

Engineering Science Guidance Notes

TENSILE TESTER KIT ES6

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Introduction

These Guidance Notes introduce you to the theory for a set of experiments in an engineering science topic. You fit different parts of your kit to a Work Panel to do an experiment. Figure 1 shows a typical experiment.

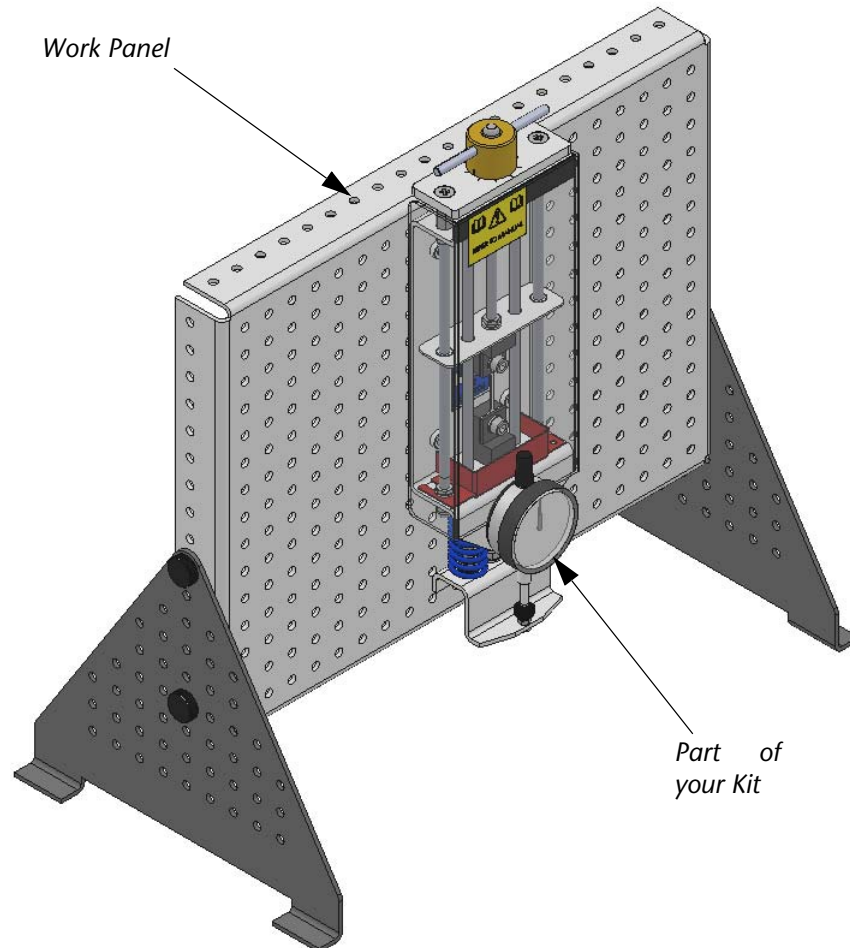


Figure 1 A Typical Experiment

Each kit can do one or more experiments and each experiment has Worksheets that tell you how to do the experiment. You must use the Worksheets with the Guidance Notes as they:

- Introduce the parts in the kit, and list the experiments that it can do.
- Give you important information you need to do the experiments or complete your Worksheet.

The ES6 Kit - What is it and what can it do?

Understanding the strength of materials and how they react to applied loads is very important to scientists and engineers. This kit includes a tensile testing machine that allows you to do tests on several common materials.

The tensile test is a destructive test that adds an increasing axial (tensile) load or force to a material specimen, while measuring its elongation. The tests help you to find the yield strength, tensile strength and elongation (an indication of ductility).

The kit comes in a plastic box with a lid and contains all the parts you need to do the experiments shown in Table 1. Refer to the Parts List in your kit to see what parts are included.

Your tutor may decide to ask you to do all the experiments or just a few. You must be sure what you need to do.

List of Experiments

Experiment	Does my teacher need me to do this experiment?	Have I got the Worksheet?
Tensile Test - Steel Specimen		
Tensile Test - Aluminium Specimen		
Tensile Test - Duralumin Specimen		
Tensile Test - PVC Specimen		

Table 1 List of Experiments

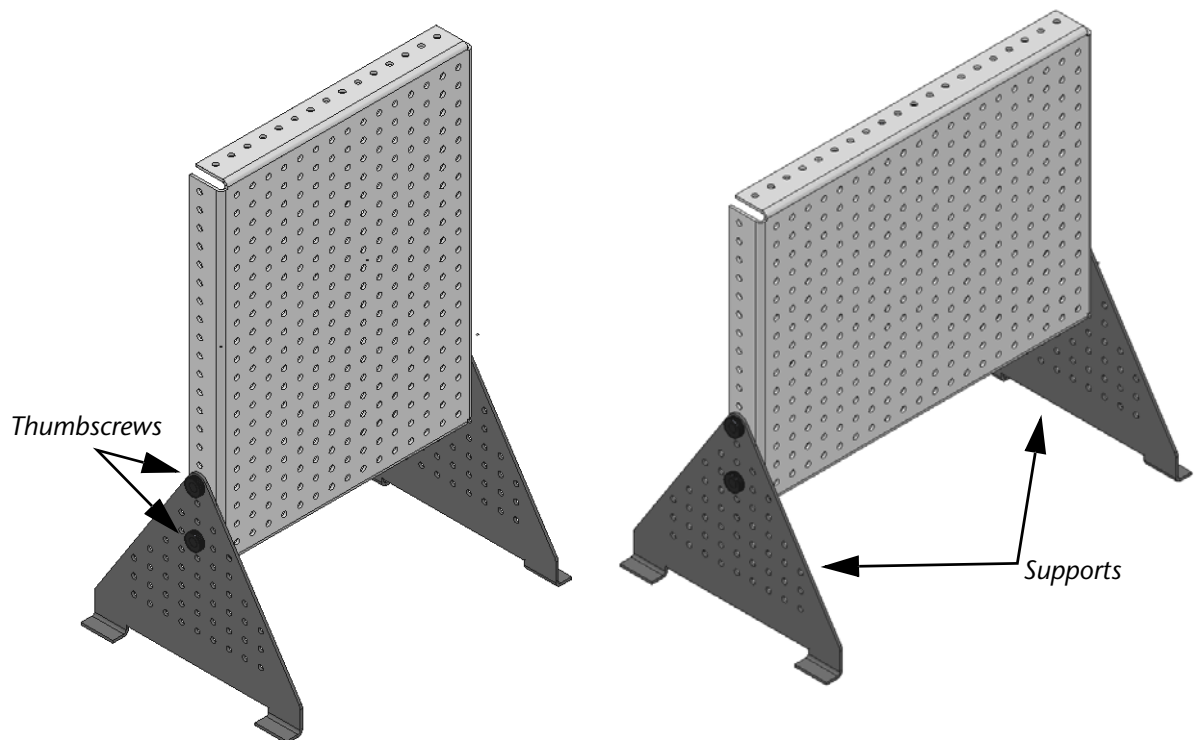
General Notes**The Work Panel**

Figure 2 The Work Panel Mounted in Two Typical ways (Portrait and Landscape)

The Work Panel mounts on its Supports in different ways as needed by each experiment. The Worksheets show you which way TecQuipment recommends you to fit the Supports but you may find an alternative that fits better on your desk. To change how the Supports hold the Work Panel, ask your Teacher or a classmate to help you hold the Work Panel while you change the Supports around. However you mount the Work Panel, you must always use two Thumbscrews and Thumbnuts to hold each Support to the Work Panel.

Using the Tensile Tester

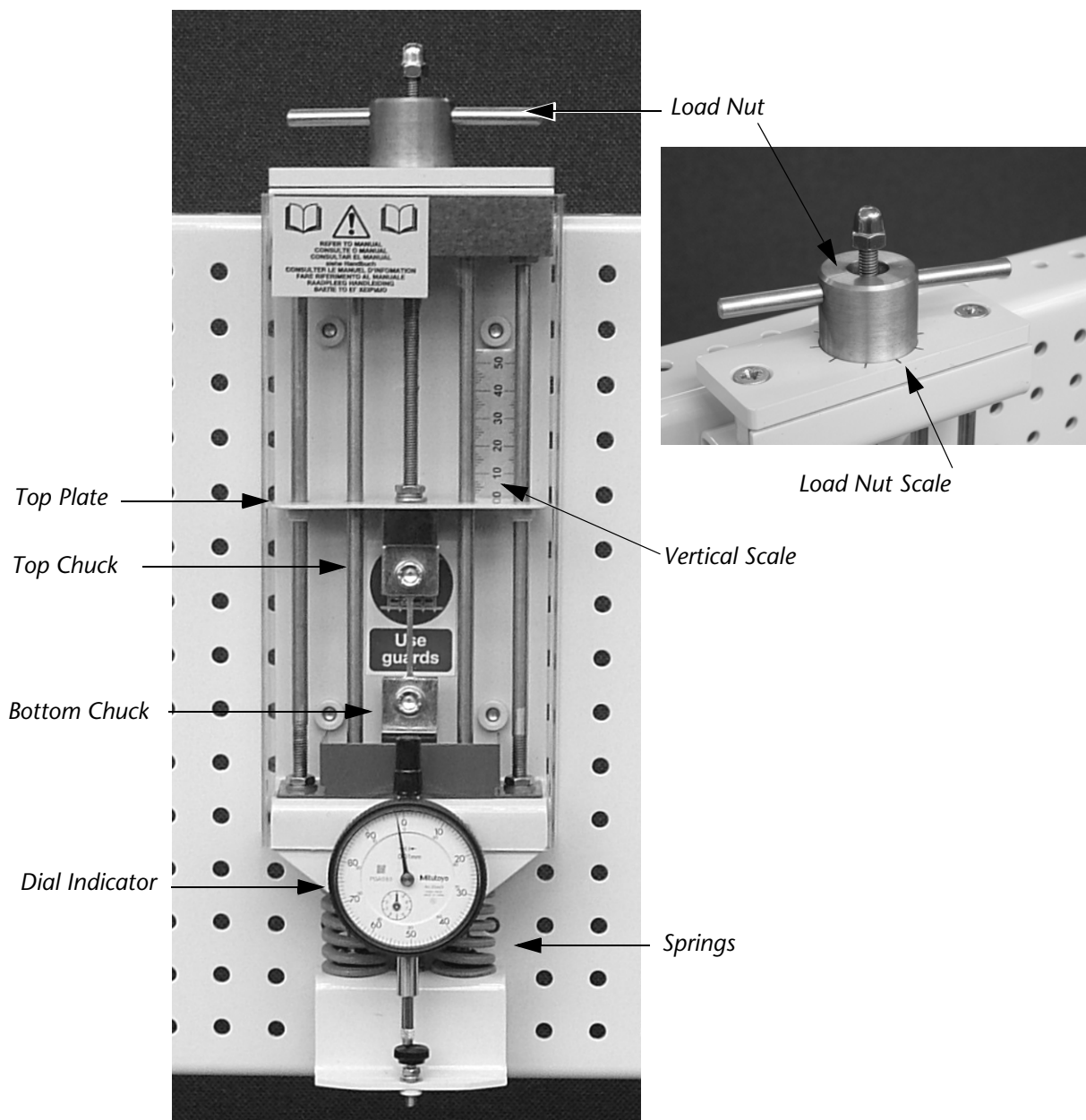


Figure 3 Front View of the Tensile Tester

The Tensile Tester is simple to use. Two chucks hold a specimen (see “Specimens” on page 11). The Load Nut at the top of the tester pulls the top chuck upwards, pulling the specimen up by 1 mm per complete turn. The Load Nut has a small notch and a scale divided into ten increments that helps you to see how far you have turned the control on each turn (each increment shows an upward pull of 0.1 mm).

The bottom chuck connects to the two large springs. A Dial Indicator measures the deflection of the springs as you apply force. The springs obey Hooke’s Law, so the measurement from the Dial Indicator helps to show force.

The Top Plate works with a vertical scale to help you to remember how many turns you have done with the Force Control (one turn = 1 mm).

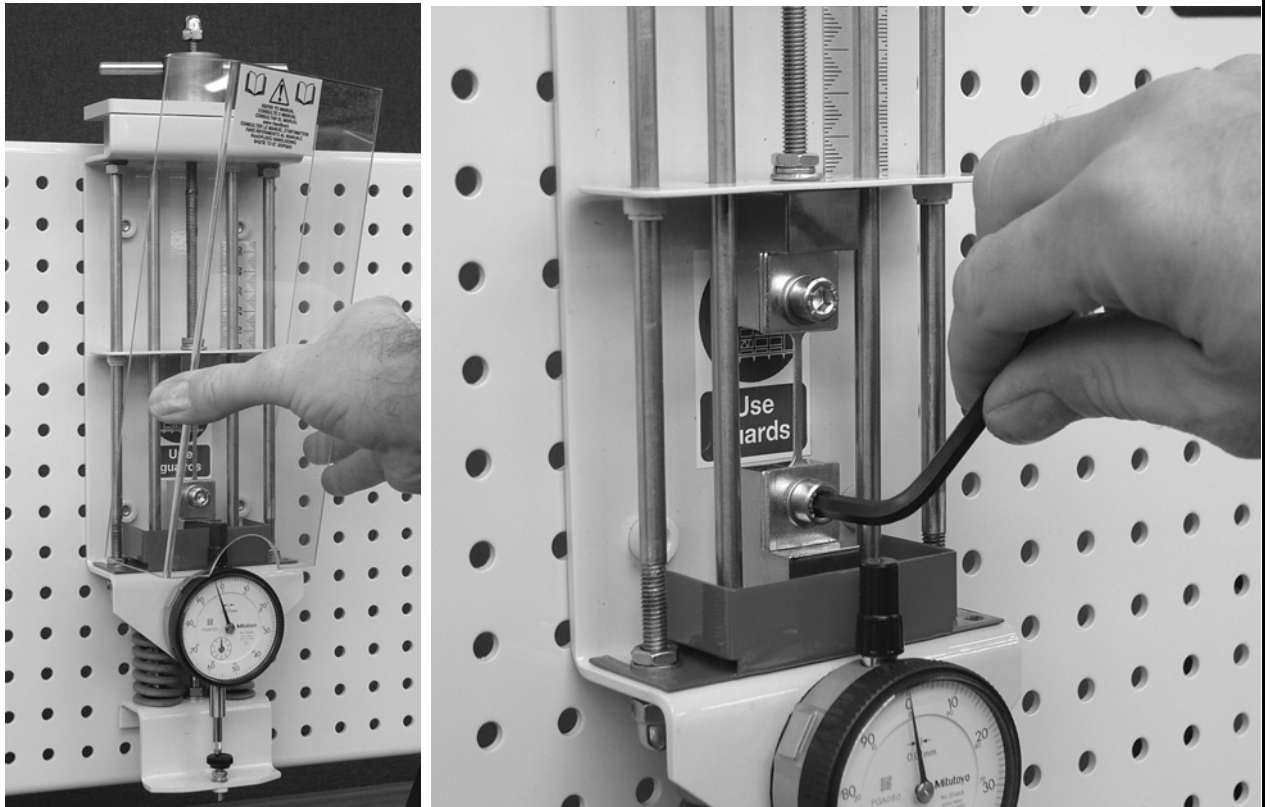
Fitting or Removing a Specimen

Figure 4 Remove the Safety Guard and Use the Hexagon Tool (supplied)

To fit a new specimen or remove a broken specimen, remove the Safety Guard and use the Hexagon Tool to undo the specimen fixings and refit them on the new specimen.

When fitting a new specimen, you may need to turn the Load Nut a few turns for the specimen to fit correctly.

Refit the Safety Guard.

Setting the Dial Indicator to Zero



Figure 5 Turn the Outer Bezel

When you fit a new specimen, carefully turn the force control clockwise until the Dial Indicator just starts to show a movement and the notch of the Force Control points to one of the ten marks of its circular scale. Now turn the outer bezel of the dial indicator so that its pointer aligns with the 0 (zero) value.

Measuring Extension and Force

$$\text{Extension (mm)} = \text{Number of Turns of Force Control (mm)} - \text{Dial Indicator Reading (mm)}$$

For example - if you have turned the control three complete turns and the Dial Indicator reading is 2.83 mm, then the extension = 3.00 - 2.83 = 0.17 mm.

The Dial Indicator also gives an indication of the force applied to the specimen. The springs have a combined spring rate of 100 N/mm. The Dial Indicator gives a direct reading of the change in spring length, so each mm it changes by is equal to a change of force of one hundred Newton.

$$\text{Force (N)} = \text{Dial Indicator reading (mm)} \times 100$$

For example - assuming you have correctly set the Dial Indicator to zero and it reads 2.83 mm after you apply the force, then the force is 283 N.

CAUTION



Never try to test specimens other than those supplied by TecQuipment. You could break the tester.

Do not apply loads of greater than 1000 N.

WARNING



Always fit the safety guard before testing a specimen.

Never use the tester without correctly fitting the safety guard.

Specimens

To test a particular material, it must be prepared in the form of a specimen. In real applications, specimens may be cut from a sample of a real part. For the tests with this kit, the specimens are specially made from different materials:

- A basic aluminium alloy
- Duralumin - a high specification aluminium alloy
- Mild steel - a basic steel alloy
- PVC (polyvinyl chloride) - a common thermoplastic

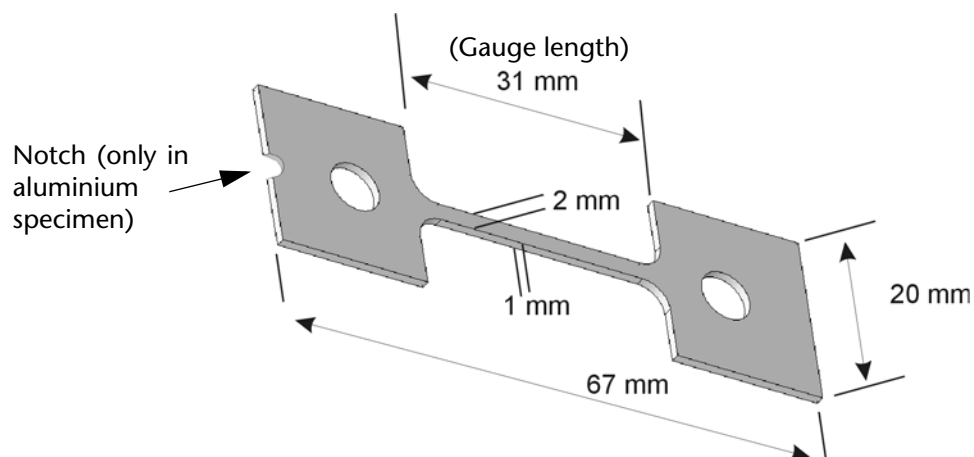
Duralumin and aluminium are very similar, so to help you, TecQuipment have put a small notch in the aluminium specimens. The steel specimens are heavier than the others and you can use a magnet (not supplied) to confirm they are made of steel. The PVC specimens are lighter in weight than the others and have a non metallic colour (usually black).



The PVC specimens may have a thin plastic film stuck to them, to help protect their surface from scratches. Remove this film before testing.

TecQuipment make the specimens to fit in the machine. Each specimen has a large flat area at each end connected by a thin section. The machine holds the flat areas and stretches the thin section. This thin section is the 'gauge length'.

For your calculations, you will need to accurately measure the dimensions of your test specimens using the Dial Caliper supplied. Figure 6 shows the nominal dimensions for reference. To help easily compare results, all specimens have the same nominal dimensions.



Nominal cross-section = 2 mm^2 (0.000002 m^2)

Figure 6 Nominal Specimen Dimensions

Accurate Results

For best results:

- Do not rush your experiment.
- Double-check each reading.
- Repeat the experiment if you are not sure of your results.

Do not expect your results to be exactly as shown in the theory. Theory always shows 'perfect' or 'ideal' results, based on perfect scientific conditions. Your 'actual' results will be slightly different to theory, based on the accuracy of the equipment and how carefully you do your experiment.

You may learn more about your experiments by making and finding mistakes than getting things right first time!

Other Things You May Need

These are things that are not in the Kit but you may need to complete your experiments. You should already have these things as part of your normal student equipment (pencil case) or your teacher may supply them:

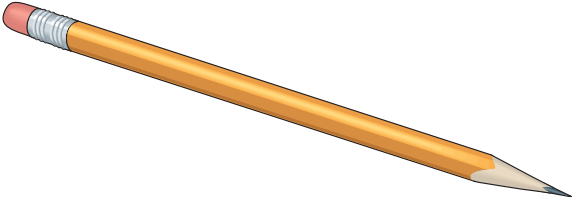
Part	Image
Pencil	

Table 2 Other Things you May Need

Theory**Notation**

Symbol	Meaning	Units
A	Area	m^2
F	Force	N
σ	Stress	N/m^2 or Pa
ε	Strain	-

Table 3 Notation

Stress (σ)

Shown by Equation 1, this is the force applied to a material over a known area.

$$\sigma = \frac{\text{Force}}{\text{Area acted on by the force}} \quad (1)$$

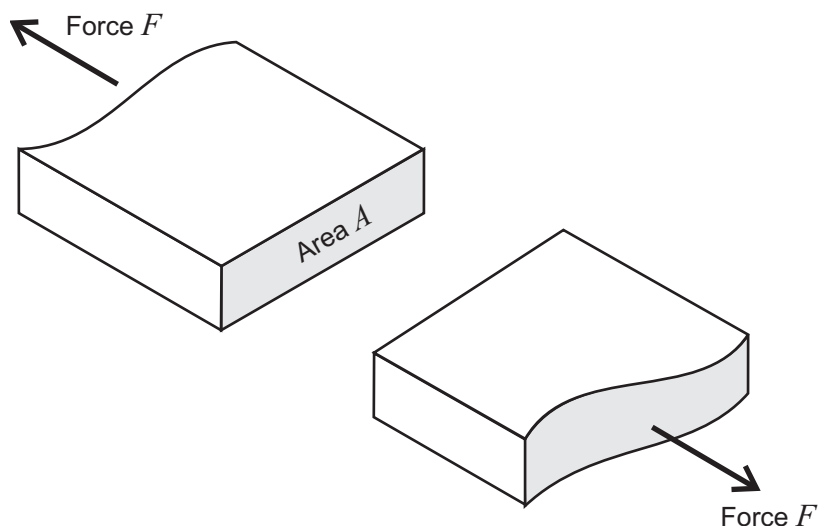


Figure 7 Force and Area

Compressive stress is where the material is compressed. It usually has a negative value.

Tensile stress is where the material is stretched. It usually has a positive value.

For the specimens in the kit, the area is the cross-sectional area of the **thinnest part** of the specimen along the gauge length, so:

$$\sigma = \frac{F}{A} \quad (2)$$

NOTE



In reality, as a specimen stretches, its cross-sectional area decreases, which has a reciprocal affect on the stress. It is normal in tensile tests to assume a constant cross-sectional area.

Units of stress are usually N/m^2 or Pa. Alternative divisions of these units are N/mm^2 and megapascals (MPa).

$$1 \text{ MPa} = 1 \text{ N/mm}^2$$

Strain (ϵ)

Shown by Equation 3, this is the change in length (distortion caused by stress) of a material over its original length.

$$\epsilon = \frac{\text{Change in Length}}{\text{Original Length}} \quad (3)$$

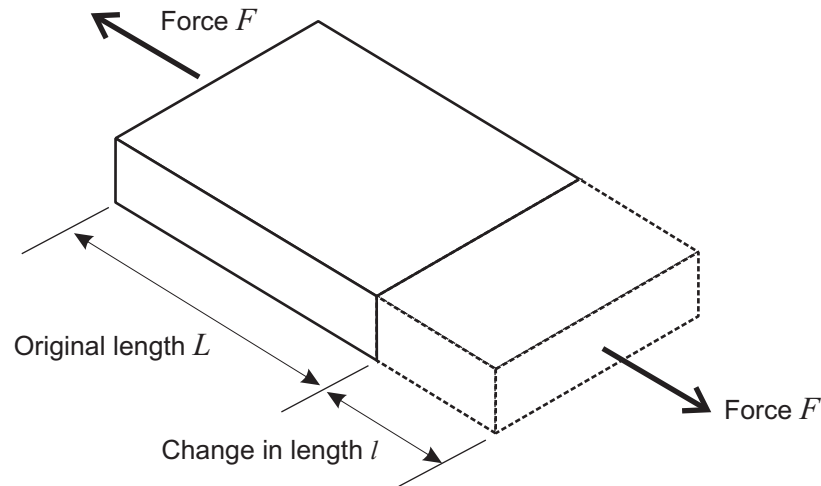


Figure 8 Change in Length

$$\epsilon = \frac{l}{L} \quad (4)$$

Because strain is the ratio of two distances, it is dimensionless (it has no units). However, since measured strain is usually very small it is often shown in the form of 'microstrain' ($\mu\epsilon$) = strain $\times 10^{-6}$.

Compressive strain is where the material has compressed. It usually has a negative value.

Tensile strain is where the material has stretched. It usually has a positive value.

Elastic Deformation

When you apply a force to a material it will stretch (change its length). If the material is perfectly elastic, then when you remove the force, the material will return to its original length and shape. Because the stress and strain directly relate to force and change in length, we can also say that as the stress increases, so does the strain.

For most engineering materials with a moderate stress, the stress and the strain are proportional, ie an increase in stress give a corresponding increase in strain. Materials that follow this relationship are said to obey Hooke's Law.

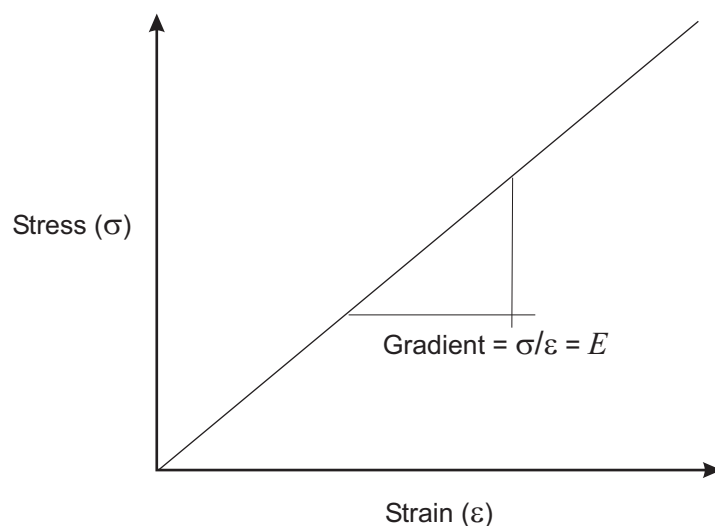


Figure 9 Stress Against Strain

The ability of a material to resist strain for a given stress is called its stiffness. The stiffness of a material is given by its **Young's Modulus** (E) named after the English Physicist Thomas Young. It is simply the ratio of stress to strain, or in other words the gradient of the stress strain graph. Stiffness should not be confused with strength, a material can be stiff but weak and vice versa. Common Engineering materials like Aluminium alloys have very similar stiffness's but their strengths can vary hugely dependant on what the pure aluminium is mixed with and how the material is processed.

Actual and Nominal Strain

For most materials, strains in the elastic region for most materials are extremely small. For the size specimens we use in the ES6 machine they are in the order of microns (one micron equals one thousandth of a millimetre or one millionth of a metre) to find the actual strain an expensive, accurate and delicate device called an **extensometer** is used. This attaches directly across the gauge length of the specimen measuring only the amount the specimen stretches (and nothing else). Since most tensile testing machines (and the ES6 Machine) measure the strain via the chucks and the body of the machine the amount of movement in the machine itself is also included in the measurements. This of course does not affect the stress measurement, only the strain. To avoid confusion this total strain is referred to as the **nominal strain**. We cannot use the nominal strain to find accurate results for the Young's modulus, but we can use the gradient of the Stress and Nominal strain plot to be a useful comparison of the stiffness of a number of different materials.

Plastic Deformation

Most materials behave perfectly elastically up to a certain stress. After this stress they no longer obey Hooke's Law. That is to say that if we remove the load after this point the material does not return to its original length and shape. At this point the material is said to have 'yielded'. The value of stress at this point is called the **Yield Stress**. After this point there is often only a relatively small increase in stress with a

corresponding large increase in strain. This is called **plastic deformation**. The plastic deformation continues until eventually the material breaks. The **maximum** stress before the material breaks is called the **tensile strength** or ultimate tensile strength.

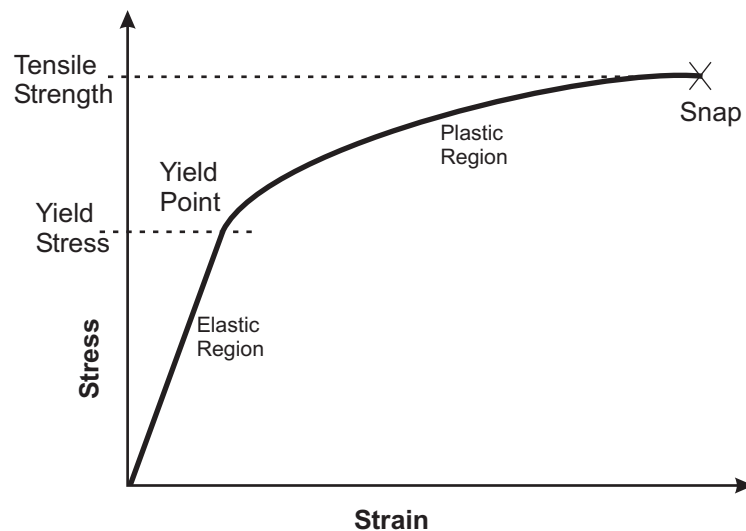


Figure 10 Stress and Strain Chart



Do not confuse the terms 'plastic', 'plasticity' or 'plastic region' with the word 'plastic' used to describe the specimen material type (for example - metal or plastic specimens).

Most engineering materials have both elastic and plastic characteristics. Materials which stretch very little once they have yielded (if they do at all) tend to be called **brittle**, whilst ones that stretch a lot tend to be called **ductile**. Examples of brittle materials are bricks, concrete and cast iron. Examples of ductile materials include mild steel, aluminium and most thermoplastics.

Typical Charts

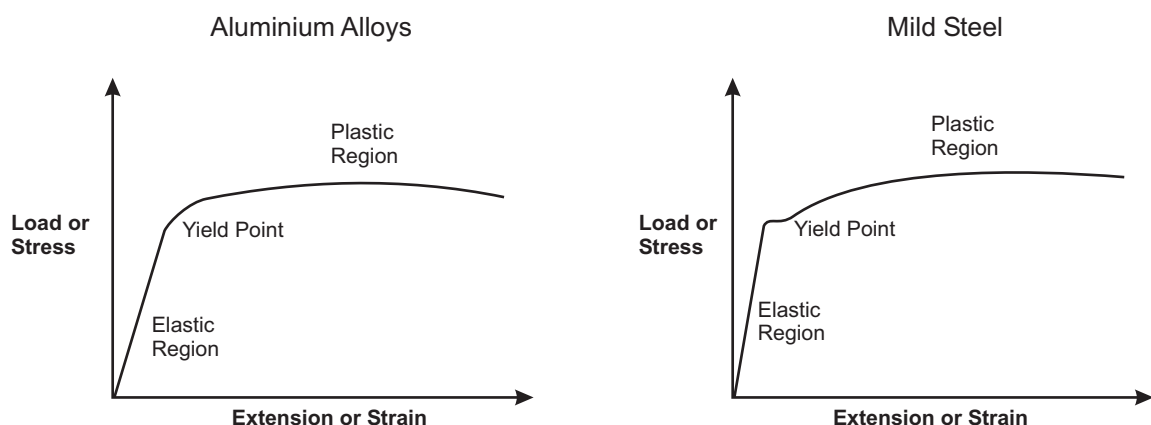


Figure 11 Typical Aluminium and Steel Charts

Figures 11 and 12 show typical charts for tests on different materials. They may be of simple force against extension or more usually, stress against strain. Aluminium alloys normally produce charts with a clear yield

point and a non-linear plastic region. Steel and other iron-based metals can give an extended yield point before entering the plastic region (determined by the way the steel is processed - cold drawn or heat treated). Most thermoplastic materials are very ductile and reach a maximum tensile strength at the yield point, then drop slightly and continue stretching with lower force in the plastic region.

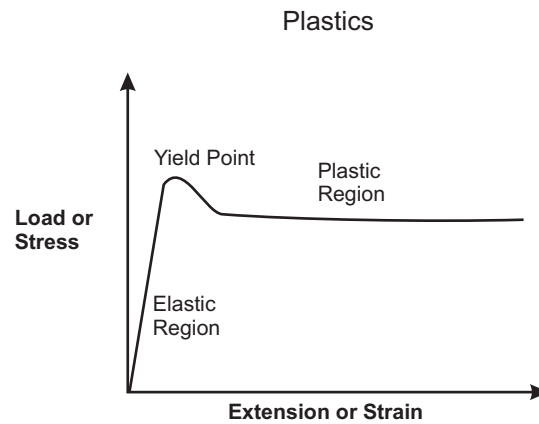


Figure 12 Typical ThermoPlastic Chart

Elongation and Percentage Elongation

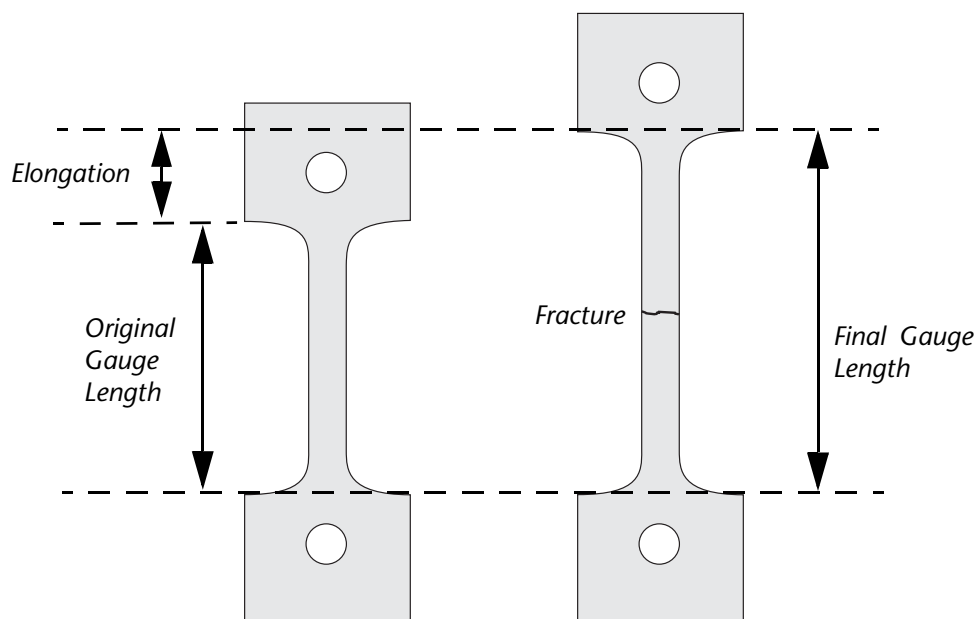


Figure 13 Elongation

Elongation is a simple value, often stated as an indication of ductility. You find it by subtracting the **final** length of the gauge length of a test specimen (**after it has broken**) by its original gauge length. You will need to carefully push the two pieces back together at the fracture point to measure the final length. The vertical scale on back of the tester should also give a reasonable indication of the elongation after fracture if you turn the force control back until the two pieces meet at the fracture.

The elongation is the difference between the final length and the original length.

$$\text{Elongation} = \text{Final Length} - \text{Original Length}$$

To calculate the value as a percentage:

$$\% \text{Elongation} = \frac{\text{Final Length} - \text{Original Length}}{\text{Original Length}} \times 100$$

Worked example:

Length of test section before test = 31 mm

Length after test = 33 mm

Elongation = 33-31 = 2 mm.

%Elongation = $[(33-31)/31] \times 100 = 6.45\%$

