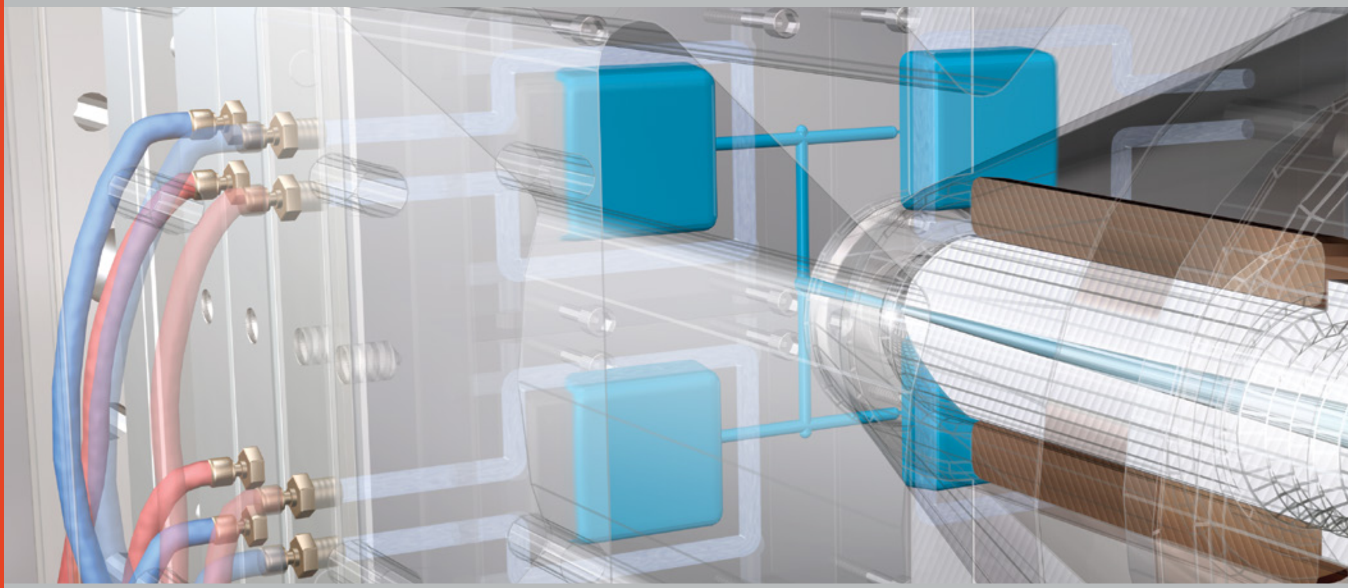
REFERENCE SERIES: DESIGN

Understanding Stress/Strain Curves for Plastics



nexeo plastics

Created exclusively for **Nexeo Plastics** by Routsis Training, this free guide contains excerpts from Routsis's ***Mold & Part Design Courses***.

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STRESS / STRAIN CURVES

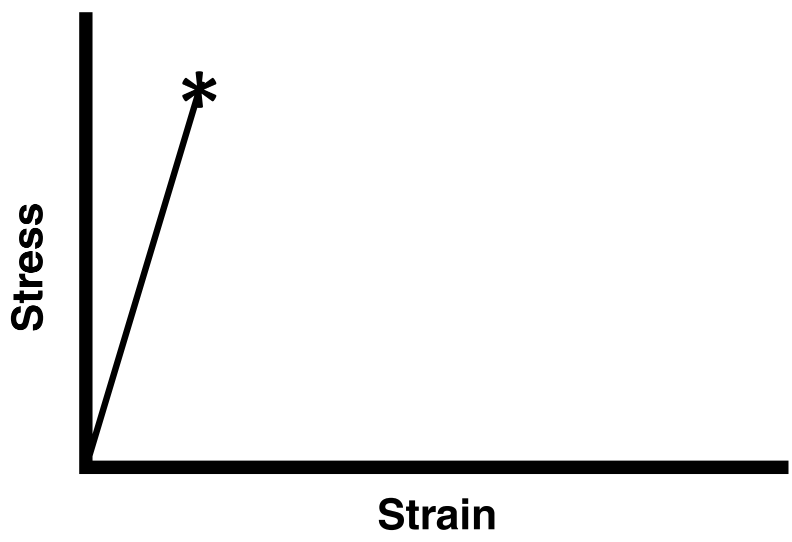
Stress/Strain Curves are used to test various material attributes. These can be performed on virtually any material — including both metallic and polymeric materials.

Strain is represented on the horizontal, or X axis. Strain is a measure of deformation in the sample. This deformation is calculated by the change in length divided by the original length. Strain is typically graphed by **Percent Strain**. Stress represented on the vertical, or Y axis.

Stress is calculated by the force applied to the sample divided by the cross sectional area and is typically graphed as **pounds per square inch** or in **megapascals**.

The curve on the graph represents the material's behavior when a stress or strain is applied. The asterisk at the end of the curve indicates failure of the test sample.

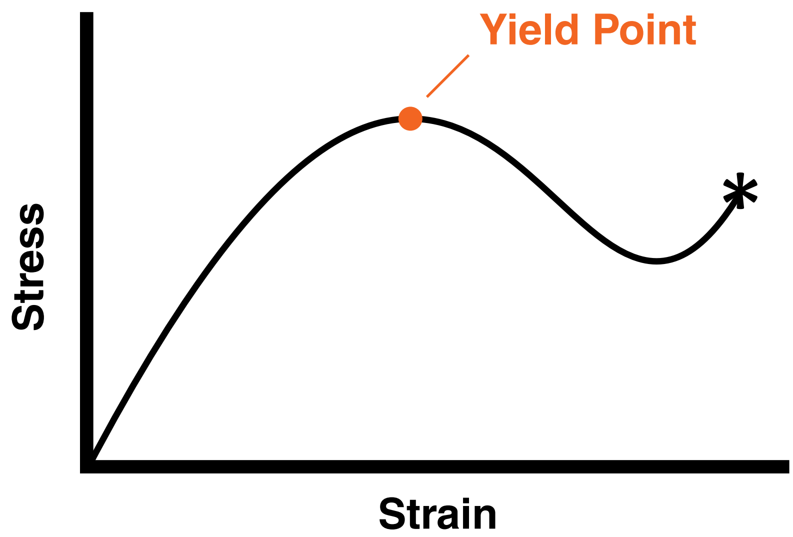
Typical Stress/Strain Curve of a Metal Material



Metals exhibit linear Stress/Strain behavior. As the sample is stressed, the resulting graph is linear — or in a straight line. The slope of the line is equal to the modulus of the material. After the sample is strained — provided it has not yielded or failed — it returns to its original shape, like a spring. This is called **Elastic Behavior**.

Polymers, on the other hand exhibit **Visco-elastic Behavior**. This means that they respond like a metal material by exhibiting elastic behavior, but also exhibit viscous behavior, like a liquid.

Typical Stress/Strain Curve of a Ductile Polymer



The Stress/Strain curves for metal materials tend to be relatively simple. The curve is linear, and the slope of the line represents the modulus of the metal. Since metals exhibit elastic behavior, the behavior of the material is fairly predictable.

Polymers do not behave in the same manner. The modulus of plastics is only for the initial slope of the line, and does not accurately depict the behavior of the material under large stresses or strains.

The linear portion of the curve is referred to as the **Elastic Region**. This region is where the polymer deformation is mostly elastic, with very little viscous flow. Most of the deformation in this region can be recovered if the stress or strain is immediately removed.

As the curve looses its linearity, it reaches what is referred to as the **Proportional Limit**. After this, the polymer flows more, and the stress required to strain the polymer slowly increases until the polymer yields.

As the polymer yields, the stress required to strain the sample lessens as strain is increased. After the **Yield Point**, the polymer exhibits unrecoverable viscous deformation.

Obtaining Stress/Strain Data

Most material suppliers provide Stress/Strain graphs for their materials. If the supplier cannot provide such information, it is possible to derive a similar graph from the material supplier's Initial Modulus, Strength & Stress at Yield, and Strength & Stress at break information. Such a graph can be useful in understanding the behavior of a polymer, but it does not represent the material's actual performance. If more accurate information is required, samples should be obtained and tested.

Various tests, such as Tensile Tests can produce Stress/Strain data. In these tests, a sample of the material is placed into a tensile tester. The sample is strained or pulled at a constant rate. The force required to pull the sample is recorded over time. The distance the sample is pulled is translated into % Strain — and the force applied to the test sample is translated into Stress, represented in p.s.i. or megapascals. This data is plotted and graphed to create the Stress/Strain curve.

When obtaining Stress/Strain information, be sure that the testing conditions are similar to that of the application. Polymeric materials are sensitive to the testing rate and temperature used. For example, if a material is tested at one rate, and is found to have a modulus of 2000 pounds per square inch, the same material could show a modulus of 3000 psi if tested at a faster rate, or at a lower temperature.

Stress/Strain Curves for Rigid Polymers

Many rigid polymers break before the polymer reaches a yield point. In very flexible polymers, the stress gradually increases with strain after the initial stress. Although these materials do not exhibit yield points, they still have a modulus, proportional limit, and breaking point.