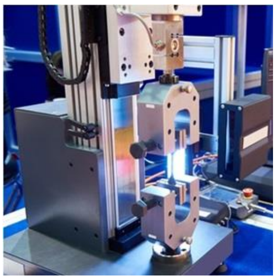
Elongation at Yield



Mechanical Property to Characterize Materials

Elongation at Yield is the ratio between increased length and initial length at the yield point.

In an ASTM test of tensile strength, the test specimen is pulled from both the ends. As the pulling progresses, the specimen bar elongates at a uniform rate that is proportionate to the rate at which the load or pulling force increases.

Beyond proportional limit & elastic stress limit, further pulling of specimen is opposite direction causes a permanent elongation or deformation of the specimen.

There is a point when an increase of strain is not provoked by an increase of stress on the test specimen i.e. beyond which the plastic material stretches briefly without a noticeable increase in load. This point is known as the **yield point**.

- Most unreinforced materials have a distinct yield point.
- Reinforced plastic materials exhibit a yield region.

Elongation at yield is related to the ability of a plastic specimen to resist changes of shape before it deforms irreversibly

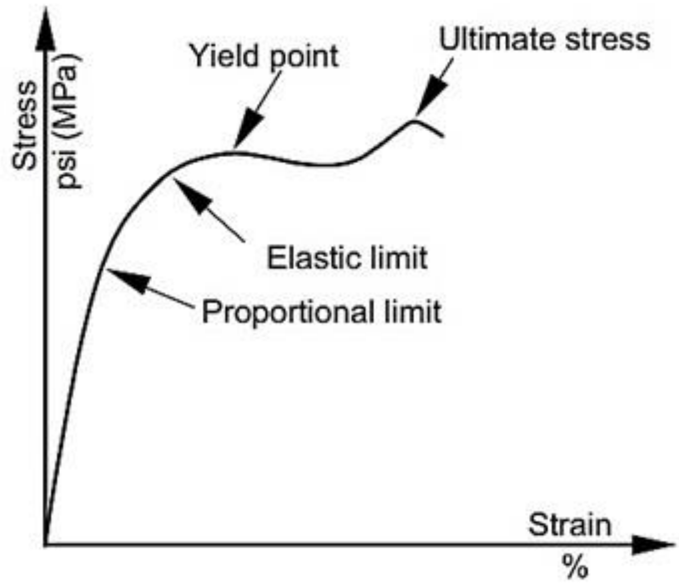
How to calculate elongation at yield point? Since, Elongation at yield is the deformation of a thermoplastic or thermoset material at this yield point, it is calculated as the relative increase in length.

$$\textbf{Elongation} = \varepsilon = (\Delta L/L) \times 100$$

Where:
- » ΔL: Change in Length
- » L: Initial Length

It is measured in % (% of elongation vs. initial size when yield point is reached).

Elongation at Yield is also known as tensile elongation at yield.



Typical Stress v/s Strain Diagram of Plastics

Also, it is equally interesting to understand the main **difference between Tensile Strength and Yield Strength**.

Yield Strength is the stress a material can withstand without **permanent deformation** or a point at which it will no longer return to its original dimensions (by 0.2% in length). Whereas, Tensile Strength is the maximum stress (usually represented in PSI) that a material can withstand while being stretched or pulled before failing or breaking.

Check out more on Elongation at Yield:

» Elongation at Yield Values of Several Plastics
» How to Calculate the Elongation at Yield of Plastic
» Factors Affecting Elongation at Yield

Also learn about **Elongation at Break** in detail.

How to Measure Elongation at Yield?

Tensile tests measure the force required to break a specimen and the extent to which the specimen stretches or elongates to that breaking point.

In general, "tensile test methods" are applied measure elongation at break of materials. The common methods used are:

ASTM D638 - Standard Test Method for Tensile Properties of Plastics
ISO 527-1:2012 - Determination of tensile properties. General principles

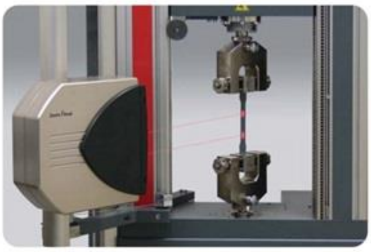
Of course, there exists several other methods as well as listed below, but they are not discussed here.

ASTM D638 and ISO 527 Test Methods

ASTM D638 and ISO 527 test methods cover the determination of the tensile properties of plastics and plastic composites under defined conditions in the form of standard dumbbell-shaped test specimens. The defined conditions can range from pretreatment, temperature, humidity, to testing machine speed.

And, the following calculations can be made from tensile test results:

- Tensile strength (at yield and at break)
- Tensile modulus
- Strain
- Elongation and percent elongation at yield
- Elongation and percent elongation at break


Source: ASTM

For ASTM D638 the test speed is determined by the material specification. For ISO 527 the test speed is typically 5 or 50mm/min for measuring strength and elongation and 1mm/min for measuring modulus.

An **extensometer** is used to determine elongation and tensile modulus.

Factors Affecting Elongation at Yield

Some of the factors impacting the Elongation at Yield values of thermoplastics include:

- Velocity of Testing - Slow testing allows for polymer relaxation and higher elongation values
- Orientation Level of Fibers - Fibers that are less oriented tend to exhibit greater degrees of elongation
- Temperature - In general, the elongation increases with an increase in temperature
- Filler Content - The elongation of composites decreases with an increase in the filler content

Other than these, the strength of polymers is further governed by their:

- **Molecular Weight**: The strength of the polymer rises with increase in molecular weight and reaches the saturation level at some value of the molecular weight.
  - At lower molecular weight - the polymer chains are loosely bonded by weak van der Waals forces and the chains can move easily, responsible for low strength, although crystallinity is present
  - At higher molecular weight polymer - The polymer chains become large and hence are crosslinked, giving strength to the polymer
- **Cross-linking**: The cross-linking restricts the motion of the chains and increases the strength of the polymer.
- **Crystallinity**: The crystalline phase of polymer increases strength; hence the intermolecular bonding is more significant. Therefore, the polymer deformation can result in the higher strength leading to oriented chains.

Elongation at Yield Values of Several Plastics

Polymer Name	Min Value (%)	Max Value (%)
ABS - Acrylonitrile Butadiene Styrene	1.70	6.00
ABS Flame Retardant	2.10	2.20
ABS High Heat	2.10	2.80
ABS/PC Blend - Acrylonitrile Butadiene Styrene/Polycarbonate Blend	3.00	5.00
ABS/PC Blend 20% Glass Fiber	1.90	2.20
ABS/PC Flame Retardant	70.0	4.00
ASA - Acrylonitrile Styrene Acrylate	3.10	3.50
ASA/PC Blend - Acrylonitrile Styrene Acrylate/Polycarbonate Blend	4.00	4.00
ASA/PC Flame Retardant	5.00	5.00
CA - Cellulose Acetate	3.10	3.50
CAB - Cellulose Acetate Butyrate	3.60	5.00
CP - Cellulose Proprionate	3.70	4.10

CPVC - Chlorinated Polyvinyl Chloride	4.00	7.00
ECTFE - Ethylene Chlorotrifluoroethylene	5.00	5.00
EVOH - Ethylene Vinyl Alcohol	1.00	8.00
HDPE - High Density Polyethylene	15.00	15.00
HIPS - High Impact Polystyrene Flame Retardant V0	1.00	2.10
LCP - Liquid Crystal Polymer	1.00	3.00
LCP Carbon Fiber-reinforced	1.00	1.00
LCP Glass Fiber-reinforced	1.00	3.00
LCP Mineral-filled	2.00	4.00
LDPE - Low Density Polyethylene	13.00	17.50
LLDPE - Linear Low Density Polyethylene	3.00	16.00
MABS - Transparent Acrylonitrile Butadiene Styrene	3.90	4.10
PA 11 - (Polyamide 11) 30% Glass fiber reinforced	3.00	4.00
PA 11, Flexible	30.00	49.00
PA 11, Rigid	5.00	10.00
PA 12 (Polyamide 12), Conductive	24.00	24.00
PA 12, Fiber-reinforced	5.00	42.00
PA 12, Flexible	25.00	26.00
PA 12, Glass Filled	5.00	6.00
PA 12, Rigid	5.00	15.00
PA 6 - Polyamide 6	3.40	140.00
PA 66 - Polyamide 6-6	3.40	30.00
PA 66, 30% Glass Fiber	3.00	3.00

Polyamide semi-aromatic	6.00	8.00
PAI - Polyamide-Imide 30% Glass Fiber	6.00	7.00
PAI, Low Friction	7.00	9.00
PAN - Polyacrylonitrile	3.00	4.00
PAR - Polyarylate	6.00	8.00
PBT - Polybutylene Terephthalate	3.50	9.00
PBT, 30% Glass Fiber	2.00	3.00
PC (Polycarbonate) 20-40% Glass Fiber	2.00	4.00
PC (Polycarbonate) 20-40% Glass Fiber Flame Retardant	2.00	4.00
PC - Polycarbonate, high heat	6.00	7.00
PC/PBT Blend - Polycarbonate/Polybutylene Terephthalate Blend	4.40	4.50
PC/PBT blend, Glass Filled	1.300	1.590
PE - Polyethylene 30% Glass Fiber	1.50	2.50
PEEK - Polyetheretherketone	5.00	5.00
PEEK 30% Carbon Fiber-reinforced	1.00	3.00
PEEK 30% Glass Fiber-reinforced	2.00	3.00
PEI - Polyetherimide	6.80	7.20
PEI, 30% Glass Fiber-reinforced	7.20	3.00
PEI, Mineral Filled	6.00	6.00
PEKK (Polyetherketoneketone), Low Cristallinity Grade	3.00	8.00
PESU - Polyethersulfone	1.90	6.70
PESU 10-30% glass fiber	2.00	6.00
PET - Polyethylene Terephthalate	3.80	3.80

PET, 30% Glass Fiber-reinforced	2.00	7.00
PET, 30/35% Glass Fiber-reinforced, Impact Modified	6.00	6.00
PETG - Polyethylene Terephthalate Glycol	3.90	4.10
PI - Polyimide	4.00	10.00
PMMA - Polymethylmethacrylate/Acrylic	2.00	10.00
PMMA (Acrylic) High Heat	2.00	10.00
PMMA (Acrylic) Impact Modified	3.80	5.00
PMP - Polymethylpentene 30% Glass Fiber-reinforced	2.00	3.00
POM - Polyoxymethylene (Acetal)	8.00	23.00
POM (Acetal) Impact Modified	10.00	15.00
PP - Polypropylene 10-20% Glass Fiber	3.00	4.00
PP, 10-40% Mineral Filled	2.00	3.00
PP (Polypropylene) Copolymer	6.00	250.00
PPA - Polyphthalamide	6.00	6.00
PPE - Polyphenylene Ether	2.00	7.00
PPE, 30% Glass Fiber-reinforced	3.00	3.00
PPE, Flame Retardant	2.00	7.00
PPE, Impact Modified	30.00	30.00
PPS - Polyphenylene Sulfide	1.00	4.00
PPS, 20-30% Glass Fiber-reinforced	1.00	2.00
PPS, 40% Glass Fiber-reinforced	1.00	2.00
PPS, Conductive	0.50	3.00
PPS, Glass fiber & Mineral-filled	1.00	3.000
PPSU - Polyphenylene Sulfone	7.20	7.20

PS (Polystyrene) Crystal	1.00	4.00
PS, High Heat	1.00	4.00
PSU - Polysulfone	5.70	6.00
PSU, 30% Glass finer-reinforced	2.00	3.00
PSU Mineral Filled	2.00	5.00
PVC (Polyvinyl Chloride), 20% Glass Fiber-reinforced	2.00	5.00
PVC Rigid	5.00	6.00
PVDF - Polyvinylidene Fluoride	2.00	16.00
SAN - Styrene Acrylonitrile	2.00	5.00
SAN, 20% Glass Fiber-reinforced	1.00	2.00
SMA - Styrene Maleic Anhydride 20% Glass Fiber-reinforced z	2.00	3.00
SMA, Flame Retardant V0	2.00	2.00