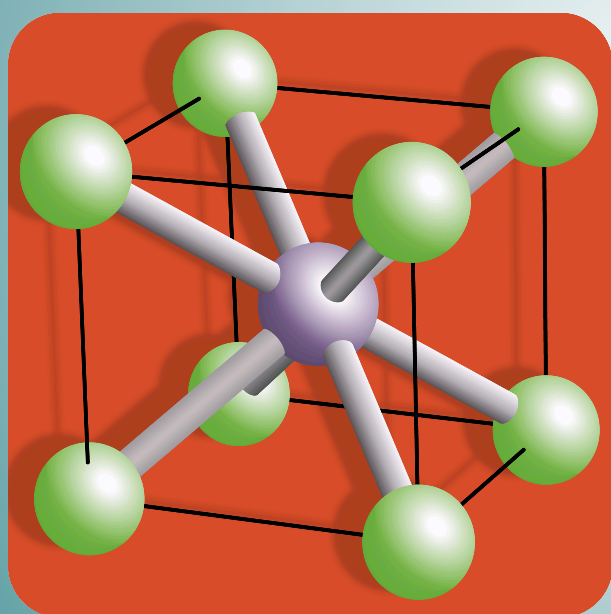
Materials

Topic 4. Tensile strength



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4.1. MECHANICAL PROPERTIES

- The mechanical properties define the behavior of materials against external forces that tend to alter their equilibrium.

- Fundamentally, for the engineer there are three types of mechanical properties:
  - **Strength:** ability to withstand certain efforts without breaking.
  - **Deformability:** aptitude to vary its form without breaking or changing state.
  - **Hardness:** indicates the cohesion of the body.

Tensile efforts tend to lengthen the material longitudinally.

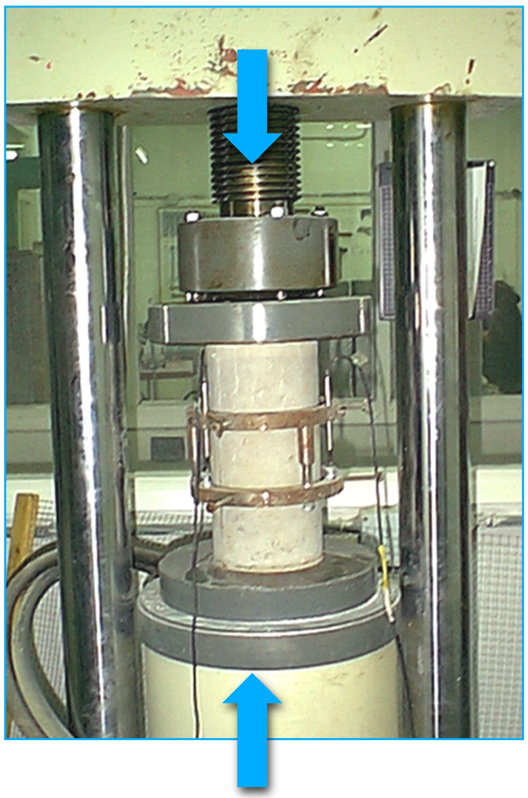
Compression efforts tend to shorten the material longitudinally.

- The tensile and compressive strength is defined by the maximum tensile or compressive stress, respectively, that the material can withstand without breaking.

- To determine these parameters it is necessary to perform the corresponding tests:

Tensile test

Compresión test



4.2. TENSILE TEST

- It is the most used test to measure the capacity to support loads in a certain material (mechanical or resistant characterization).

- The information obtained from this test is very complete, being possible to determine elastic parameters (Young's modulus), resistant parameters (yield stress, tensile strength) and ductility parameters (strain under maximum load, strain elongation at break, reduction in area).

- It involves applying a load to a specimen or sample of the material, generally up to its fracture, in order to determine the mechanical properties previously indicate.

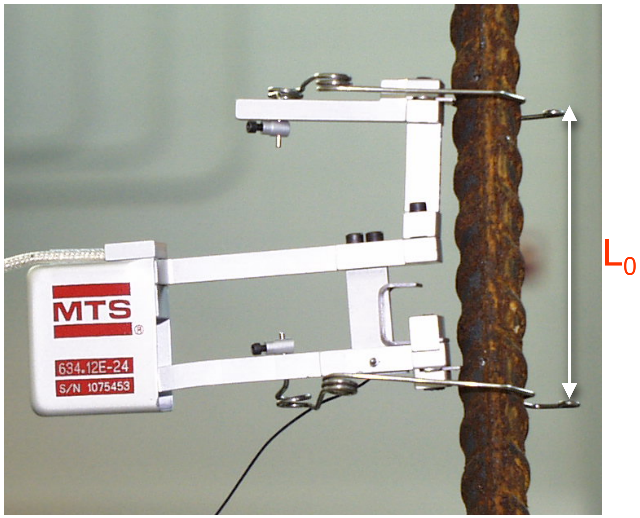
Universal testing machines

Controlled application of loads on the material.

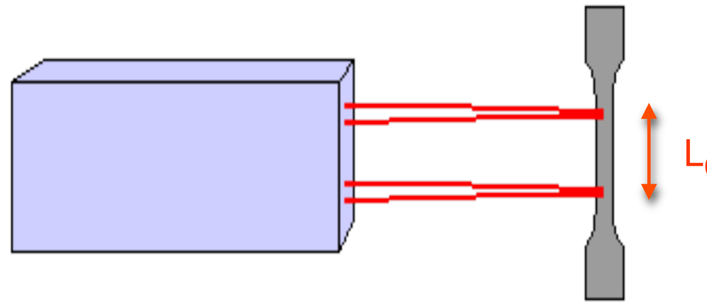
Load cells

Continuous recording of the load (F) applied on the material.

Extensometers



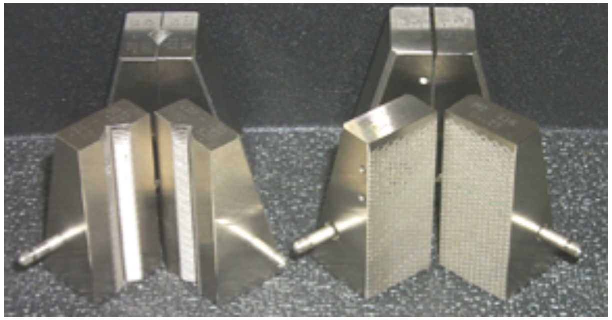
Pin extensometer (with contact).



Laser extensometer (contactless).

- **Continuous record of elongation (ΔL) experienced by the material.**
- **The initial opening (distance between reference points) defines the gauge, base of measurement, (L_0) for the calculation of deformation.**

Grips



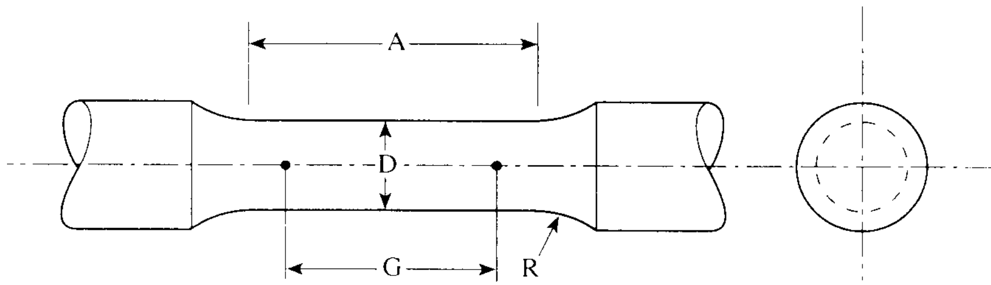
For cylindrical or flat specimens.

Wedge system with self-tightening.

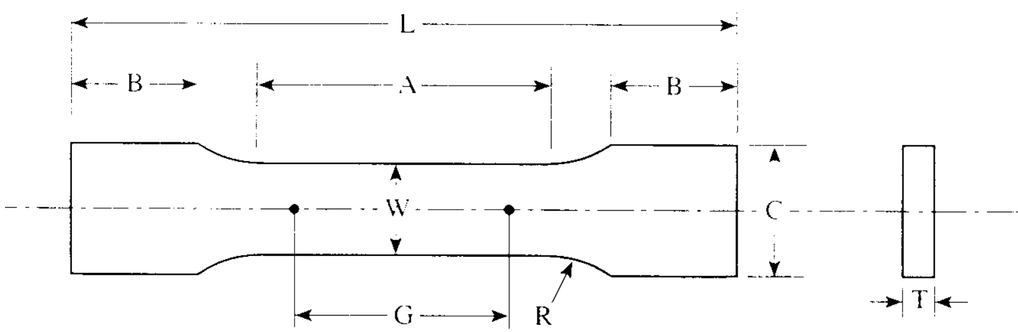
Pneumatic or hydraulic system with pressure control.

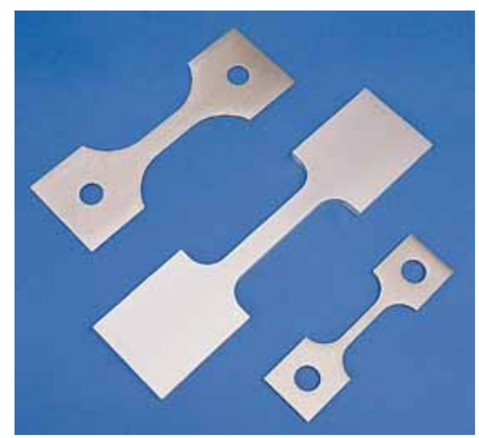
Samples

- **Whenever possible it is advisable to adjust to standardized geometries.**



A: minimum parallel length. *G: gauge length.*
D: diameter. *R: radius.*





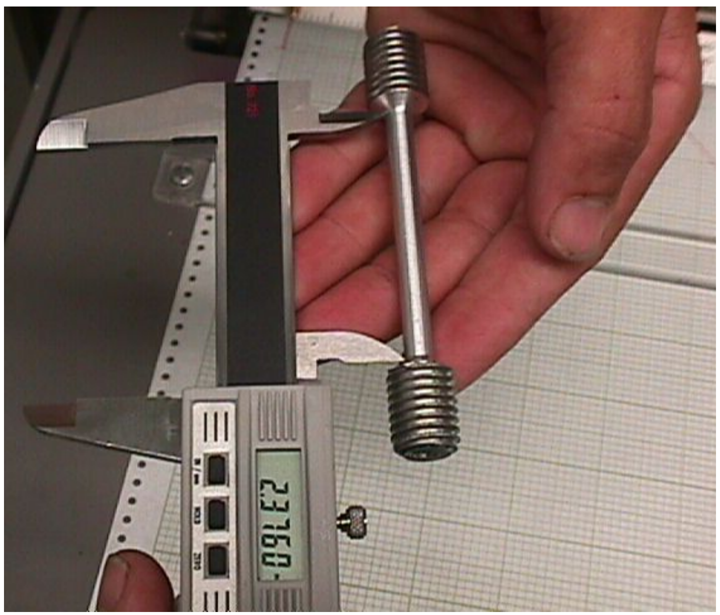
A: minimum parallel length. *G: gauge length.*
B: length of grip section. *R: radius.*
C: width of grip section. *W: width.*
L: overall length. *T: thickness.*

Samples

- **Non-standardized geometries.**

Testing procedure

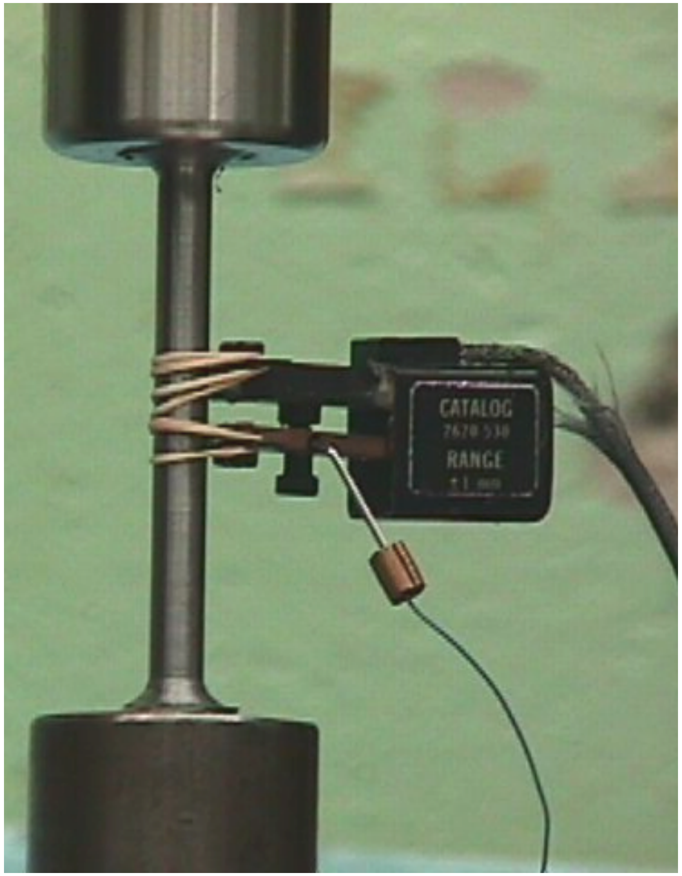
Set a reference length (L_0) to determine the elongation at break (marks every 5 diameters in corrugated bar).



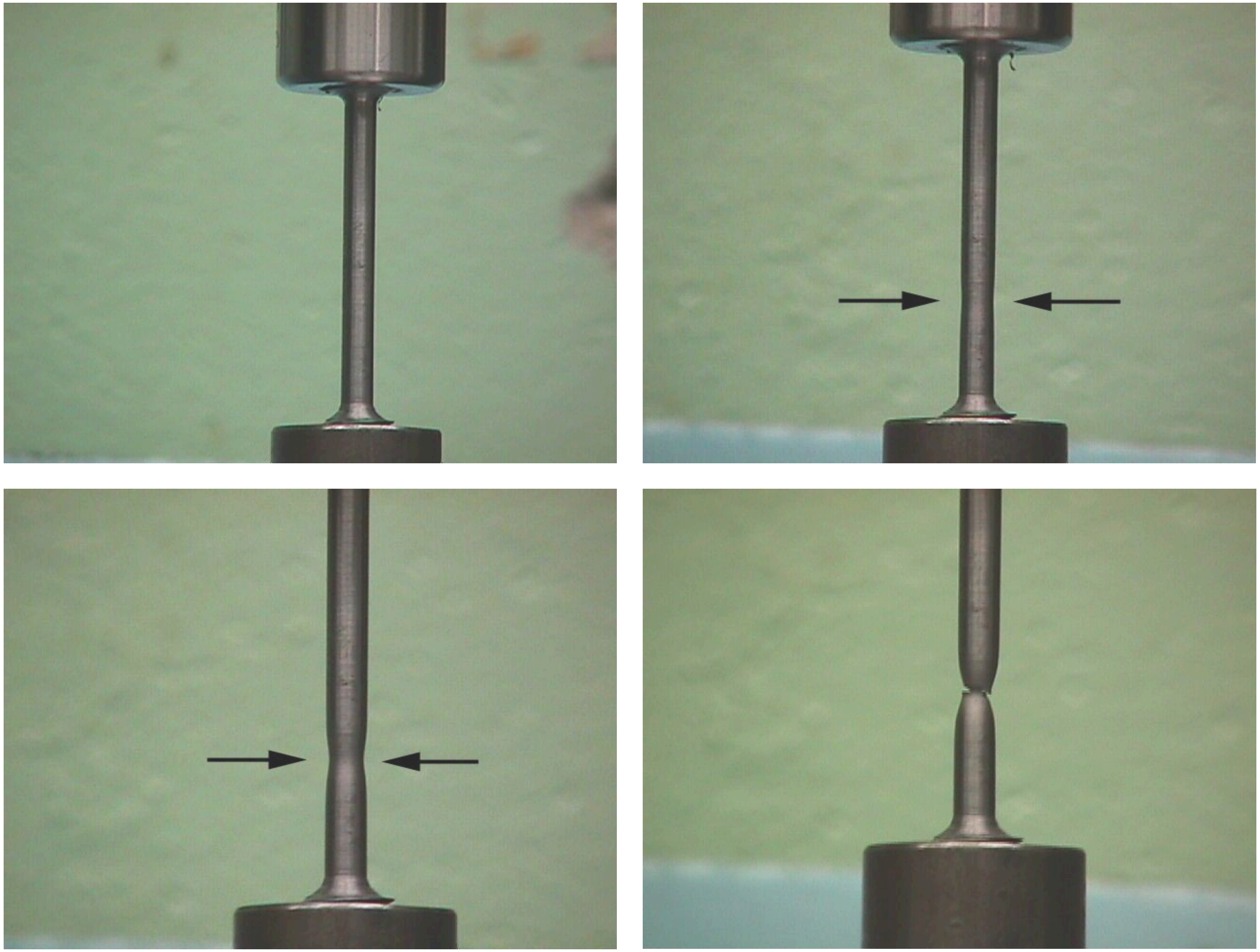
Determine the initial cross section (A_0) of the specimen to calculate the reduction in area after the test.

Sample positioning

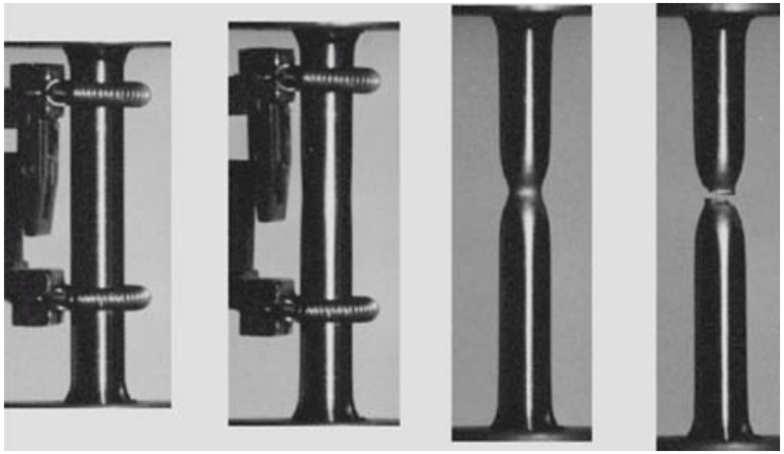
Extensometer positioning

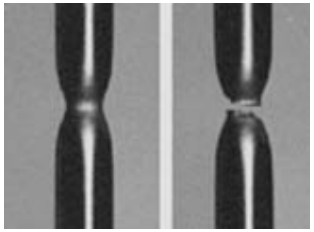


- Application of progressive load, initially at slow speed (elastic region).

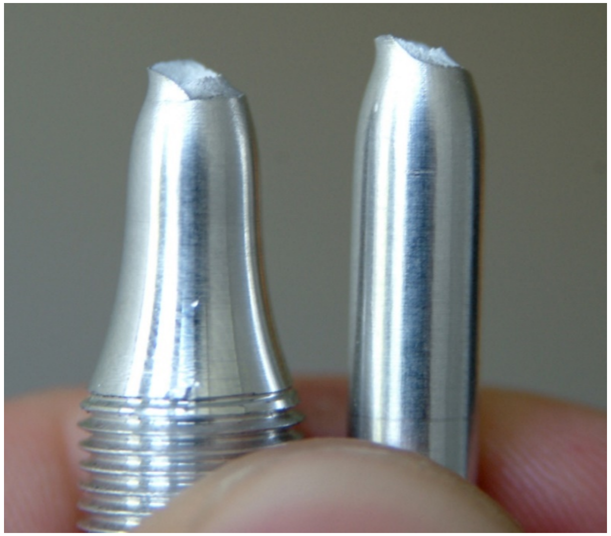


Necking formation

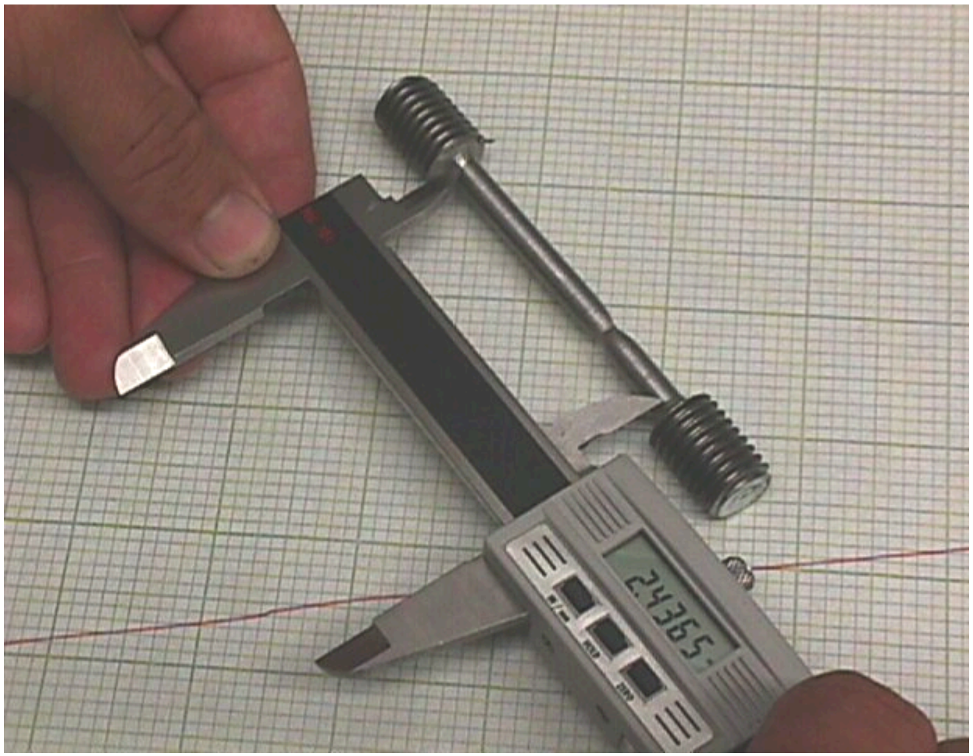


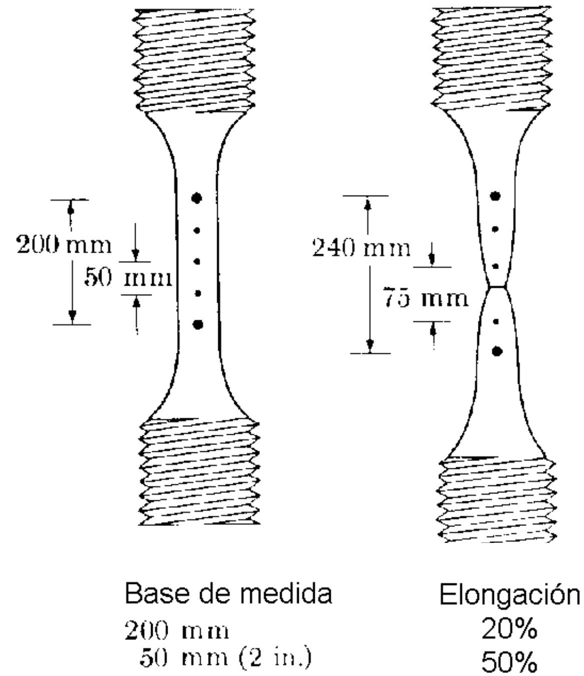


Appearance of the specimen after the breakage



- **Measurement of the reference length (L_f) of the specimen after the breakage.**





- **Ductility, as percent elongation:**

$$\varepsilon_R(\%) = \frac{L_f - L_0}{L_0} \cdot 100$$

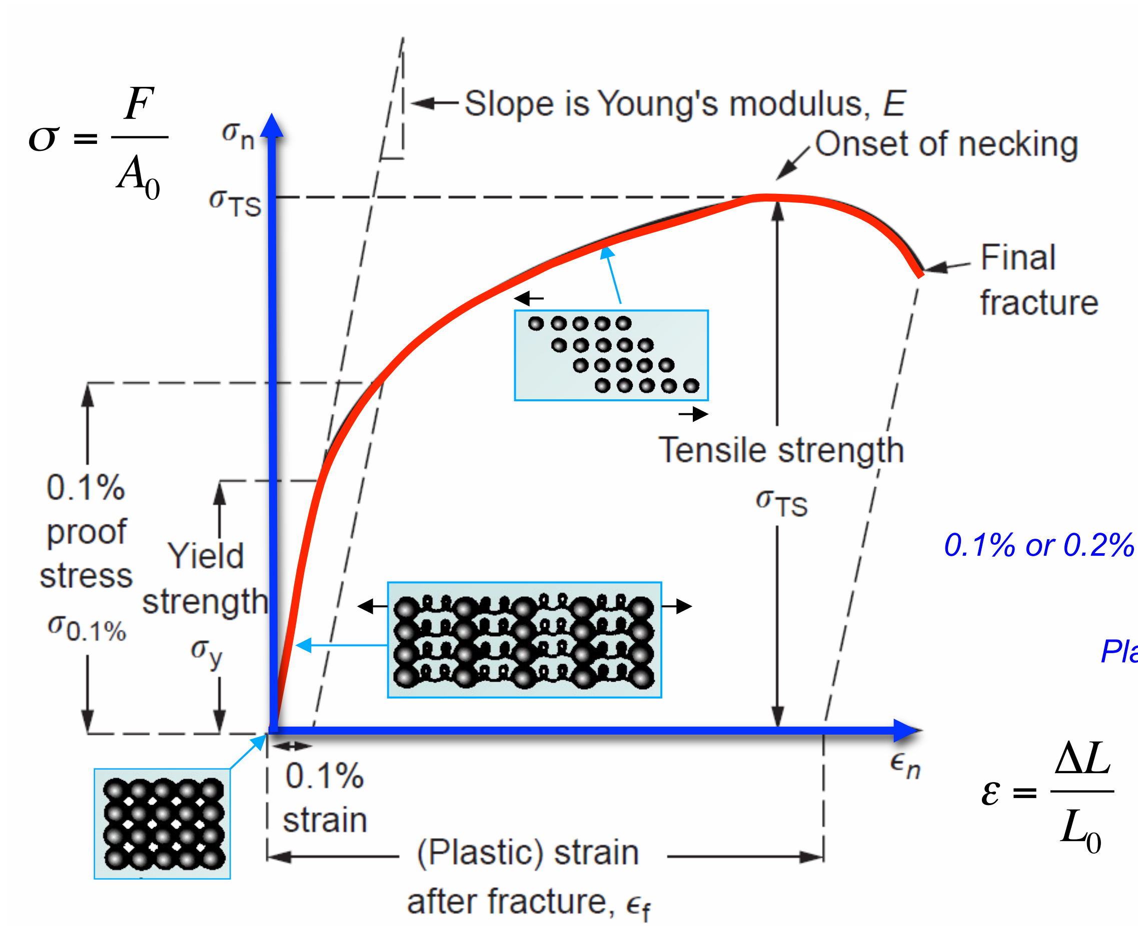
- Measurement of the final cross section (A_f) of the specimen after the breakage.

- Ductility, as percent reduction in area:

$$RA(\%) = \frac{A_0 - A_f}{A_0} \cdot 100$$

4.3. RESULTS: STRESS – STRAIN CURVE

- A **load – displacement** (**F – ΔL**) record is obtained as a result of the test that can be converted immediately into a **stress – strain** (**σ – ε**) curve.



Parameters:

Young´s modulus (E)

Yield strength (σ_Y)

0.1% or 0.2% proof stress ($\sigma_{Y\,0.1\%}$, $\sigma_{Y\,0.2\%}$)

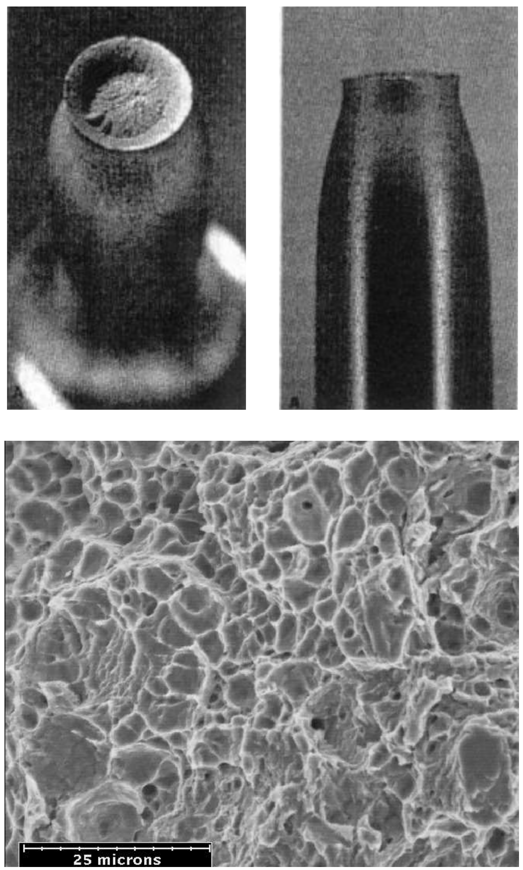
Tensile strngth (σ_{TS})

Plastic strain afeter fracture (ε_f)

4.4. FRACTOGRAPHIC ANALISYS

- It is possible to obtain information on the behavior of the material from the microscopic observation of the appearance of the fracture surfaces after the test.

Ductile fracture



Brittle fracture