Heat Deflection Temperature of Plastics

HDT stands for Heat Deflection Temperature or Heat Distortion Temperature. The heat deflection temperature is a **measure of polymer's resistance to distortion** under a given load at elevated temperature.

In other words, it is the temperature at which a given polymer test bar will be bended of 0.25 mm under a given load. It is one of the two basic methods for assigning a value to the performance of plastics at high temperature. The value of 0.25 mm is an arbitrary value and has no specific significance.

The deflection temperature is also known as the 'deflection temperature under load' (DTUL), 'heat deflection temperature under load (HDTUL)', or 'heat distortion temperature' (HDT).

HDT is a measure of the "stiffness" of the material as the temperature increases

The two common loads used in heat deflection testing are:

- **0.46 MPa (67 psi)**
- **1.8 MPa (264 psi)**

Although tests performed at higher loads such as 5.0 MPa (725 psi) or 8.0 MPa (1160 psi) are occasionally encountered but they are not discussed here.

Limitations that are associated with the determination of the HDT is that the sample is not thermally isotropic and, in thick samples in particular, will contain a temperature gradient.

Applications include:

- Screen materials for injection molding developments
- Manufacture of products using thermoplastic components
- Defines use of materials in heating elements

Check out more on HDT:

- **HDT Values of Several Plastics**

» **Significance of HDT**
» **How to Calculate the HDT for plastics**
» **Heat Deflection Temperature Vs Vicat Softening Temperature**
» **Heat Deflection Temperature Vs Glass Transition Temperature (Tg)**
» **Factors Affecting Heat Deflection Temperature**

Significance of HDT

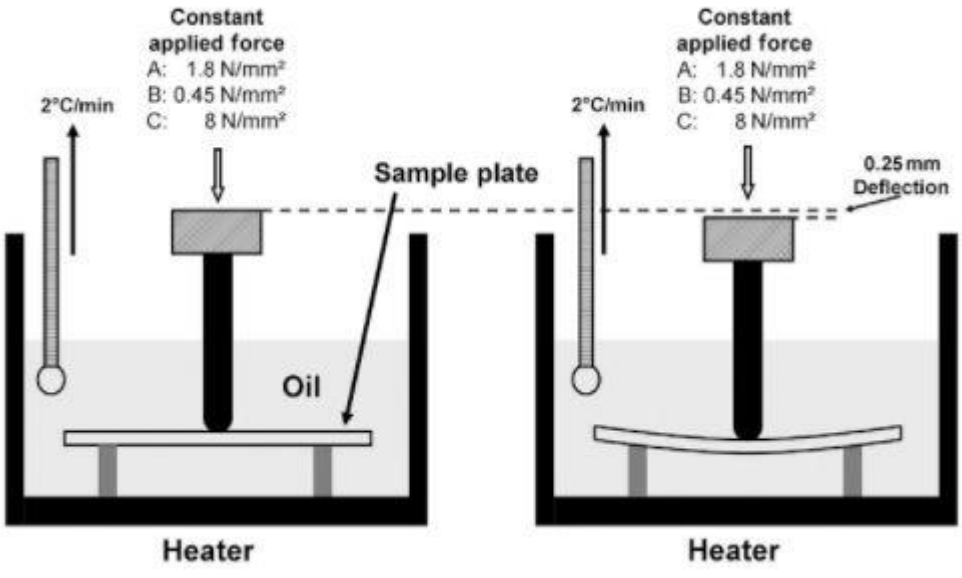
» Represents a value which can be used to compare different materials with each other
» Applied in many aspects of product design, engineering and manufacture of products using thermoplastic components
» Higher heat deflection temperature means a faster molding process in injection molding processes

How to measure HDT value for plastics?

The ASTM test is **ASTM D 648 (which is equivalent to the ISO 75)**.

» In the case of the HDT @ 1.8 MPa the load value is exactly 1820 kPa, which is commonly referenced as 1.8MPa (264 psi)
» In the case of the HDT @ 0.46MPa the load value is 0.46 MPa (66 psi)

The test is performed using an apparatus as shown below.



A test bar is molded of a specific thickness and width. The test sample is submerged in oil for which the temperature is raised at a uniform rate (usually 2°C per minute). The load is applied to the midpoint of the test bar that is supported near both ends. The temperature at which a bar of material is deformed 0.25mm is recorded as the HDT.

Factors Influencing Thermal Performance

This test measures short term performance under load at elevated temperatures for a by measuring the effect of temperature on stiffness. However, this is only an estimate, and cannot predict how the final part will perform. Other factors such as:

» The time of exposure to elevated temperature
» The rate of temperature increase
» The part geometry

… will significantly influence the final thermal performance of an application.

It is also important to note that HDT for a specific polymer grade will depend on the base resin and on the presence of reinforcing agents, fillers and plasticizers.

» Reinforced and filled grades have high HDT (harder and stiffer under the heat), while
» Plasticizers decrease HDT by making polymer softer and more flexibility

Heat Deflection Temperature Vs Vicat Softening Temperature

Vicat test is used to identify a temperature at which a needle of specified dimensions penetrates into plastic specimen a specified distance under a given load.

Compared with the Heat Deflection Temperature (HDT) test, the vicat test reveals the temperature at which the specimen loses its “stability-form” and softens, while HDT test measures the temperature at which the specimen loses its “load-bearing” capability. The Vicat point is closer to the actual melting or softening point of the polymer, the Vicat number will typically be higher.

Heat Deflection Temperature Vs Glass Transition Temperature (Tg)

As discussed above, HDT gives an indication of how the material behaves when

stressed at elevated temperatures. A material can have only “one” HDT. While **Glass transition temperature** of a material is entirely different.

The Glass transition temperature is the temperature at which a crystalline or semi-crystalline portion of the polymer melts and changes from an ordered structure to an amorphous structure. And, since it depends primarily on the polymer structure or morphology, Tg for a material is very little affected by addition od reinforcement, fillers, plasticizers or any other type of additive. Though it is also important to note- It is possible that a material can have more than one Tg, one for each structurally distinct crystalline phase.

Factors Affecting Heat Deflection Temperature

» **Extrusion Conditions** - Higher Orientation levels generally lead to higher HDT values
» **Morphology** - Higher crystallinity levels mean higher HDT values
» **Filler Loadings** - An increase in filler loadings leads to an increase in the HDT

HDT Values of Several Plastics

» **HDT @0.46 Mpa (67 psi)**
» **HDT @1.8 Mpa (264 psi)**

Max Continuous Service Temperature
This is the maximum acceptable temperature above which mechanical properties (tensile strength, impact strength) or electrical properties (dielectric strength, linked to insulation properties) of a plastic part are significantly degrading, over the reasonable life time of the tested product.

UL 746 is the test method generally used to calculate Relative Temperature Index (RTI). RTI is measured in °C.

Learn About Continuous Service Temperature in Detail

Max. Continuous Service Temperature Values of Several Plastics

Polymer Name	Min Value (°C)	Max Value (°C)

ABS - Acrylonitrile Butadiene Styrene	86.0	89.0
ABS Flame Retardant	65.0	95.0
ABS High Heat	75.0	110.0
ABS High Impact	65.0	100.0
ABS/PC Blend - Acrylonitrile Butadiene Styrene/Polycarbonate Blend	70.0	110.0
ABS/PC Blend 20% Glass Fiber	70.0	110.0
ABS/PC Flame Retardant	70.0	110.0
ASA - Acrylonitrile Styrene Acrylate	80.0	90.0
ASA/PC Blend - Acrylonitrile Styrene Acrylate/Polycarbonate Blend	90.0	110.0
ASA/PC Flame Retardant	90.0	110.0
ASA/PVC Blend - Acrylonitrile Styrene Acrylate/Polyvinyl Chloride Blend	80.0	90.0
CA - Cellulose Acetate	45.0	95.0
CAB - Cellulose Acetate Butyrate	60.0	105.0
CP - Cellulose Proprionate	60.0	105.0
CPVC - Chlorinated Polyvinyl Chloride	80.0	100.0
ECTFE - Ethylene Chlorotrifluoroethylene	140.0	150.0
ETFE - Ethylene Tetrafluoroethylene	140.0	155.0
EVA - Ethylene Vinyl Acetate	45.0	70.0
EVOH - Ethylene Vinyl Alcohol	80.0	100.0
FEP - Fluorinated Ethylene Propylene	205.0	205.0
HDPE - High Density Polyethylene	100.0	120.0
HIPS - High Impact Polystyrene	60.0	80.0
HIPS Flame Retardant V0	60.0	80.0
Ionomer (Ethylene-Methyl Acrylate	34.0	48.0

Copolymer)		
LCP - Liquid Crystal Polymer	200.0	240.0
LCP Carbon Fiber-reinforced	200.0	240.0
LCP Glass Fiber-reinforced	200.0	240.0
LCP Mineral-filled	200.0	240.0
LDPE - Low Density Polyethylene	80.0	100.0
LLDPE - Linear Low Density Polyethylene	90.0	110.0
MABS - Transparent Acrylonitrile Butadiene Styrene	75.0	80.0
PA 46 - Polyamide 46	110.0	150.0
PA 46, 30% Glass Fiber	130.0	160.0
PA 6 - Polyamide 6	80.0	120.0
PA 6-10 - Polyamide 6-10	80.0	150.0
PA 66 - Polyamide 6-6	80.0	140.0
PA 66, 30% Glass Fiber	100.0	150.0
PA 66, 30% Mineral filled	120.0	140.0
PA 66, Impact Modified, 15-30% Glass Fiber	110.0	140.0
PA 66, Impact Modified	80.0	130.0
Polyamide semi-aromatic	88.0	135.0
PAI - Polyamide-Imide	220.0	280.0
PAI, 30% Glass Fiber	220.0	220.0
PAI, Low Friction	220.0	220.0
PAR - Polyarylate	130.0	130.0
PBT - Polybutylene Terephthalate	80.0	140.0
PBT, 30% Glass Fiber	80.0	140.0

PC (Polycarbonate) 20-40% Glass Fiber	90.0	125.0
PC (Polycarbonate) 20-40% Glass Fiber Flame Retardant	90.0	125.0
PC - Polycarbonate, high heat	100.0	140.0
PC/PBT Blend - Polycarbonate/Polybutylene Terephthalate Blend	60.0	121.0
PC/PBT blend, Glass Filled	121.0	193.0
PCL - Polycaprolactone	45.0	45.0
PCTFE - Polymonochlorotrifluoroethylene	150.0	175.0
PE - Polyethylene 30% Glass Fiber	100.0	130.0
PEEK - Polyetheretherketone	154.0	260.0
PEEK 30% Carbon Fiber-reinforced		240.0
PEEK 30% Glass Fiber-reinforced		240.0
PEI - Polyetherimide	170.0	170.0
PEI, 30% Glass Fiber-reinforced	170.0	170.0
PEI, Mineral Filled	170.0	170.0
PESU - Polyethersulfone	175.0	180.0
PESU 10-30% glass fiber	180.0	180.0
PET - Polyethylene Terephthalate	80.0	140.0
PET, 30% Glass Fiber-reinforced	100.0	140.0
PET, 30/35% Glass Fiber-reinforced, Impact Modified	80.0	140.0
PETG - Polyethylene Terephthalate Glycol	63.0	63.0
PFA - Perfluoroalkoxy	240.0	260.0
PHB-V(5% valerate)	95.0	95.0
PI - Polyimide	260.0	360.0

PMMA - Polymethylmethacrylate/Acrylic	70.0	90.0
PMMA (Acrylic) High Heat	100.0	150.0
PMMA (Acrylic) Impact Modified	70.0	90.0
PMP - Polymethylpentene	90.0	110.0
PMP 30% Glass Fiber-reinforced	90.0	110.0
PMP Mineral Filled	90.0	110.0
POM - Polyoxymethylene (Acetal)	80.0	105.0
POM (Acetal) Impact Modified	80.0	100.0
POM (Acetal) Low Friction	80.0	105.0
POM (Acetal) Mineral Filled	80.0	105.0
PP - Polypropylene 10-20% Glass Fiber	100.0	130.0
PP, 10-40% Mineral Filled	100.0	130.0
PP, 10-40% Talc Filled	100.0	130.0
PP, 30-40% Glass Fiber-reinforced	100.0	130.0
PP (Polypropylene) Copolymer	100.0	130.0
PP (Polypropylene) Homopolymer	100.0	130.0
PP, Impact Modified	90.0	115.0
PPA - Polyphthalamide	140.0	140.0
PPA, 30% Mineral-filled	154.0	156.0
PPA, 33% Glass Fiber-reinforced	184.0	186.0
PPA, 45% Glass Fiber-reinforced	184.0	186.0
PPE - Polyphenylene Ether	80.0	110.0
PPE, 30% Glass Fiber-reinforced	80.0	110.0
PPE, Flame Retardant	80.0	110.0
PPE, Impact Modified	80.0	110.0

PPE, Mineral Filled	80.0	110.0
PPS - Polyphenylene Sulfide	200.0	220.0
PPS, 20-30% Glass Fiber-reinforced	200.0	220.0
PPS, 40% Glass Fiber-reinforced	200.0	220.0
PPS, Conductive	200.0	220.0
PPS, Glass fiber & Mineral-filled	200.0	220.0
PPSU - Polyphenylene Sulfone	149.0	210.0
PS (Polystyrene) 30% glass fiber	75.0	122.0
PS (Polystyrene) Crystal	65.0	80.0
PS, High Heat	75.0	90.0
PSU - Polysulfone	150.0	180.0
PSU, 30% Glass finer-reinforced	150.0	180.0
PSU Mineral Filled	150.0	150.0
PTFE - Polytetrafluoroethylene	260.0	290.0
PTFE, 25% Glass Fiber-reinforced	260.0	260.0
PVC (Polyvinyl Chloride), 20% Glass Fiber-reinforced	50.0	80.0
PVC, Plasticized	50.0	80.0
PVC, Plasticized Filled	50.0	80.0
PVC Rigid	50.0	80.0
PVDC - Polyvinylidene Chloride	70.0	90.0
PVDF - Polyvinylidene Fluoride	70.0	150.0
SAN - Styrene Acrylonitrile	65.0	95.0
SAN, 20% Glass Fiber-reinforced	65.0	95.0
SMA - Styrene Maleic Anhydride	75.0	100.0
SMA, 20% Glass Fiber-reinforced	75.0	100.0

SMA, Flame Retardant V0	75.0	100.0
SMMA - Styrene Methyl Methacrylate	94.0	100.0
UHMWPE - Ultra High Molecular Weight Polyethylene	110.0	130.0
XLPE - Crosslinked Polyethylene	67.0	82.0

Min Continuous Service Temperature

This is the minimum acceptable temperature above which mechanical properties (tensile strength, impact strength) or electrical properties (dielectric strength, linked to insulation properties) of a plastic part are significantly degrading, over the reasonable life time of the tested product.

UL 746 is the test method generally used to calculate Relative Temperature Index (RTI). RTI is measured in °C.

Learn About Continuous Service Temperature in Detail

Min. Continuous Service Temperature Values of Several Plastics

Polymer Name	Min Value (°C)	Max Value (°C)
ABS - Acrylonitrile Butadiene Styrene	60.0	80.0
ABS Flame Retardant	-40.0	-20.0
ABS High Heat	-40.0	-20.0
ABS High Impact	-40.0	-20.0
ASA/PVC Blend - Acrylonitrile Styrene Acrylate/Polyvinyl Chloride Blend	0.0	8.0
CA - Cellulose Acetate	-30.0	-30.0
ETFE - Ethylene Tetrafluoroethylene	-100.0	-100.0
EVA - Ethylene Vinyl Acetate	-60.0	-60.0
FEP - Fluorinated Ethylene Propylene	-150.0	-150.0

HDPE - High Density Polyethylene	-70.0	-70.0
HIPS - High Impact Polystyrene	-40.0	-20.0
HIPS Flame Retardant V0	-40.0	-20.0
Ionomer (Ethylene-Methyl Acrylate Copolymer)	-70.0	-55.0
LCP - Liquid Crystal Polymer	-200.0	-50.0
LCP Carbon Fiber-reinforced	-200.0	-50.0
LCP Glass Fiber-reinforced	-200.0	-50.0
LCP Mineral-filled	-200.0	-50.0
LDPE - Low Density Polyethylene	-70.0	-70.0
LLDPE - Linear Low Density Polyethylene	-70.0	-70.0
PA 46 - Polyamide 46	-40.0	-40.0
PA 6 - Polyamide 6	-40.0	-20.0
PA 66 - Polyamide 6-6	-80.0	-65.0
PA 66, 30% Glass Fiber	-20.0	-20.0
PA 66, Impact Modified	-80.0	-65.0
PAI - Polyamide-Imide	-196.0	-196.0
PAR - Polyarylate	-100.0	-95.0
PBT - Polybutylene Terephthalate	-40.0	-40.0
PCTFE - Polymonochlorotrifluoroethylene	-250.0	-250.0
PE - Polyethylene 30% Glass Fiber	-100.0	-100.0
PEEK - Polyetheretherketone	-65.0	-70.0
PEEK 30% Carbon Fiber-reinforced	-65.0	-70.0
PEEK 30% Glass Fiber-reinforced	-60.0	-75.0
PESU - Polyethersulfone	175.0	180.0

PESU 10-30% glass fiber	-98.0	-101.0
PET - Polyethylene Terephthalate	-40.0	-40.0
PETG - Polyethylene Terephthalate Glycol	-40.0	-40.0
PFA - Perfluoroalkoxy	-150.0	-150.0
POM - Polyoxymethylene (Acetal)	-40.0	-40.0
POM (Acetal) Impact Modified	-50.0	-40.0
POM (Acetal) Low Friction	-40.0	-40.0
PP - Polypropylene 10-20% Glass Fiber	-40.0	-5.0
PP, 10-40% Mineral Filled	-20.0	-5.0
PP, 10-40% Talc Filled	-20.0	-5.0
PP, 30-40% Glass Fiber-reinforced	-30.0	-5.0
PP (Polypropylene) Copolymer	-20.0	-10.0
PP (Polypropylene) Homopolymer	-20.0	-10.0
PP, Impact Modified	-40.0	-20.0
PPE - Polyphenylene Ether	-50.0	-40.0
PPE, 30% Glass Fiber-reinforced	80.0	110.0
PS (Polystyrene) Crystal	20.0	20.0
PS, High Heat	20.0	20.0
PSU - Polysulfone	-100.0	-100.0
PTFE - Polytetrafluoroethylene	-200.0	-200.0
PVC (Polyvinyl Chloride), 20% Glass Fiber-reinforced	-10.0	1.0
PVC, Plasticized	-40.0	-5.0
PVC, Plasticized Filled	-40.0	-5.0
PVC Rigid	-10.0	1.0
PVDF - Polyvinylidene Fluoride	-40.0	-40.0

SAN - Styrene Acrylonitrile	20.0	20.0
SAN, 20% Glass Fiber-reinforced	20.0	20.0
UHMWPE - Ultra High Molecular Weight Polyethylene	-30.0	-30.0