Mechanical Testing of Materials

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Mechanical Testing of Materials

- Tensile Testing
- Tests of Hardness
- Creep
- Fatigue and
- Impact Testing

Why are Materials Tested ?

- ✓ Ensure quality
- ✓ Test properties
- ✓ Prevent failure in use
- ✓ Make informed choices in using materials
- ✓ Factor of Safety is the ratio comparing the actual stress on a material and the safe useable stress.

Two Forms of Testing

Destructive Testing (DT, Mechanical Tests)

- ❖ The material may be physically tested to destruction. Will normally specify a value for properties such as strength, hardness, toughness, etc.
- ❖ Destructive testing changes the dimensions or physical and structural integrity of the specimen. (It is essentially destroyed during the test) e.g., Tensile, Compression, Shear and Rockwell Hardness.

Non-destructive tests (**NDT**)

- ❖ Non-Destructive testing does not affect the structural integrity of the sample. (A measurement that does not effect the specimen in any way) e.g., weighing, measurements etc.
- ❖ The samples or finished articles are tested before being used.

Mechanical Testing

- **Ultimate Tensile Strength**: The maximum tensile stress that a material is capable of developing during a test.

- **Load**: Applied force either Pounds or Newtons

- **Stress**: The intensity of the internally-distributed forces or components of forces that resist a change in the form of a body. Commonly measured in units dealing with force per unit area, such as pounds per square inch (PSI) or Megapascals (Mpa). The three basic types of stress are tension, compression, and shear. The first two, tension and compression, are called direct stresses.

- **Elastic Limit**: The greatest amount of stress a material can develop without taking a permanent set.

- **Percent Elongation**: The total percent strain that a specimen develops during testing.

Modulus of Elasticity - Also known as Young's modulus; calculated by finding the slope of the stress-strain curve for a given material within the range of its linear proportionality between stress and strain.

Proportional Limit - The greatest stress a material can develop without deviating from linearity between stress and strain. Otherwise stated, the greatest stress developed in a material within its elastic range.

Percent Reduction in Area - The difference between the original and final cross-sectional areas of a test piece, expressed as a percentage.

Yield Point – Also referred to as Elastic Limit, is the point at which any additional stress will result in permanent deformation.

Yield Strength - The stress at which a material exhibits a specified limiting permanent set.

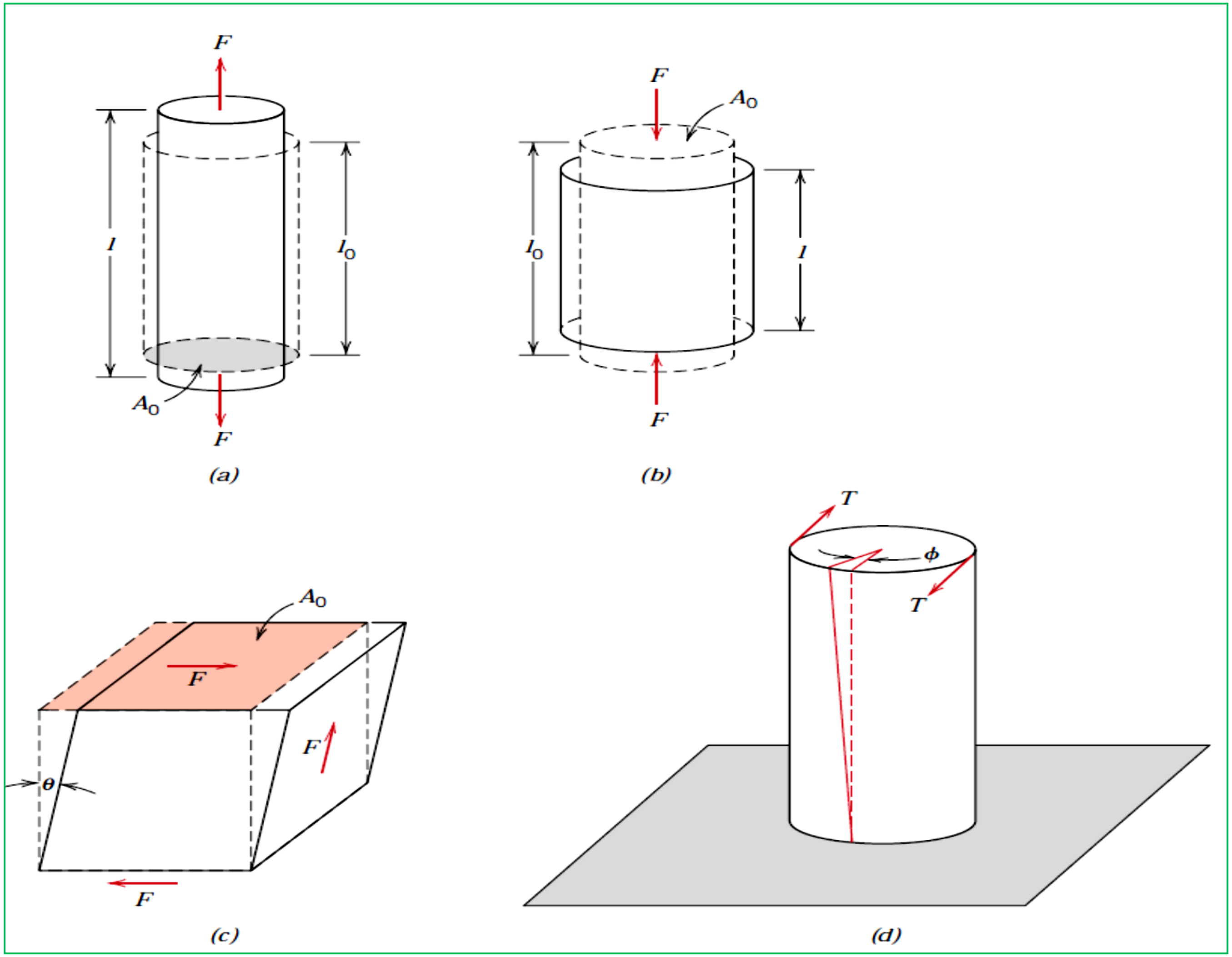


Figure:
(a) Schematic illustration of how a tensile load produces an elongation and positive linear strain. Dashed lines represent the shape before deformation; solid lines, after deformation.
(b) Schematic illustration of how a compressive load produces contraction and a negative linear strain.
(c) Schematic representation of shear strain.
(d) Schematic representation of torsional deformation (i.e., angle of twist) produced by an applied torque *T*.

Tensile Testing

- The tensile test is a common test performed on metals, wood, plastics, and most other materials.

- Tensile loads are those that tend to pull the specimen apart, putting the specimen in tension. They can be performed on any specimen of known cross-sectional area and guage length to which a uniform tensile load can be applied.

- Tensile tests are used to determine the mechanical behavior of materials under static, axial tensile, or stretch loading.

The engineering stress is:

$$\sigma = \frac{P}{A_0}$$

P is the load in lbs. on the specimen and A_0 is the original cross-sectional area near the center of the specimen.

The engineering strain is:

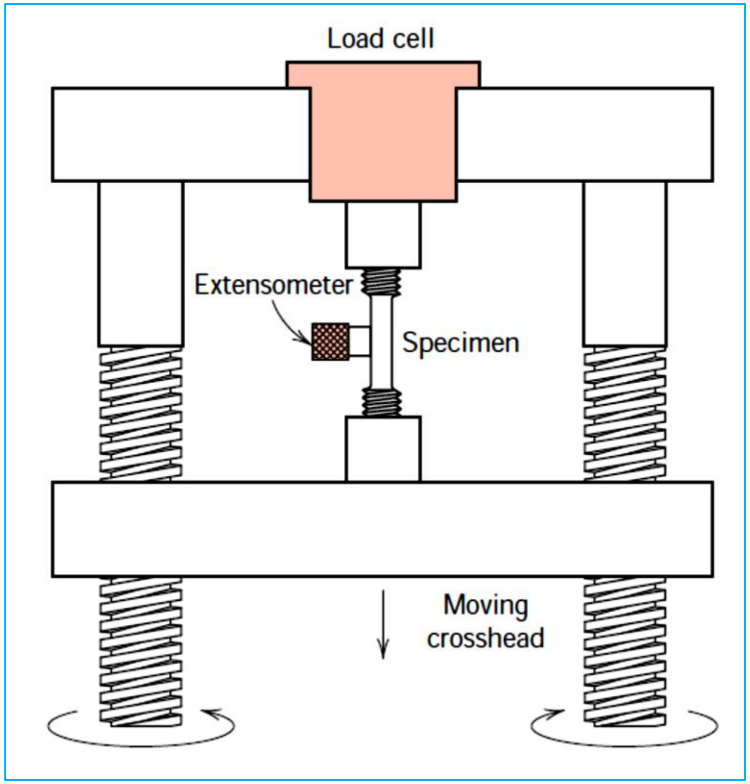
$$\varepsilon = \frac{l - l_0}{l_0}$$

l is the gage length at a given load and $\mathbf{l_0}$ is the original guage length with zero load

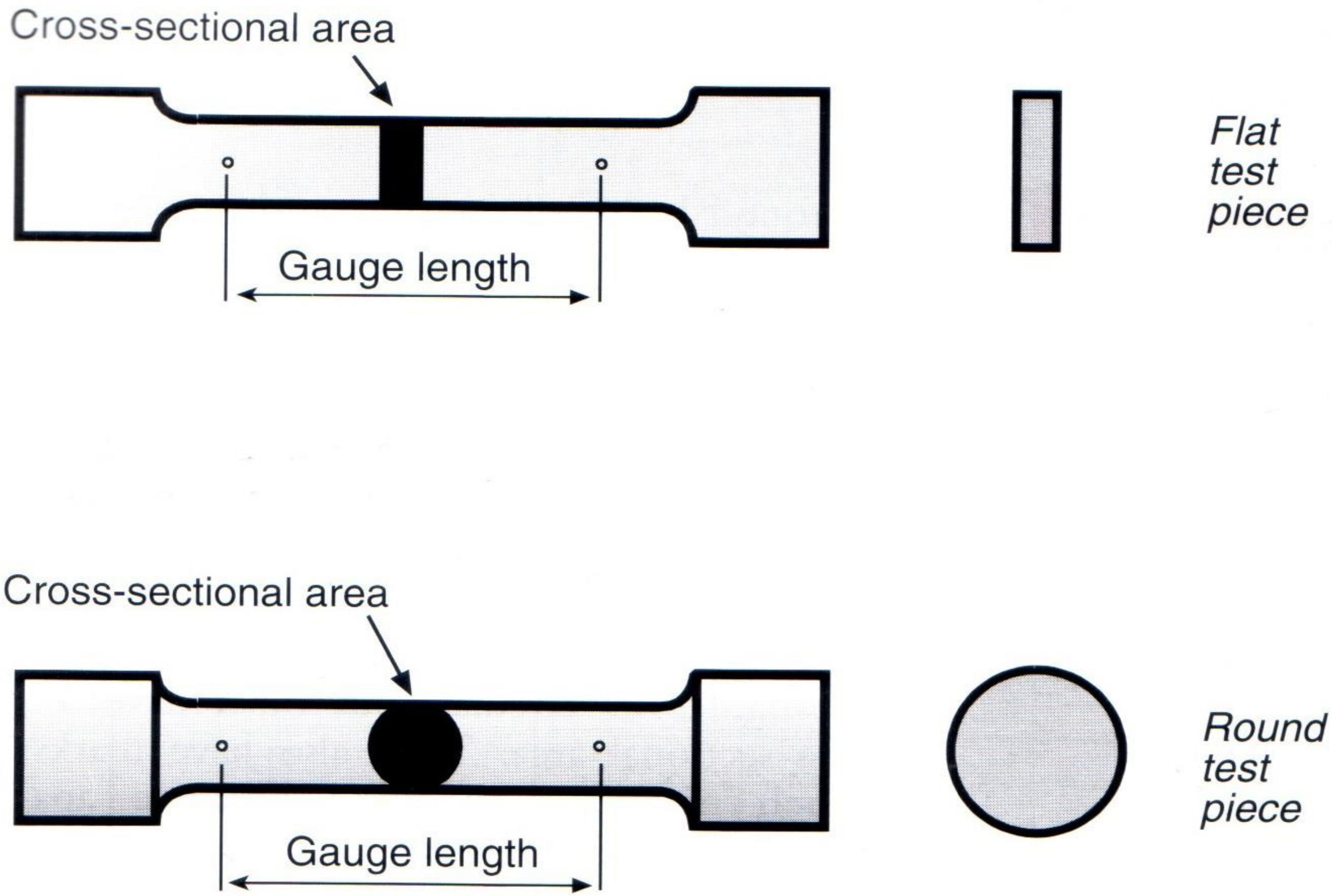
Tensile Testing

- Uses an extensometer to apply measured force to an test specimen. The amount of extension can be measured and graphed.
- Variables such as strain, stress, elasticity, tensile strength, ductility and shear strength can be gauged.
- Test specimens can be round or flat.

Extensometer



Tensile test specimens



Standard lengths are given below. As well as gauge length, minimum parallel, and total lengths, radii, width, and for round pieces, diameter, are also specified

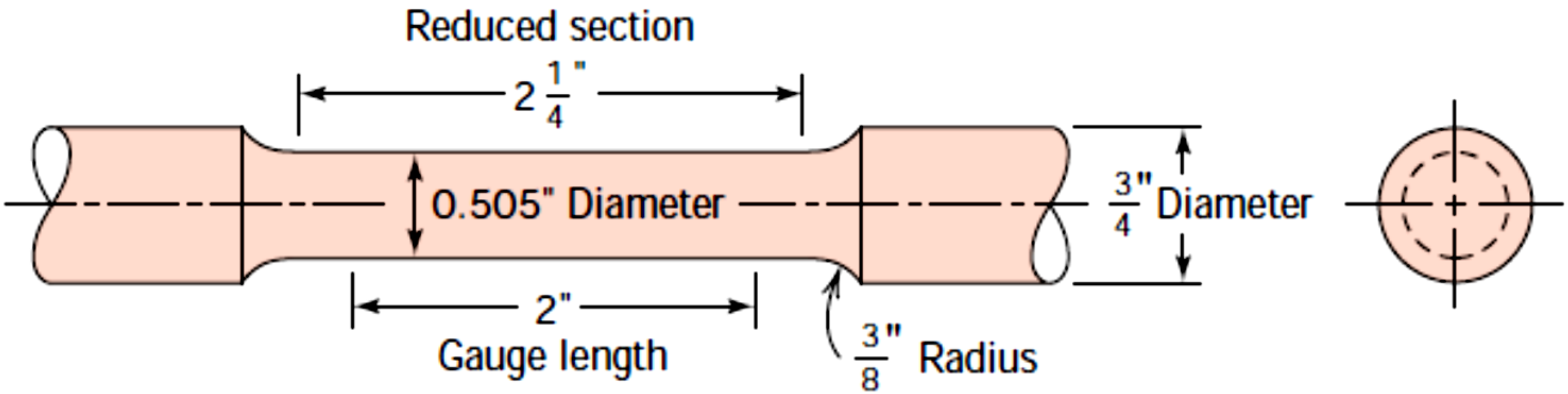


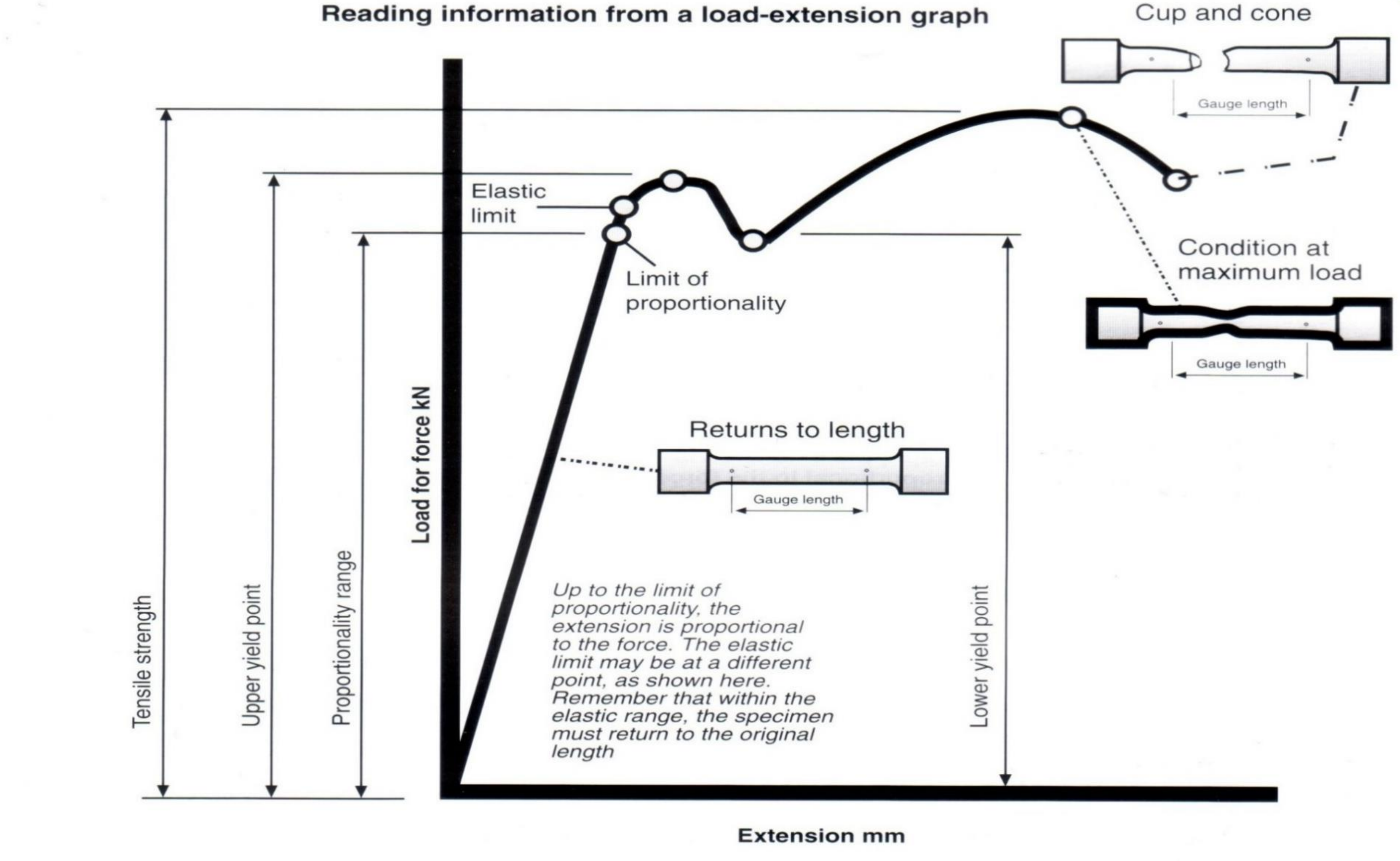
Figure: A standard tensile specimen with circular cross section.

- Standard diameter of Specimen is approximately 12.8 mm (0.5 in.)
- Reduced section length should be at least four times this diameter; 60 mm (2 x 1/4 in.)
- Gauge length is used in ductility computations, the standard value is 50 mm (2.0 in.).

Producing Graphs

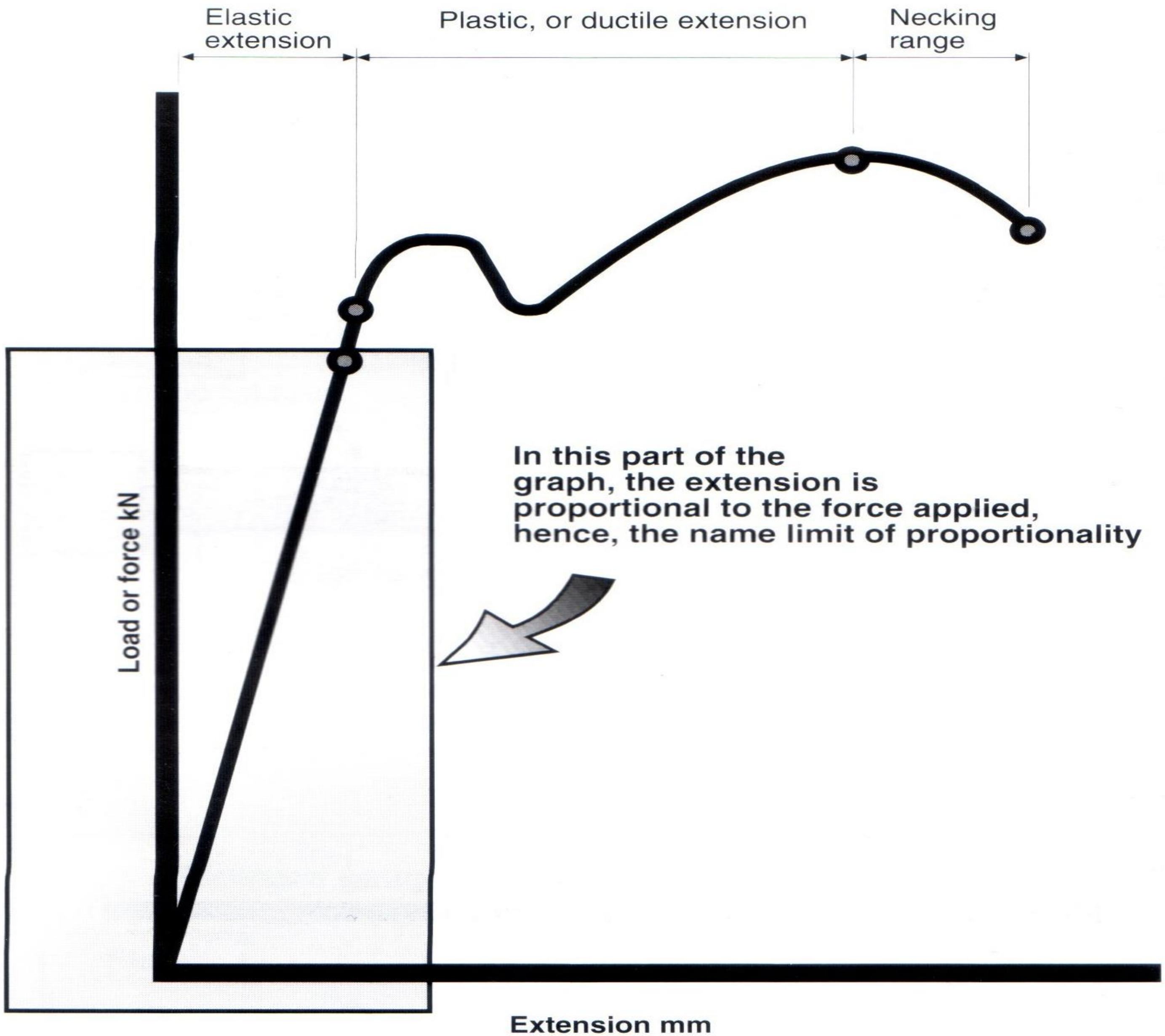
Two basic graphs
- Load / extension graph.
- Stress / strain graph.

Load - Extension graph for low carbon steel



Graph similar to that for a low carbon steel, that has a definite yield point

Types of extension



Tensile Test Results

Cup and cone fracture signifies a ductile material

A shear fracture would indicate a brittle material

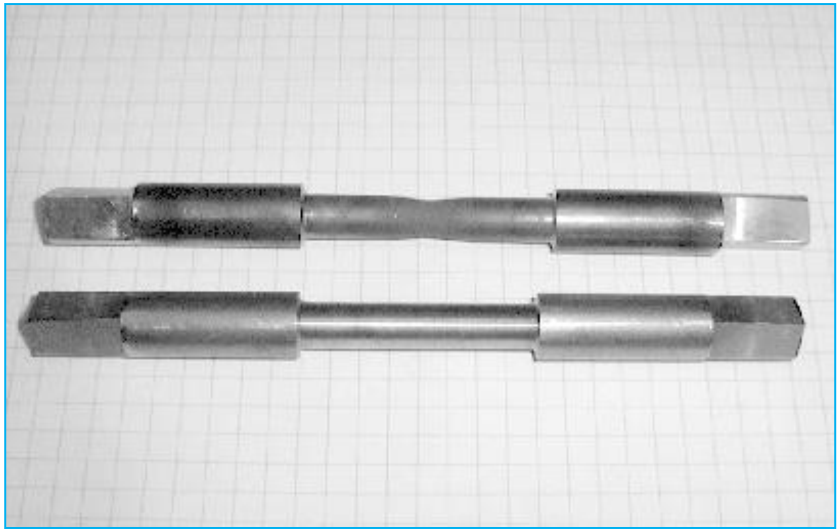
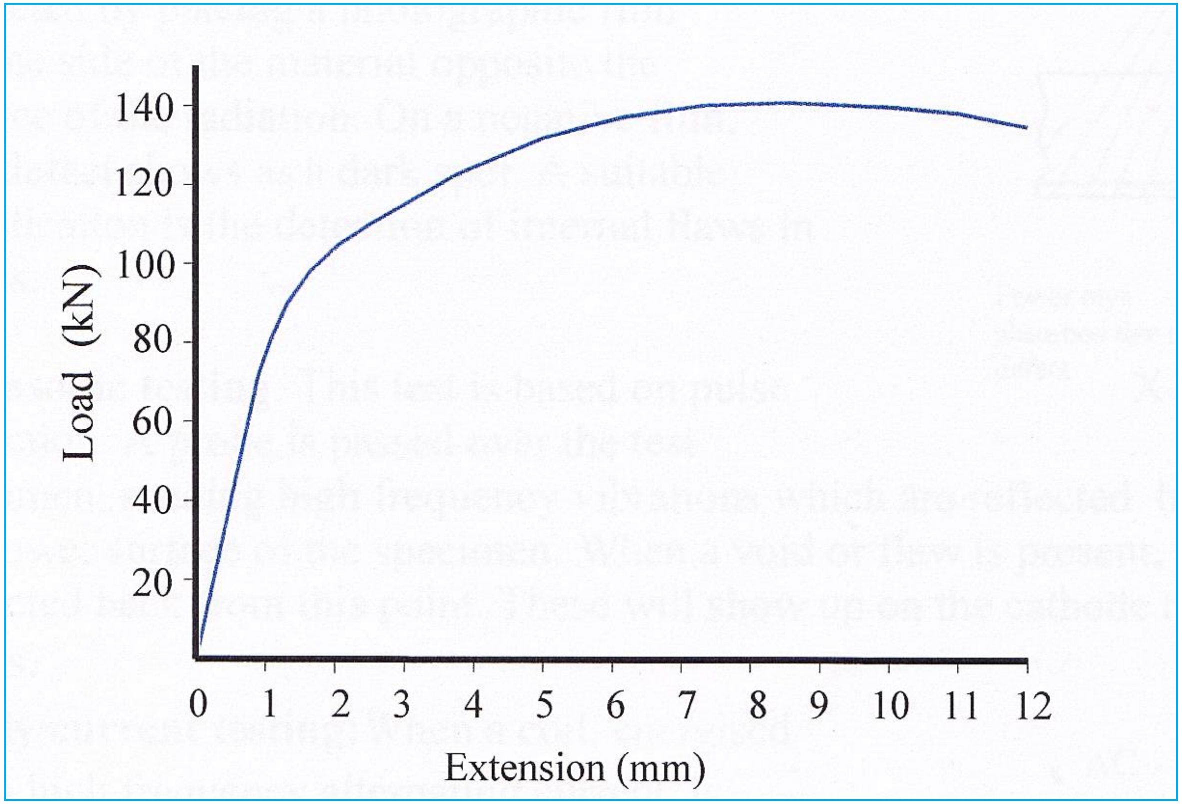


Figure 4: Necking in a tensile specimen.

Draw graph for this tensile test?

The following data was obtained from a tensile test on a specimen of 10 mm diameter and gauge length 60 mm.

Load (kN)	16	32	56	72	95	110	132	142	140	135
Extension (mm)	0.2	0.4	0.7	0.9	1.5	2.5	5.0	8.5	10.0	12.0



Identify the straight line part of the graph

Young's Modulus (E)

$$E = \frac{\text{Stress}}{\text{Strain}}$$

$$\text{Stress} = \frac{\text{Load}}{\text{Cross section area}}$$

$$\text{Strain} = \frac{\text{Extension}}{\text{Original length}}$$

Young's Modulus for Load – Extension Graph

$$\text{Youngs Modulus} = \frac{Stress}{Strain}$$

$$\text{Stress} = \frac{Load}{CSA} = \frac{32}{78.55} = 0.407\text{kN}/\text{mm}^2$$

$$\text{Strain} = \frac{Extension}{OrigLgth} = \frac{0.4}{60} = 0.0067$$

$$\text{Youngs Modulus} = \frac{0.407}{0.0067} = 60.7\ \text{kN}/\text{mm}^2$$