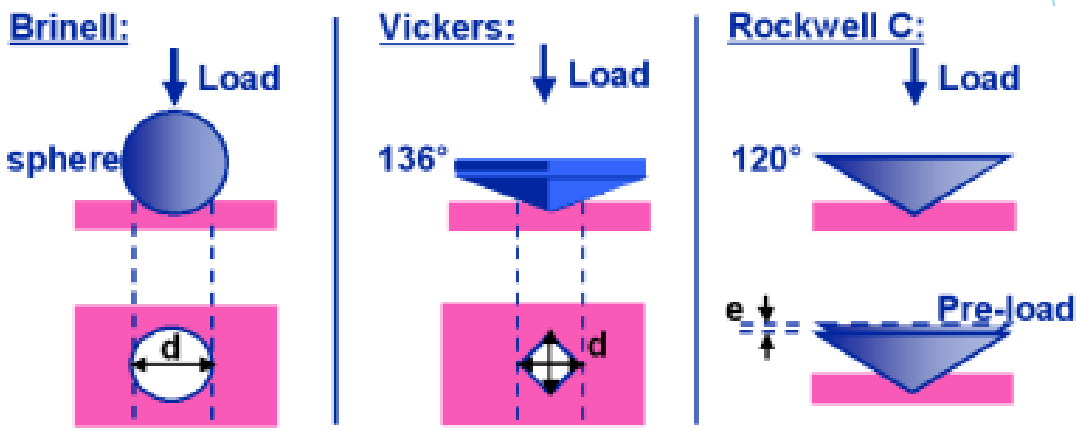
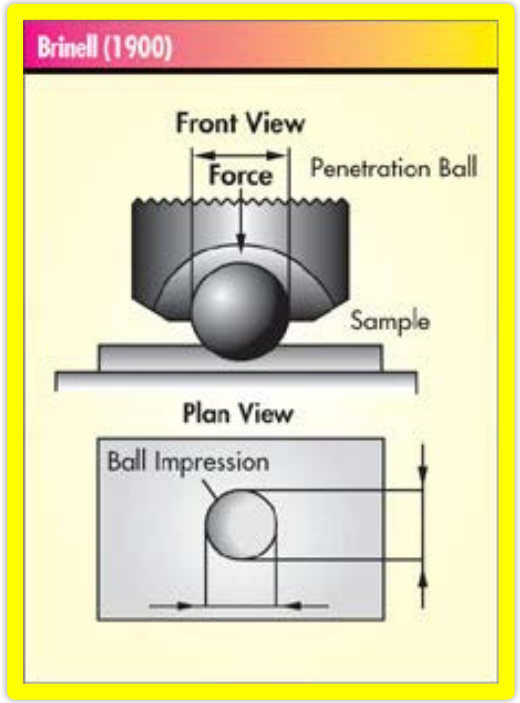
HARDNESS TESTING

Hardness testing

- 3 main methods
- all rely on applying a force to the surface to be tested and measuring the indentation



BRINELL hardness test



https://www.youtube.com/watch?v=RJXJpeH78iU

- 1st standardised indentation hardness test – 1900
- Can be applied to almost any metallic material
- It consists in indenting the metal surface with a steel or hard material ball of fixed diameter ranging from 1 mm to 10 mm at a load range of 500-3000 kg
- The load is applied for a standard time (10-15 max 30 s), and the diameter of the indentation is measured in millimetres under the microscope

+ pros

- Different loads are used to cover a wide range of hardness of commercial metals
- The B. ball makes the deepest and widest indentation, so the test averages the hardness over a wider amount of material

- cons

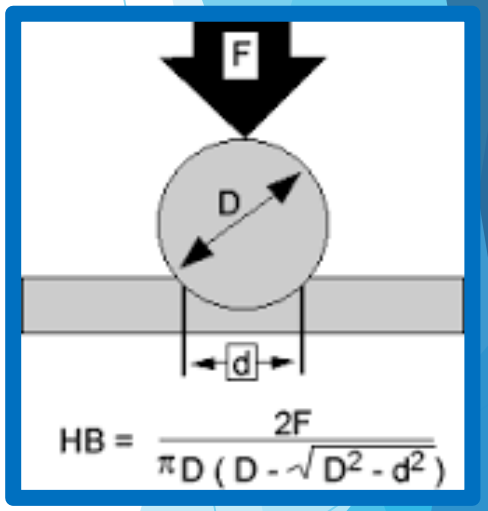
- Limitations on small specimens or in critically stressed parts

- 2 diameters of the impression (at right angles to each other) are measured

- **Test Method Illustration**

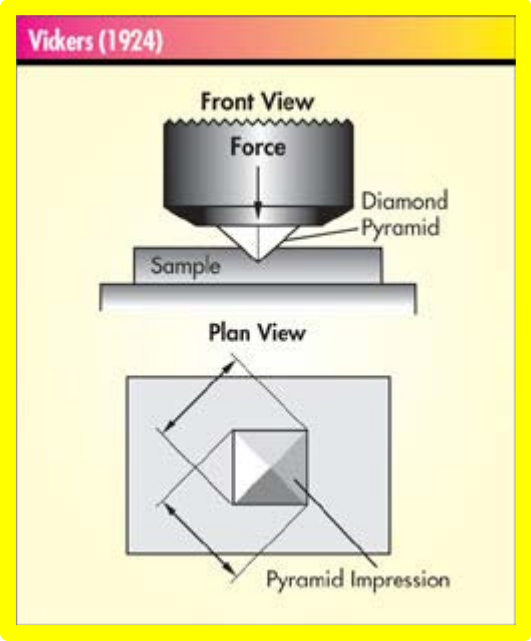
  HB = Brinell result

  D = Ball diameter
  d = impression diameter
  F = load (kgf)



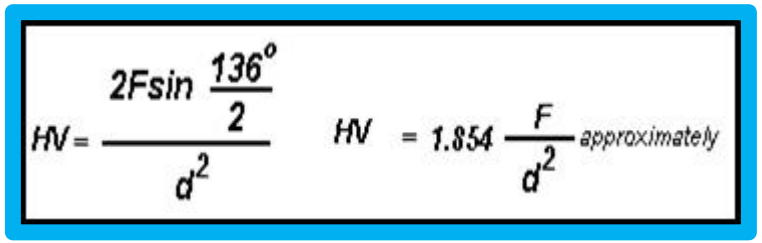
- Printed tables , from which the hardness number can be more rapidly obtained, are available.

VICKERS hardness test



- The Vickers test indenter is a diamond pyramid with a square base with an inclination on 136°.
- The load (which varies from 1 to 120 kg) is normally applied for 10-15 s and then removed
- The diagonals of the indentation left in the surface of the material after removal of the load are measured with a microscope or a measuring device capable of determining the length of the indentation diagonals

https://www.youtube.com/watch?v=7Z90OZ7C2jI



+ pros

- extremely accurate readings can be taken
- just one type of indenter is used for all types of metals and surface treatments

- cons

- the Vickers machine is a floor standing unit that is more expensive than the Brinell or Rockwell machines

- The area of the sloping surface of the indentation is calculated.
- The Vickers hardness is the quotient obtained by dividing the kgf load by the square mm area of indentation.
- The Vickers number (HV) is calculated using the following formula:

  HV = 1.854(F/D2),

  with F being the applied load (measured in kilograms-force) and

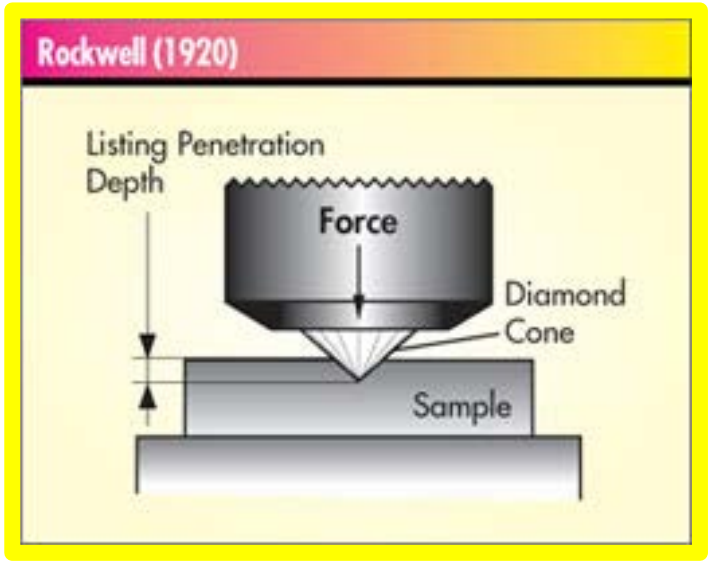
  D2 the area of the indentation (measured in square millimetres).

  The applied load is usually specified when HV is cited.

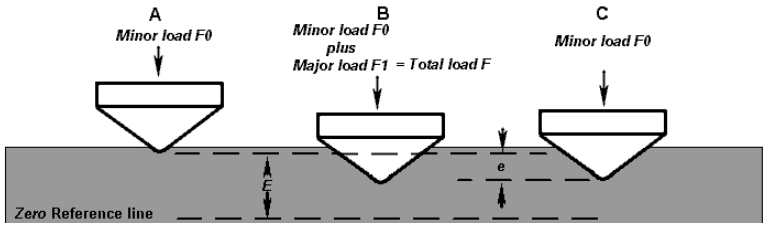
ROCKWELL hardness test

https://www.youtube.com/watch?v=G2JGNIIvNC4

- The Rockwell hardness test method consists of indenting the test material with a diamond cone or hardened steel ball indenter.



- The Rockwell test uses two loads, one applied directly after the other. The first load, known as the "minor", load of 10 kilograms is applied to the specimen to help seat the indenter and remove the effects, in the test, of any surface irregularities. In essence, the minor load creates a uniformly shaped surface for the major load to be applied to. The difference in the depth of the indentation between the minor and major loads provides the Rockwell hardness number.



+ pros

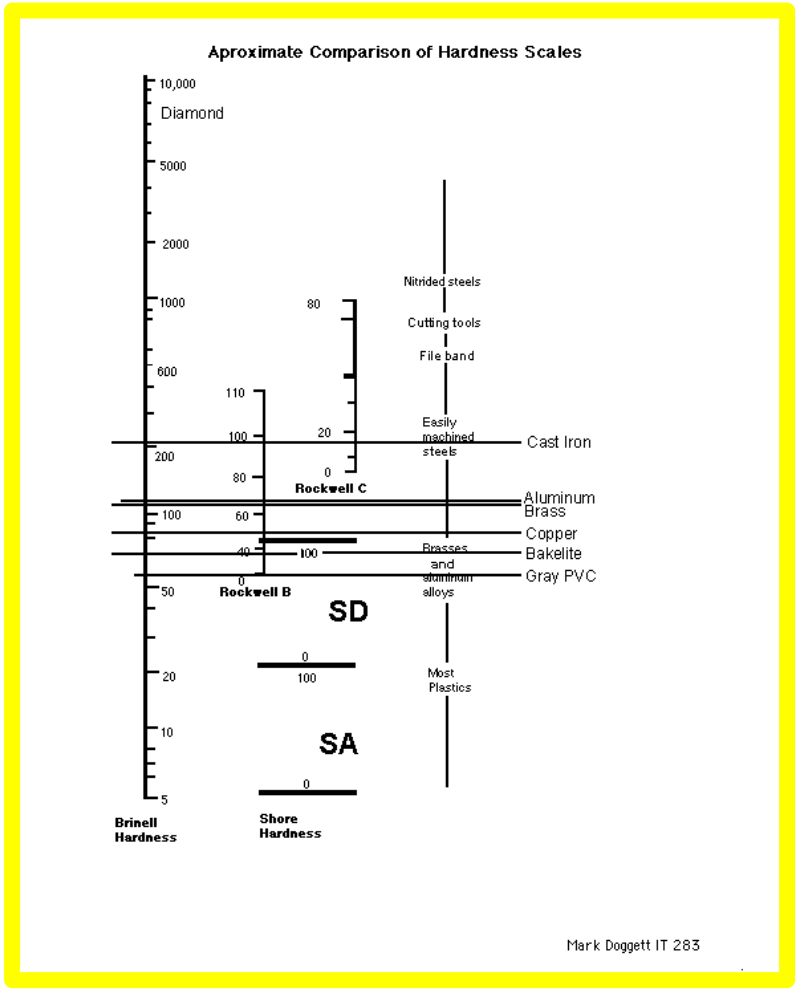
- rapid testing time
- direct Rockwell hardness number readout

- cons

- many arbitrary non-related scales
- possible effects from the specimen support anvil (incudine)

- For soft materials such as copper alloys, soft steel, and aluminum alloys a 1/16" diameter steel ball is used with a 100-kilogram load and the hardness is read on the "B" scale.
- In testing harder materials, hard cast iron and many steel alloys, a 120 degrees diamond cone is used with up to a 150 kilogram load and the hardness is read on the "C" scale.

COMPARISION OF HARDNESS MEASUREMENTS



TEST	TEST METHOD	TEST FORCE RANGE	INDENTER TYPES	ASTM TEST METHOD	MEASURE METHOD
Rockwell	Regular	60, 100, 150 kgs	Conical Diamond & Small Ball	E 18	Depth
	Superficial	15, 30, 45 kgs	Conical Diamond & Small Ball	E 18	Depth
	Light Load	3, 5, 7 kgs	Truncated Cone Diamond	N/A	Depth
	Micro	500, 100 grams	Small Truncated Cone Diamond	N/A	Depth
	Macro	500 to 3000 kgs	5, 10 mm Ball	E 103	Depth
Micro-Hardness	Vickers	5 to 2000 grams	136° Pyramid Diamond	E 384	Area
	Knoop	5 to 2000 grams	1300 x 1720° Diamond	E 384	Area
	Rockwell Type	500, 3000 grams	Truncated Cone Diamond	N/A	Depth
	Dynamic	.01 to 200 grams	Triangular Diamond	N/A	Depth
Brinell	Optical	500 to 3000 kgs	5mm, 10 mm Ball	E 10	Area
	Depth	500 to 3000 kgs	5mm, 10 mm Ball	E 103	Depth
Shore	Regular	822 (A), 4550 (D) grams	35° Cone (A) 30° Cone (D)	D 2240	Depth
	Micro	257 (A), 1135 (D) grams	35° Cone (A) 30° Cone (D)	N/A	Depth
IRHD	Regular	597 grams	2.5 mm Ball	D 1415	Depth
	Micro	15.7 grams	.395 mm Ball	D 1415	Depth