ME 330: Engineering Materials

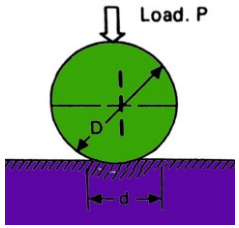
Lab - 1

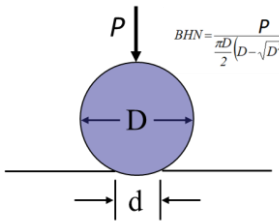
Hardness and Compression Testing

Overview

Hardness Test

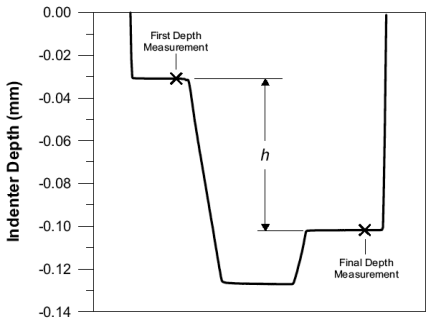
Brinell



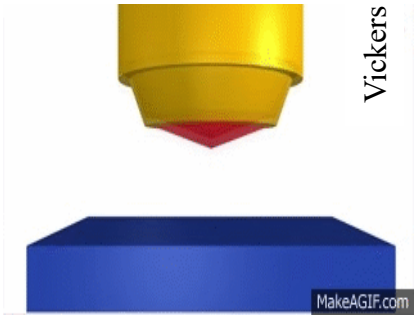


Rockwell

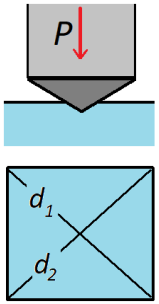
Rockwell



Vickers



Vickers



Compression test

Hardness Testing

Hardness: Measure of the "ability to resist *plastic* deformation"

Idea: Relate hardness to other mechanical properties (Specially strength and wear resistance)

Advantage: Evaluate mechanical properties without destroying sample

Mohs Hardness Scale

Scratch test.

1812 by Friedrich Mohs, German mineralogist.

Relative hardness with common materials.

If the test material scratches the standard material, it is at least as hard as the standard.

Very useful for classification of minerals and geologic materials.

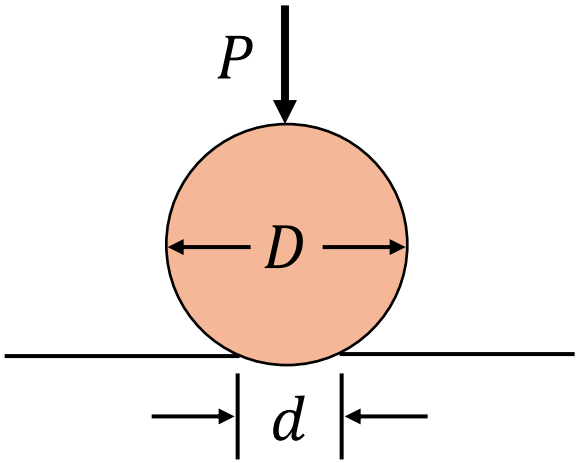
Little information in engineering terms – specifically strength.

Mohs No.	Material
10	Diamond
9	Corundum
8	Topaz
7	Quartz
6	Orthoclase Feldspar
5	Apatite
4	Fluorite
3	Calcite
2	Gypsum
1	Talc

Brinell Hardness

J.A. Brinell, Swedish engineer, 1900

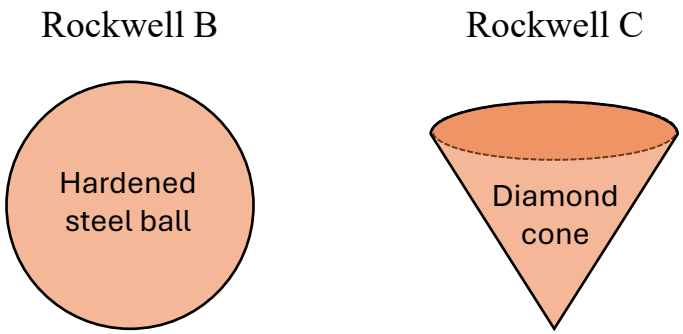
Press a steel sphere into a surface with a known load and then measure the amount of plastic deformation.

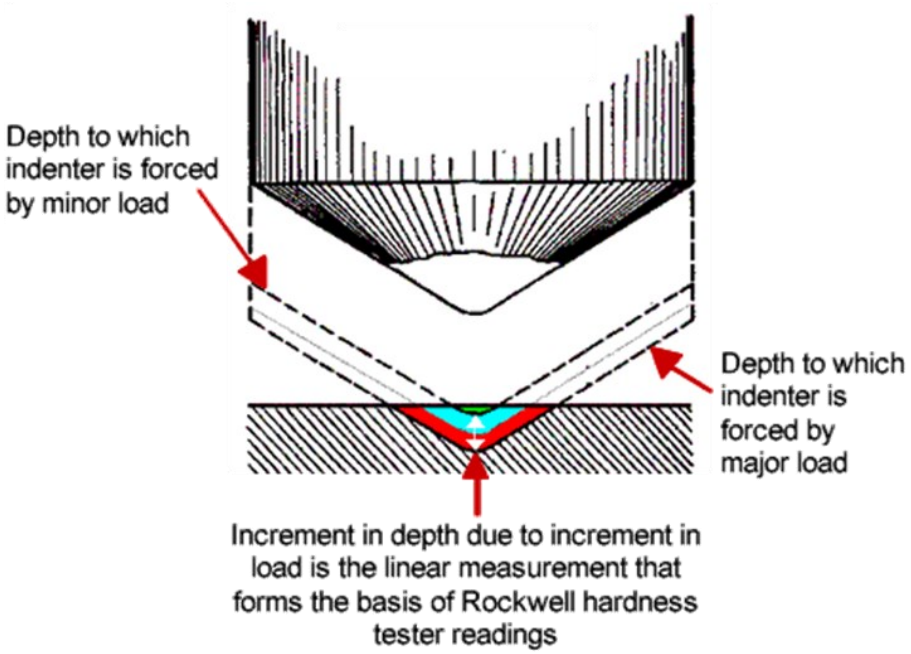


$$BHN = \frac{P}{\frac{\pi D}{2}\left(D - \sqrt{D^2 - d^2}\right)}$$

- Large, hard spherical indenter
- Relatively large loads (500-3000 kg)
- Hold load for 15 sec
- Produces a large indentation on surface
- Manually measure indentation with calibrated microscope
- Continuous scale for all materials
- Takes average hardness over many grains

Rockwell Hardness





- Many scales are used.
- Two (02) most used scales are:

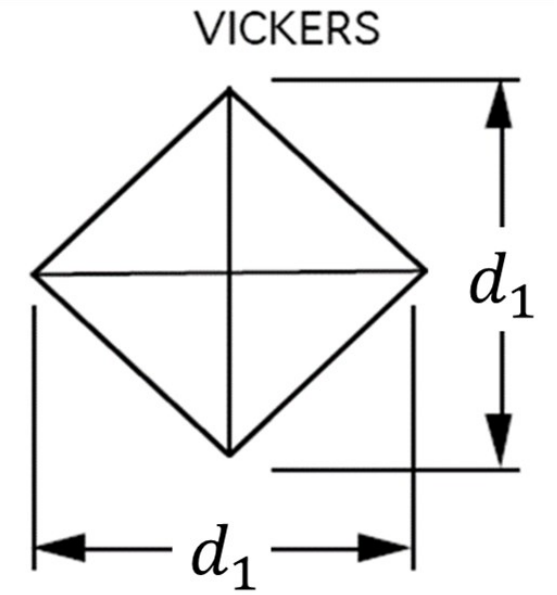
  Rockwell B: soft materials
  - Spherical indenter (1/16 inch)
  - Medium load (100 kg)
  - Small indention

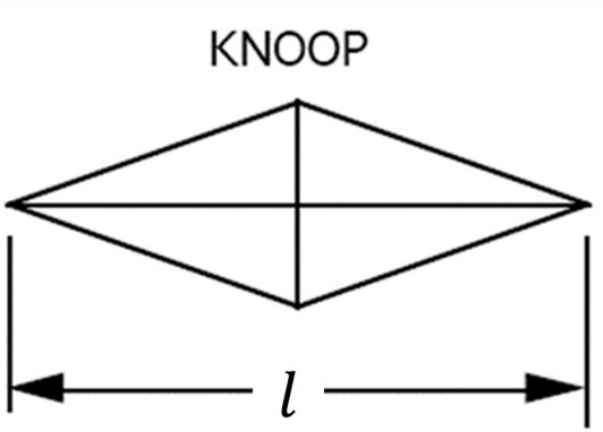
  Rockwell C: hard materials
  - Conical indenter
  - Slightly higher loads (150 kg)
  - Very small indention

- Measures differential penetration depth (initial preload, 10 kg)

- Machines are automated
- Scale limits
  - 0-100 HRB
  - 20-80 HRC
  - If out of range, switch test

Vickers and Knoop Microhardness





$$VHN = \frac{1.85\ M}{(d_1)^2}$$

$$KHN = \frac{14.2\ M}{(l)^2}$$

Correlations and Conversions

- Brinell Hardness number (HB) is approximately related to tensile strength by:

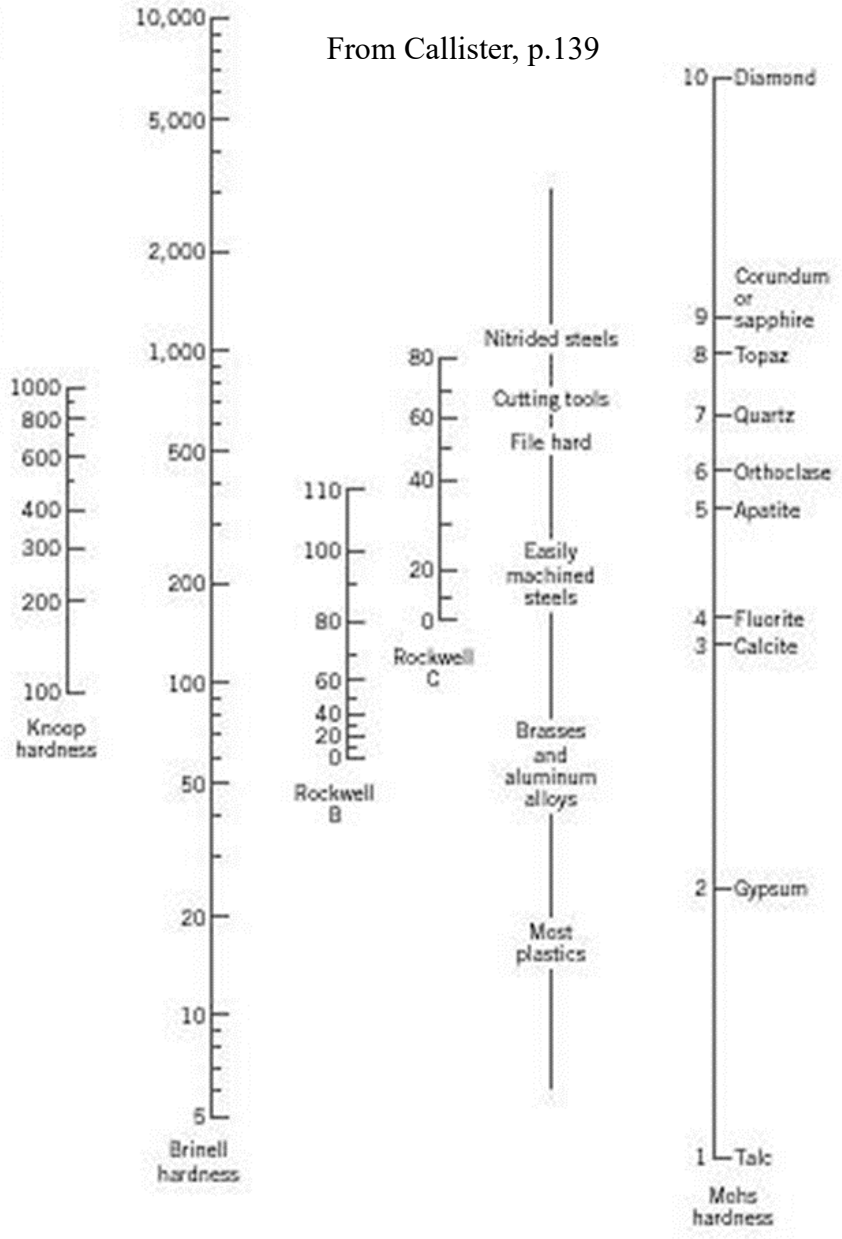
$$\sigma_{UTS} = 3.45 \times BHN \quad \text{(MPa)}$$
$$\sigma_{UTS} = 0.5 \times BHN \quad \text{(ksi)}$$

  - Works only for low–C steels
  - Empirical relation

- Conversion to another scales: *Approximately*

Why Brinell has the longest scale?

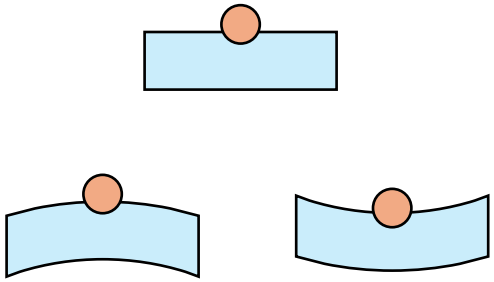
From Callister, p.139



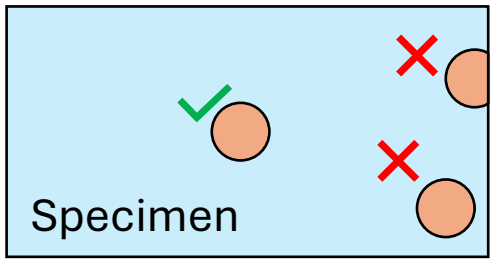
Notes on Hardness Testing

All scales are designed for flat specimens

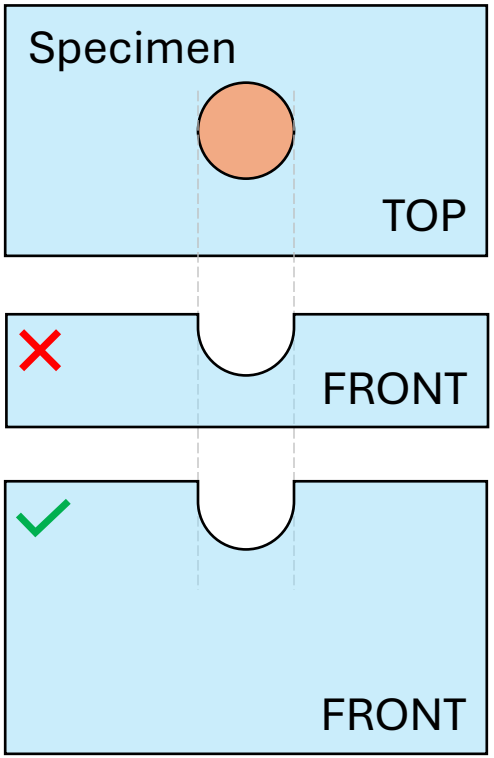
- Need “curvature correction” for round specimens



- Avoid specimen edges and other indents

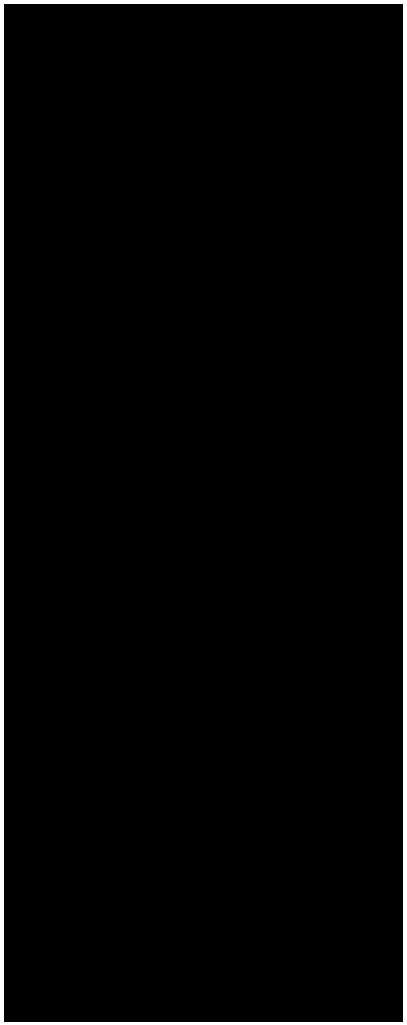


- Specimen thickness must be at least 10x indention depth

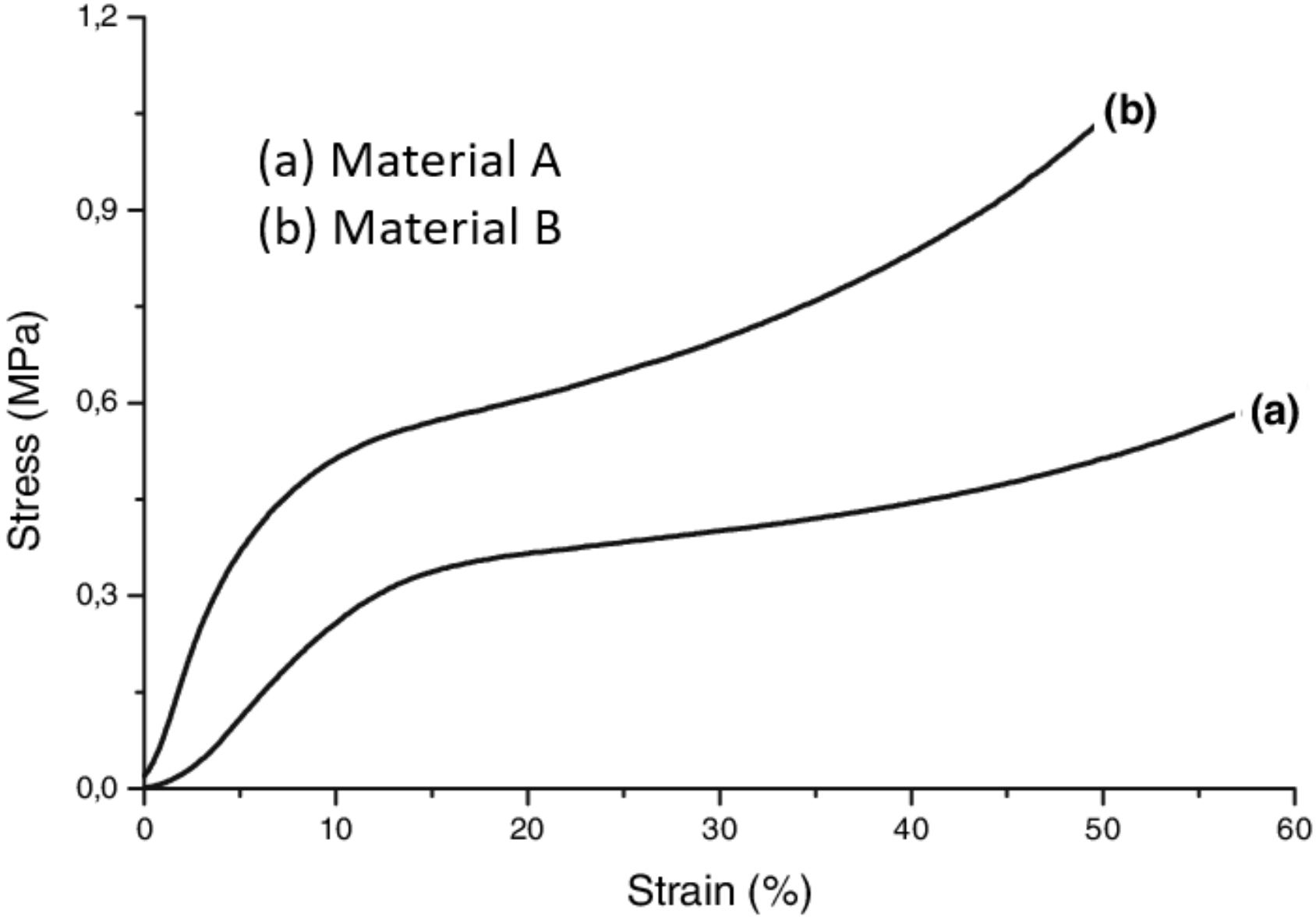


Uniaxial Compression Test

- Like tension test.
- Some materials are stronger in compression than tension.
  - Gray Cast Iron
  - Concrete
- Sometimes tension test impractical.
- Necking does not occur.
- Diameter increases for materials with positive Poisson's ratio (Barreling).
- Buckling can be a problem.
- Friction can cause barreling.



Compression test: Stress-strain Diagram



Technical Report

Must have…

1. Title Page (Course, class, experiment and student info)
2. Introduction (History, what/why)
3. Experimental Procedure (how-diagrams are preferred)
4. Results and Discussions (graphs, table, diagrams)
5. Conclusions (not an introduction/what you conclude from 4)
6. Acknowledgments (other sections, lab mates, instructors etc.)
7. References (lab manual, books, journal article, conference papers)

   - not Wikipedia