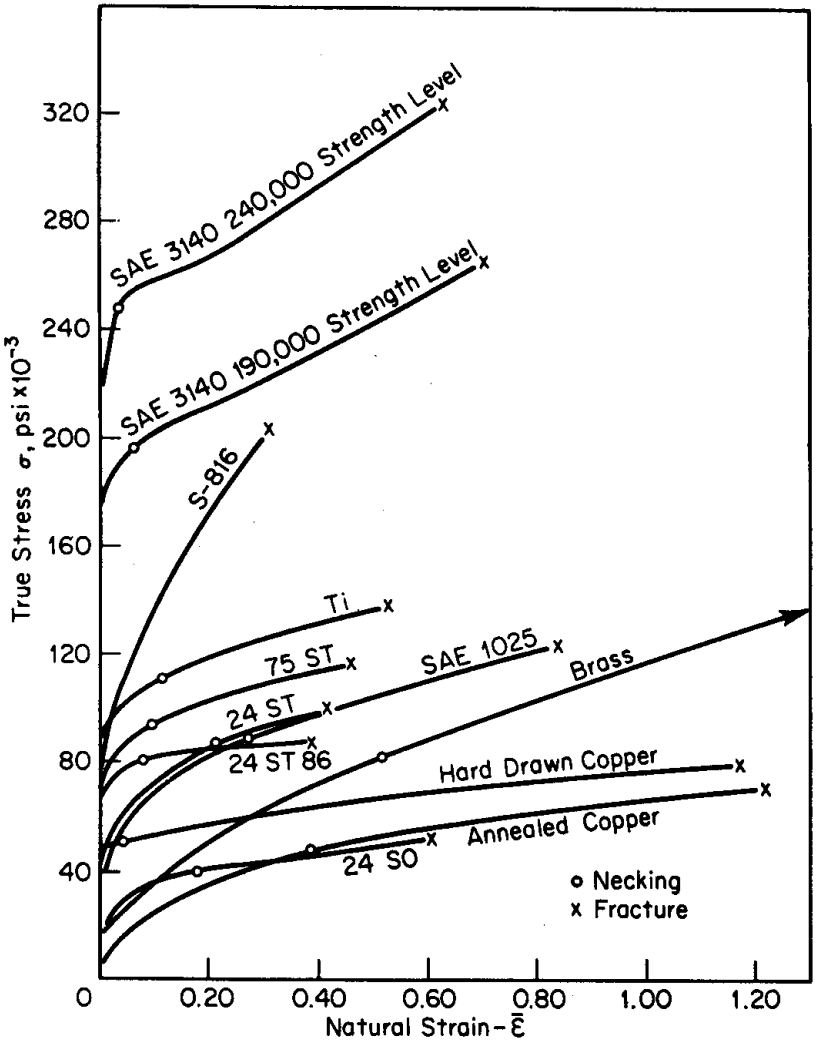
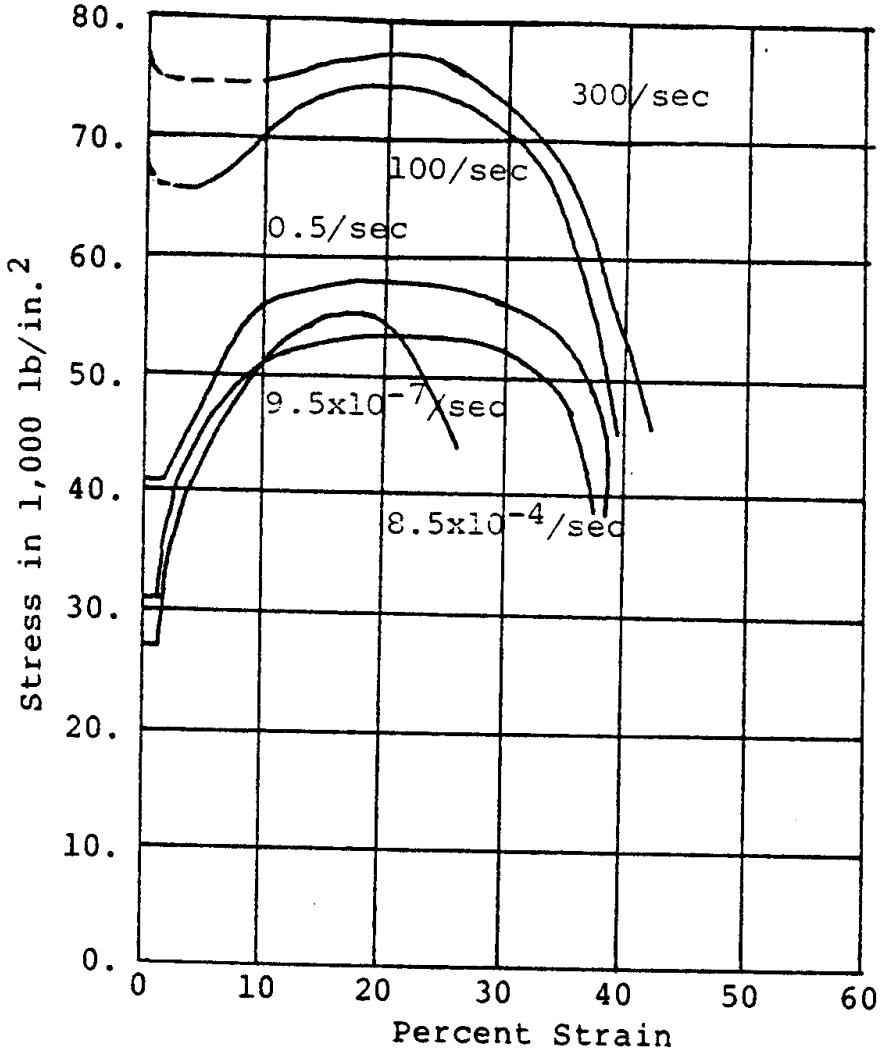


FIGURE 2.2.2 True stress–strain curves for several materials.

True Stress-Logarithmic Strain Curves for Several Metallic Materials

H. Schwartzbart, W.F. Brown, Jr., "Notch-Bar Tensile Properties of Various Materials and their Relation to the Unnotch Flow Curve and Notch Sharpness," Trans. ASM, 46, 998, 1954.

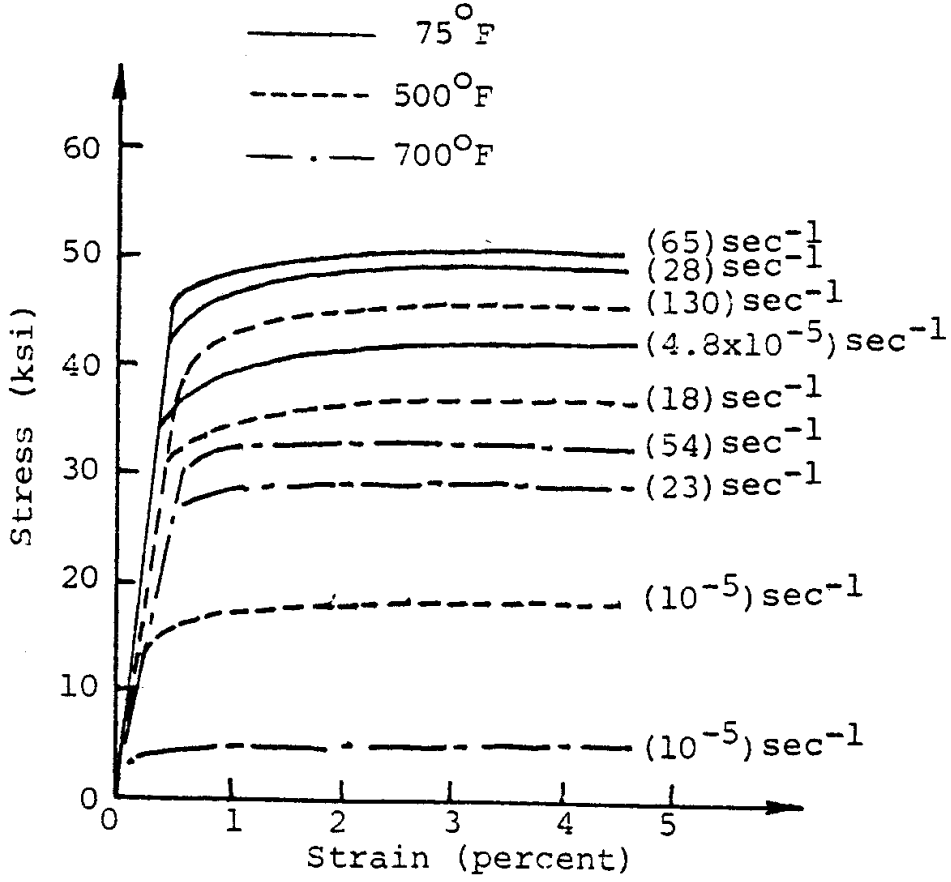
Mechanical Properties
(High Strain Rates)



Stress-Strain Curves for Mild Steel at Room Temperatures at Various Rates of Strain

Manjoine, M.J., "Influence of Rate of Strain and Temperature on Yield Stresses of Mild Steel," Journal of Applied Mechanics, 11(A):211-218, December 1944.

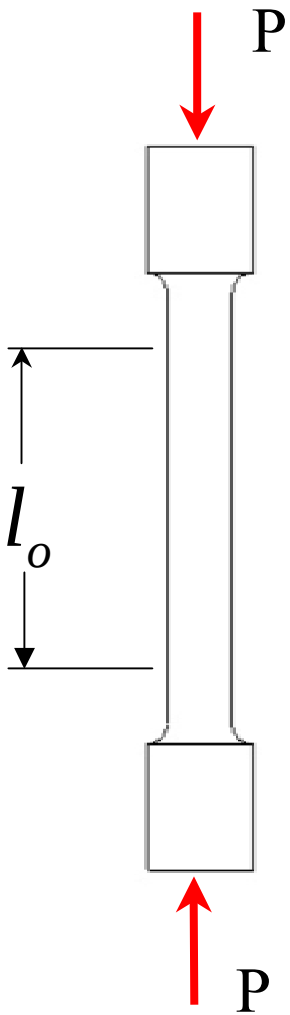
Mechanical Properties
(High Strain Rates & High Temperatures)



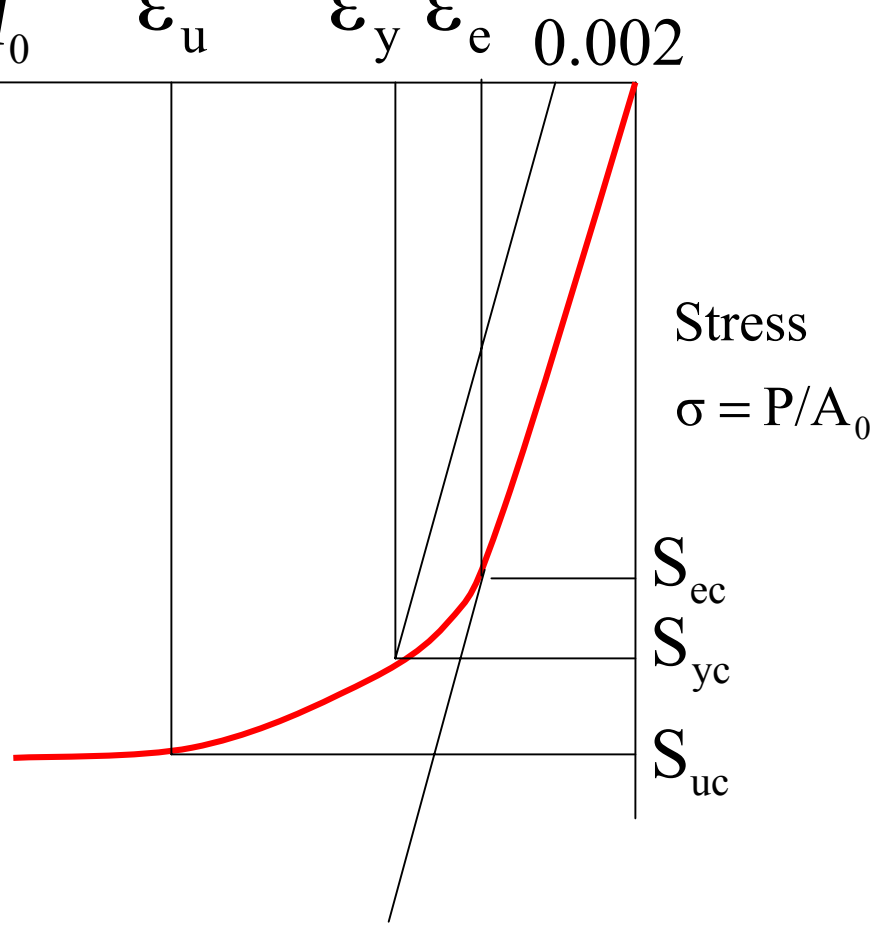
Experimental Data for 6061-T6 Aluminum

Hoge, K.G., "Influence of Strain Rate on Mechanical Properties of 6061-T6 Aluminum under Uniaxial and Biaxial States of Stress," Experimental Mechanics, 6:204-211, April 1966.

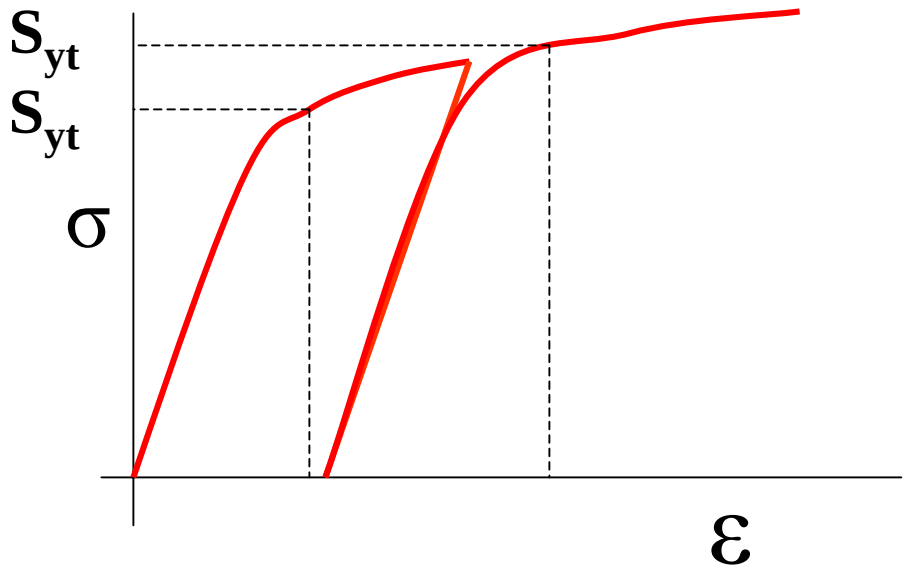
Mechanical Properties
(Monotonic Compression)



$$\varepsilon = \frac{l_i - l_0}{l_0}$$



Mechanical Properties
(Work Hardening or Cold Working)

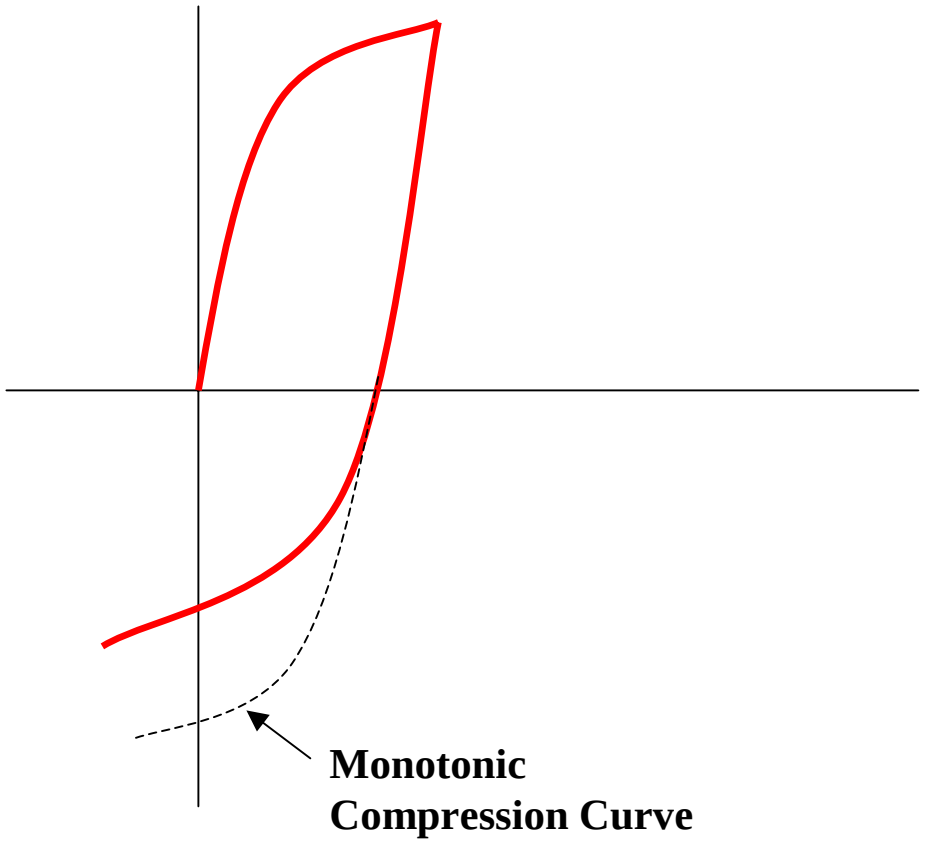


Mechanical Properties
(Reverse Loading)

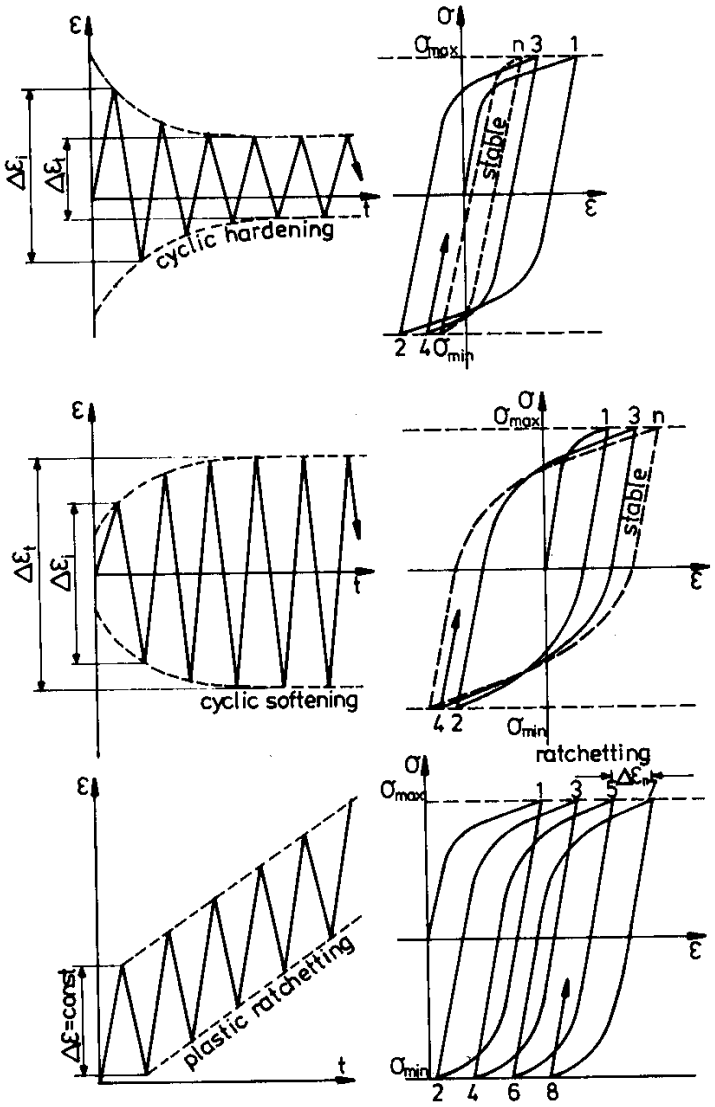
Bauschinger's Effect

Yield stress in compression may decrease after an initial load application past the tension yield point.

This phenomena is an important topic in plasticity theory.



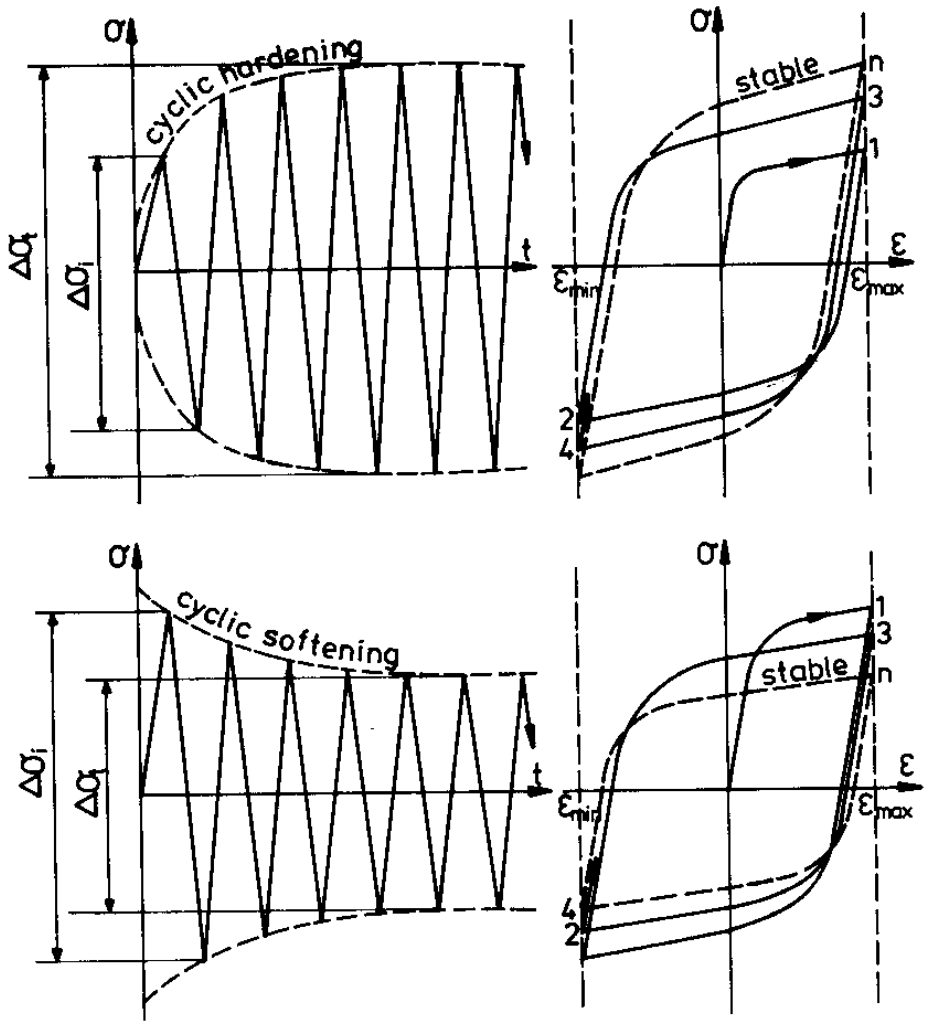
Mechanical Properties
(Stress Controlled Cyclic Loading)



Materials can demonstrate three characteristics: 1) cyclic hardening, 2) cyclic softening, and 3) cyclic strain accumulation (ratcheting).

Skrzypek, J.J., Plasticity and Creep: Theory, Examples, and Problems, CRC Press, 1993, 130.

Mechanical Properties
(Strain Controlled Cyclic Loading)

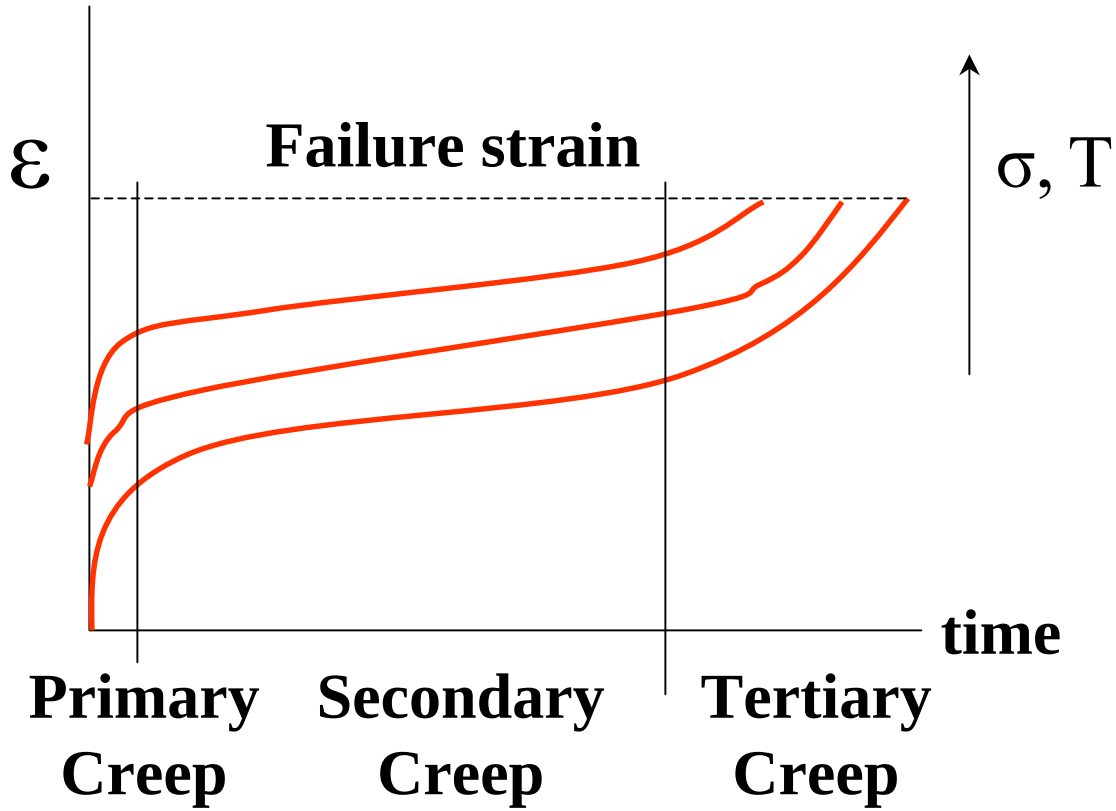


Materials can demonstrate two characteristics: 1) cyclic hardening and 2) cyclic softening.

Skrzypek, J.J., Plasticity and Creep: Theory, Examples, and Problems, CRC Press, 1993, 130.

Mechanical Properties
(Creep)

Creep is most pronounced at high temperatures. It may also occur at room temperatures when the stress level is close to the yield strength.



Typical curves obtained from constant stress/temperature tests.

Summary

The strength of ductile metallic materials is dependent on several parameters.

1. Load Direction (Tensile or Compressive)
2. Strain Rate (Slow or Fast)
3. Temperature (Hot or Cold)
4. Load History (Monotonic or Cyclic)
5. Fabrication Process (Next Class)

- Metals are complex materials when used throughout their total response envelope.
- Fortunately their elastic properties are most commonly used.

Assignment

Read pages 25-34 in Mott.