# CREEP TEST

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## ▶OBJECTIVE:

The fundamental objectives of this study are:

1. Students are required to study the principal of creep testing and practice the testing procedure.
2. To demonstrate and calculate creep in different temperatures.
3. To experimentally obtain the creep curve.

## ▶APPARATUS REQUIRED:

SM1006 Creep Machine, Lead specimens(CP1010), Vernier Caliper, Weights, Heating Controller, Thermometer


## □THEORY:

### Elasticity and Plasticity (or Elastic and Plastic Deformation)

When a material is stressed so that it compresses or stretches (deforms), then returns to its original shape when the stress is removed, the material is perfectly elastic.

The atoms in the material have not moved, but the bonds between them have stretched, then returned to their original position. When a material is stressed so that it compresses or stretches (deforms), then does not return to its original shape when the stress is removed, the material is perfectly plastic. The atoms have actually moved and will not return. Most materials have both elastic and plastic properties. When stressed by a small amount, they behave like an elastic material, up to their elastic limit. When stressed by a large amount (that takes them past their elastic limit), they behave like a plastic material. Rubber and soft plastic materials usually have more elasticity than more brittle materials like metal or ceramics.

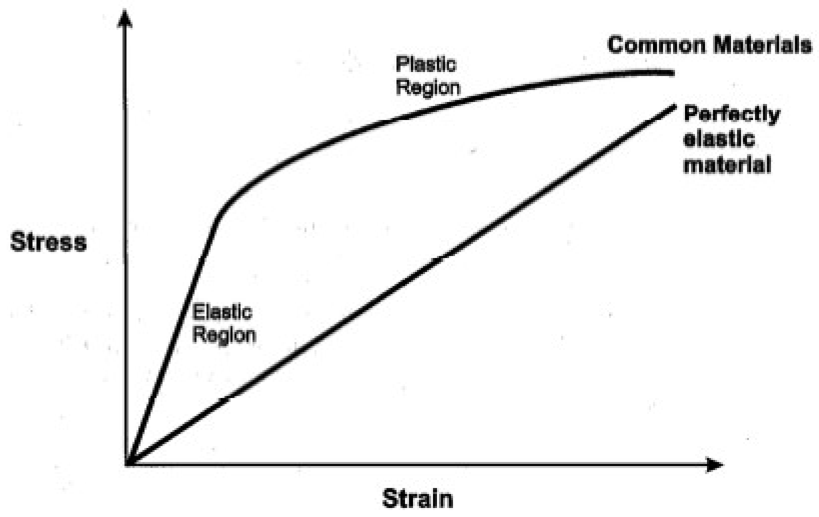


**Fig. 1 Stress/Strain Curves**

## Creep – An Increase in Strain Over Time

When the stress on a material takes the material above its elastic limit and into its plastic region, then the material permanently deforms, due to the movement of atoms in the material. If the stress is maintained, the deformation continues. This slow, gradual deformation is called 'creep'. It is an increase in strain over time. Even hard materials like concrete will creep under stress, given enough time (many years). Creep happens due to long term stress levels that are below yield stress. The material permanently deforms to relieve the stress.

Creep is easily measured in pure metals when their temperature is one third (or 30%) of their melting temperature.

Four main things determine the speed and amount of creep:

· Applied load – higher loads give higher stresses that increase the speed of creep

· Type of material – softer materials creep more quickly for the same value of stress · Dimensions of the material – thinner materials take higher stresses for the same value of load

· Temperature of the material – higher temperatures encourage faster creep

The applied load and the dimensions of the material determine the stress, so you could say that three main things determine creep: stress, material and temperature.

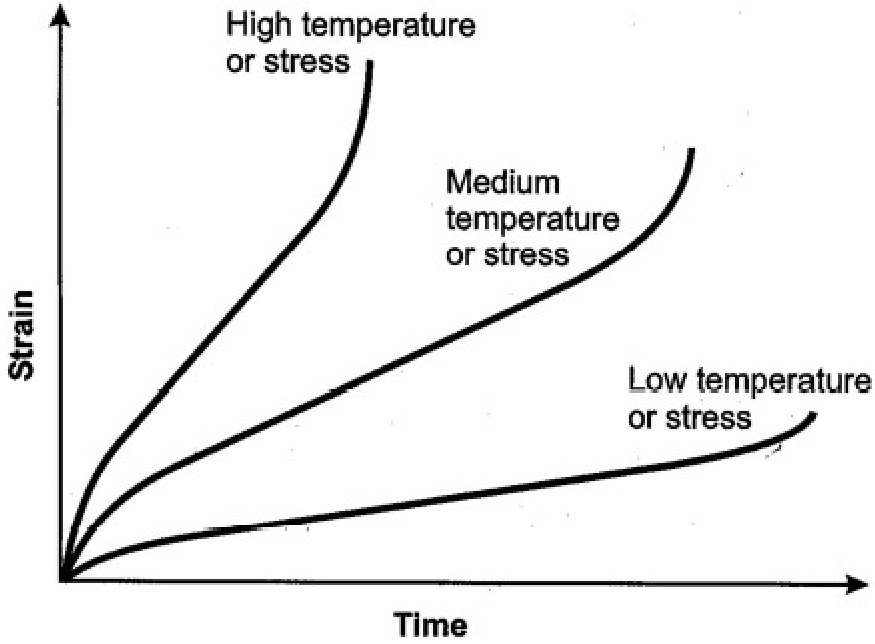


**Fig. 2 Curves of Creep at Different Temperatures and Stress**

## Material Failure (Fracture)

When a material is subject to creep, after enough time, the material will fail (fracture). Rubber materials can deform much more than plastic materials before they fail. Plastic materials can deform much more than metals before they fail. Metals can deform much more than silicone based material before they fail. This is because the failure is determined by the molecular structure of the material.

## Three Stages of Creep

Three regions can be readily identified on the curve:

· Primary Creep - creep proceeds at a diminishing rate due to work hardening of the metal.

· Secondary Creep - creep proceeds at a constant rate because a balance is achieved between the work hardening and annealing (thermal softening) processes.

· Tertiary Creep - the creep rate increases due to necking of the specimen and the associated increase in local stress.

Primary creep does not start until the material has passed its elastic limit.

The secondary creep stage is almost linear because this is the stage where the material is actually becoming ‘work hardened’, which helps to resist the load. The gradient of the secondary creep determines the creep rate for the material.

The point between the second and third stage is the ‘Transition Point’. This indicates that the material is starting to fail and may already start to crack in places.

Engineers must realize that they can allow materials to enter the first and second stages of creep, but never the third, as the part (or structure) will fail. It is important for engineers to know the second stage creep rate, so that they when to change a part in a machine or structure.

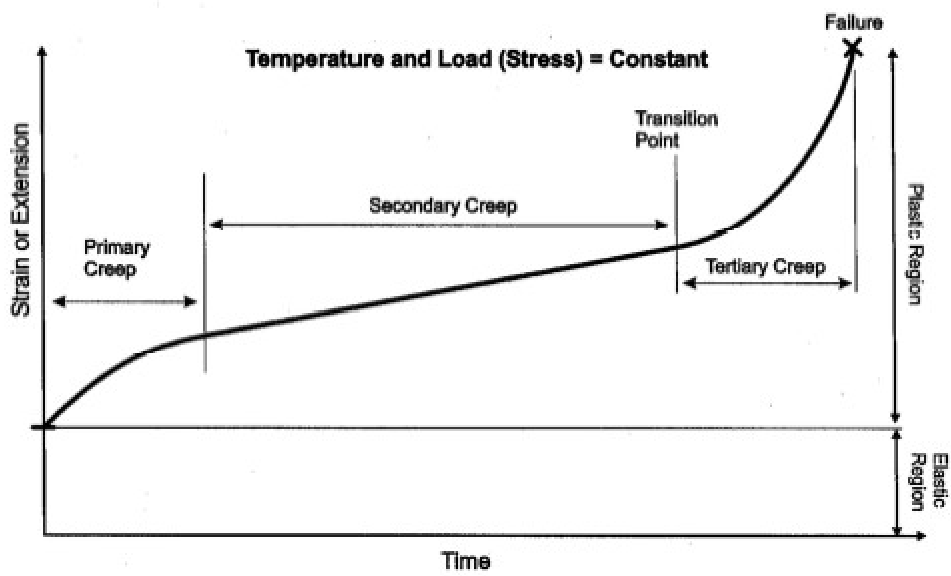


**Fig. 3 The Three Stages of Creep**

## Calculation of Creep Rate (secondary creep)

Secondary creep rate is linear, so to find it you only need a measurement of the change in dimension (strain) of the material over time, from a test at a constant temperature and stress. The equation for this is:

$$\dot{\epsilon} = \frac{\Delta\epsilon}{\Delta t}$$

TESTS:

## Procedure

1. Accurately measure and record the width and thickness of the specimen.
2. Put the weight hanger in position and fit its support pin in its highest hole to hold the arm up and ready for the test specimen. 3. Fit the steel specimen support clips to the specimen.
4. Fit the specimen into place between the black support block and the arm, and fit the pins.
5. Put the transparent cover into place around the specimen. Make sure that the thermometer is in its hole in the top of the cover and its tip is near to the specimen. Wait for at least five minutes for the temperature reading to stabilize, and then record the temperature around the specimen.
6. Fit a suitable weight to the Weight Hanger, to give a stress that gives the longest test time that you can allow.
7. Carefully remove the Weight Hanger support pin from the highest hole in the Weight hanger.
8. Switch on the digital indicator and press its origin button to set its display to zero. Make sure that it is set to work in reverse (press the +/- button so that the word REV is shown in its display).
9. Lift the Weight Hanger and support it while you fit the support pin in the lowest hole.
10. Gently (and at the same time) – let go of the Weight Hanger and start your timer. Slide the rubber mat (supplied) onto the Base Plate, underneath the Weight Hanger.
11. Record the specimen extension, until it fracture or stops extending.
12. Repeat the test; increase the temperature around the specimen using the heater.

## □Results

1. For each test, plot a chart of specimen extension (mm) of the vertical axis against time (second) on the horizontal axis.
2. On the most linear (secondary creep) part of your curve, calculate the gradient. This is the creep rate (in mm/sec).
3. For each value of stress at a constant temperature, on one chart, plot curves of the natural log on strain rate(ln ε□) (vertical axis) against natural log of the stress value(ln σ) (horizontal axis).

For a correct comparison, the units of strain rate must be in mm/s and the units of stress must be in N.mm-2. Also, remember that strain is a change in overall length, so you must divide the creep rate by the total length of the test part of the specimen to get strain rate.

$$\dot{\epsilon} = \frac{creep\ rate(\frac{mm}{min})}{60\ \times\ 20}$$

4. From your curves, find the vertical difference in ln ε□ between two temperature curves. Use equation to find the activation energy

$$Q = \frac{\Delta(ln\ \dot{\epsilon})}{\Delta(\frac{1}{T})} \times R$$

## ▶ Discussion(For each result)

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