

Stanyl® PA46

General information on
applications, processing
and properties



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DSM

DSM is active worldwide in life science products, performance materials and industrial chemicals. The group has annual sales of close to EUR 6 billion and employs about 20,000 people at more than 200 sites across the world. DSM ranks among the global leaders in many of its fields. The company's strategic aim is to grow its sales (partly through acquisitions) to a level of approx. EUR 10 billion in 2005. By that time at least 80% of sales should be generated by specialties, i.e. advanced chemical and biotechnological products for the life science industry and performance materials.

DSM Engineering Plastics is a Business Group in the performance materials cluster of DSM, with sales in 2001 of EUR 603 million and approx. 1350 employees worldwide. It is one of the world's leading players in the field of engineering thermoplastics offering a broad portfolio of high performing products.

DSM Engineering Plastics operates in all major markets of the world including the Americas, Asia, and Europe. Within each region customers can count on our innovative research, development, and support facilities. Our in-house resources are backed by a corporate research and development center that is utilized in creating new solutions for customer needs. The advanced level of account management, in combination with our effective global communication network secures the support customers need wherever it is required.

With polymerization and compounding facilities for a range of polyamides, polyesters, polycarbonate and Ultra High Molecular Weight PE and extrudable adhesive resins, we serve our global customers base and assure a constant, reliable supply of products.

All our compounding facilities in the world (in the Netherlands, Belgium, USA, Canada, China and India) are being expanded continuously to keep up with the growing demand.

As a result of a constant product innovation and creation process, DSM Engineering Plastics can offer a cohesive portfolio of high performing engineering plastics.

Established trade names are:

Akulon® (PA6 and PA66)
Akulon® Ultraflow™
 (high flow Akulon PA6)
Arnite® (PBT, PET)
Arnitel® (TPE-E)
Stamylan® UH (UHMWPE)
Stanyl® PA46 (PA46)
Stanyl® PA46 High Flow™
 (high flow PA46)
Stapron® (PC-blends)
Xantar® (PC)
Xantar® C (PC/ABS-blends)
Yparex® (extrudable adhesive resins)

Complemented in some regions by products as:

Electrafil® (conductive products)
Fiberfil® (reinforced polypropylene)
Nylatron® (PA66 specialties)
Plaslube® (lubricated products)

These materials all have their specific properties, yet they share the same high quality, thanks to state-of-the-art production processes and quality systems, like Total Quality Management, ISO 9001 and QS 9000.

It's an approach to quality that can be found throughout the DSM organization:

- in relations with industry partners, working closely together in true co-makership, ready to meet any technical challenge
- in technical service and after sales, providing support to help customers, optimize their processes
- in logistics and delivery, shipping products anywhere in the world, quickly and reliably.

From product concept, through processing, to final application DSM Engineering Plastics brings the portfolio, the skills and the global presence to help its industrial partners create world-class products and solutions.

It's surprising what we can do together!

Production sites

Europe

Emmen - Netherlands
 (polymerization and compounding)
Geleen - Netherlands
 (polymerization)
Genk - Belgium
 (compounding)
Stade - Germany
 (polymerization)

North America

Evansville - Indiana
 (compounding)
Augusta - Georgia
 (polymerization)
Stoney Creek - Ontario Canada
 (compounding)

Asia Pacific

Jiangsu - China
 (compounding)
Pune - India
 (compounding)
Tokyo - Japan
 (M/S joint venture and toll compounding)

Introduction

Stanyl® PA46 overview

Stanyl (polyamide 46) is DSM's heat resistant polyamide. Stanyl is used in demanding applications in the automotive and electrical and electronics industries, but it also meets many other application requirements. It is an aliphatic polyamide formed by the polycondensation of 1,4-diaminobutane and adipic acid. Although there are similarities between the molecular structure of Stanyl (see Figure 1) and that of PA66, the higher number of amide groups per given chain length and the more symmetrical chain structure of Stanyl result in the higher melting temperature of 295 °C, a higher crystallinity, and a faster rate of crystallization (see Table 1).

Stanyl's crystallinity is approximately 70%, compared with 50% for PA66. This results in a high heat distortion temperature of 190 °C for unreinforced Stanyl and 290 °C for glass fibre reinforced Stanyl. These features give Stanyl a technical edge over other engineering plastics like polyamide 6 and 66, polyesters and semi-aromatic polyamides (PPA's) with regard to heat resistance, mechanical properties at elevated temperatures, wear and friction behaviour and, due an advantage in cycle-time, improved processing economics.

Stanyl is produced and marketed exclusively by DSM and is available worldwide. Compounding is carried out in Europe, the USA, Asia and Japan. Technical support in design, moulding, and material selection is provided by a dedicated staff of specialists. This support is provided locally and on a global basis.

Front view of the complete Stanyl plant at the DSM site in Geleen.



Table 1. Typical properties dependent on structure.

Properties	PA6	PA66	Stanyl
Melting point (°C)	225	265	295
Density (kg/m ³)	1140	1140	1180
Crystallization rate - at 200 °C (min ⁻¹) - at 230 °C	0.2 0	6 0.7	>15 10

Table 2. Most important grades of the Stanyl product portfolio.

Grades	Non-reinforced	GF-reinforced	% GF
Non-flame retardant (HB or V-2)	TW341 TW363	TW200F3	15
		TE200F6	30
		TW200F6	30
		TW200F8	40
		TW241F10	50
Flame retardant (V-0)	TE350	TE250F6	30
		TE250F8	40
		46HF5040	40
Wear and friction	TW371	TW271F6	30

Figure 1.
Differences in the
structure of
polyamides.

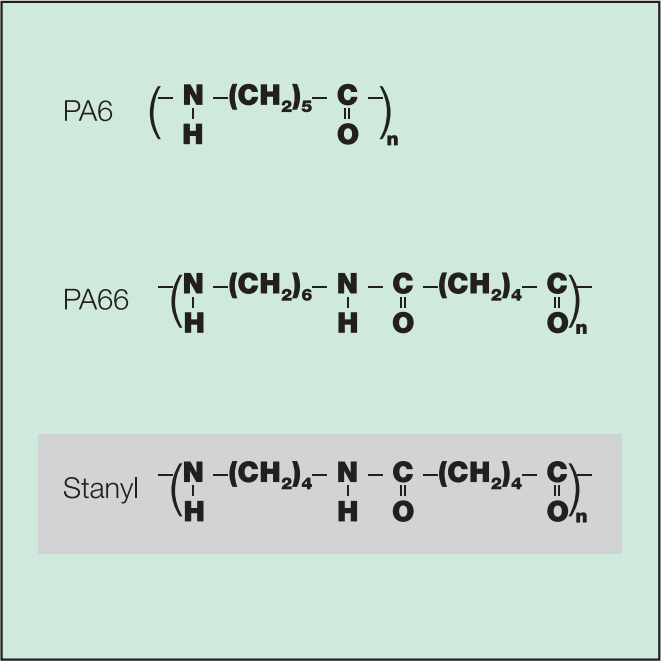
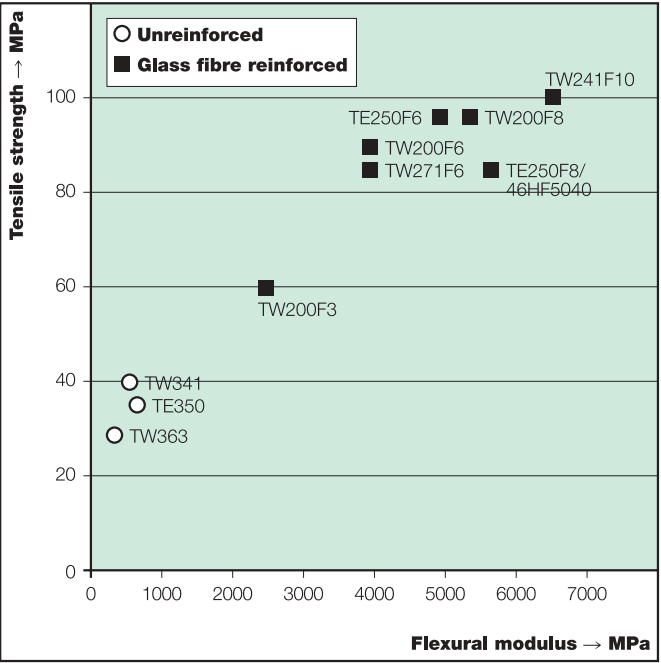


Figure 2. Stanyl's
excellent properties at
elevated temperature
(160 °C).



Stanyl's excellent properties (see Table 1 and Figure 2) lead to important advantages for the customer such as cost reduction, longer lifetime, and high reliability. Stanyl bridges the gap between conventional engineering plastics such as PA6, PA66, PBT and PET, and exotic materials such as LCP, PPS and PEEK.

Benefits for both moulders and end users include:

- resistance to high temperatures
- 30% productivity increase of moulding equipment
- greater design freedom due to the excellent mechanical properties and good mould-flow behaviour
- economical, safe and convenient processing due to the use of water-heated moulds
- no post-treatment due to the absence of flash
- no retooling necessary when switching from PA6, PA66 or polyesters.

Stanyl® PA46 product range

Stanyl is offered in a wide variety of grades including unfilled (non-reinforced), as well as grades containing glass fibres, minerals, lubricants, impact modifiers or flame retardants. A list of the most important grades can be found in Table 2.

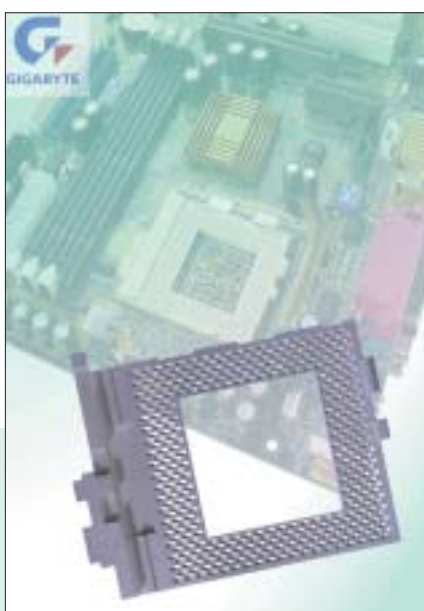
A detailed overview of the Stanyl product coding and nomenclature can be found in Tables 3a and b.

Table 3b. Stanyl High Flow product coding.

	46	HF	50	40
Polymer type				
High flow				
Flame retardant				
40% Glass fibres				

Table 3a. Stanyl product coding.

	T	W	2	00	F	6
T = granulate						
W = standard heat stabilizer E = heat stabilizer for E&E applications						
Indication of viscosity 2 = low 3 = medium 4 = high						
Indication of modification material 00 = unmodified 40's = lubricated 50's = flame retardant 60's = impact modified 70's = low friction/wear						
Reinforcement F = glass fibres K, M = minerals S = glass spheres						
Percentage reinforcement # x 5 = % reinforcement (e.g. 3 x 5 = 15% reinforcement)						



ZIF PGA. Stanyl 46HF5040 is used for its extreme good flow and its reduced warpage sensitivity.

General

Heat resistant plastics are increasingly replacing traditional engineering plastics in automotive applications. The driving force behind this development is the need to respond to three major industry trends:

- the growing use of new electronic systems for improved safety, comfort and motor management.
- the demand for longer warranty periods and operating life time.
- the increase in under-the-bonnet temperatures caused by:
 - encapsulation of the engine for acoustic-insulation and/or aesthetic reasons
 - introduction of turbo chargers and catalytic converter systems, which radiate considerable amounts of heat
 - size reduction of the engine compartment due to more compact design.

Stanyl has proven to be an ideal replacement for metal for economic reasons. Stanyl offers excellent creep resistance, strength, stiffness and fatigue resistance, not only at ambient temperatures but especially at high temperatures, while at the same time providing the well-known advantages of plastics. These are freedom to develop complex designs and integrated functions, easier processing and limited finishing requirements, weight and noise reduction, and corrosion resistance. Stanyl has been approved by all major automotive manufacturers.

Table 4. Typical automotive applications of Stanyl

Engine	Chain tensioners, engine covers, oil filter parts
Transmission	Clutch rings, shift forks, thrust washers, bearing cages, torsion damper parts, one way clutch cages
Air-inlet	Emission control systems, air-inlet devices, engine management parts, valves for exhaust gas control and pump housings for secondary air supply systems
Cooling	Intercooler end-caps
Electrical components	Alternator parts, sensors and switches, connectors, electromotor parts, ignition parts
Others	Clips, fasteners, cable channels, tubing

Stanyl withstands high loads and stresses at high temperatures and exposure to aggressive environments, and is therefore suitable for under-the-bonnet applications. Typical Stanyl applications are to be found in the engine and transmission, engine-management, air-inlet, brake, air cooling and electronic systems (see Table 4). Many automotive fasteners have also been produced in Stanyl, because of its excellent creep resistance, toughness and good wear characteristics.

Engine

Engine applications are generally used in very demanding environments where Stanyl's high stiffness at elevated temperatures, its high melting point (295 °C), toughness, and excellent wear properties provide outstanding performance regardless of engine size or configuration. With trends in weight, cost and noise reduction, Stanyl offers opportunities in all kinds of engines.

Metal replacement with Stanyl has been especially successful in parts integration, Noise Vibration Harshness (NVH) and component wear and durability improvement.

- Successful and potential high performance engine applications include:
- air-intake manifolds
 - chain tensioners and guides
 - threaded oil filter housings
 - sensors
 - timing and starter gears
 - belt tensioner parts
 - gasket carriers
 - intercooler parts.

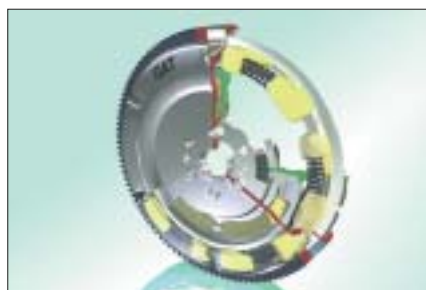
Stanyl for automotive signalling lamps

Stanyl is applied in automotive lighting for signalling lamps. It is used for lamp bases and is selected for a combination of properties: high peak temperature, high heat resistance, high toughness and laser markability. See internet website www.lighting.philips.com/automotive for further information.





Oil filter lid, Stanyl TW200F6.



Mechanical torsion damper spring seats, Stanyl TW341.



Bearing cages, Stanyl TW200F6.

With guarantees exceeding 100.000 km for engines between tune-ups and roadside service at the car companies expense, engine and power train components must be lasting and durable. Stanyl's proven success makes it an ideal candidate for engine component improvement.

Stanyl is highly suitable for applications that involve contact with hot motor oil or transmission oil. Extensive testing has shown that Stanyl retains a high degree of stiffness, good impact resistance, excellent stability and wear properties in such environments. Even in the more aggressive environment of automatic transmission oils the decrease in properties over time is remarkably low. Stanyl displays a clear advantage over PA66 with its superior mechanical performance before and after ageing at 150 °C for 1.000 hours (see Figure 39). Under normal running conditions, the temperature of motor oil varies between 130 °C and 150 °C, while peak temperatures of 165 °C or even higher can occur.



At these temperatures the retention of properties of the plastics used is crucial.

A successful application of Stanyl in these conditions is the chain tensioner. Stanyl chain tensioners are commercially used by all major automotive manufacturers worldwide. The requirements for materials used in chain tensioners are high stiffness at elevated temperatures, excellent resistance to wear and good resistance to oils. Chain tensioners made of Stanyl wear considerably slower than those made of PA66. Moreover, the high stiffness at elevated temperatures enables the replacement of the frequently used system (a metal frame with a PA66 top layer) by a full-plastic Stanyl solution. This results in a very cost-effective system, with operating life three to seven times longer than that of a PA66 system.

Transmission

Stanyl's properties remain at an acceptable level in applications where aggressive oils and high temperatures limit the use of conventional polyamides. Stanyl can therefore replace expensive materials such as PEEK and PES.

One example is the use of Stanyl in the guide sleeve that protects the Bowden cable at the point where it is connected to the transmission. This component comes into contact with ATF oil, for which peak temperatures of 182 °C have been measured over a period of one hour.

Stanyl containing 30% glass fibres has been chosen for this application. Stanyl is less sensitive to ageing than POM and PA66 and does not undergo deformation at these temperatures.

Stanyl can also be used in other transmission components, such as thrust washers, gear-shift forks, housings and speedometer gear wheels. Fatigue, limiting pressure velocity (PV), wear and torque resistance are critical in these applications. The thrust washer, for example, has to absorb high compression loads arising in the differential during acceleration.

Another example is the use of Stanyl in the self-adjusting clutch ring. The self-adjusting clutch allows pedal pressure to remain constant as the clutch disc wears. Its spring loaded thermoplastic ring features forward facing wedge shaped serrations to maintain the proper gap between the pressure plate and the cover fulcrums.

Self-adjustable clutch ring, Stanyl TW200F6.



Air-inlet manifold, Stanyl TW200F6.



Automotive connector, Stanyl TW200F6.



Positioning switch, Stanyl TW200FM33.

This results in a consistent feel for the driver throughout the vehicle's life. This self-adjusting feature eliminates traditional threaded cable mechanisms for manual clutches, thus reducing maintenance and associated costs. Dimensional tolerances for the serrations are extremely narrow, and Stanyl's low post-shrinkage and high creep resistance at elevated temperatures make it the ideal material for the clutch ring.

Stanyl is also used in a dual-mass flywheel containing flexible elements consisting of springs mounted between two plastic seats. This flywheel is used to dampen vibrations and thereby enhance comfort. Neither PPS (with 40% glass fibres) nor PA66 meets the requirements specified for the flywheel regarding creep resistance. The temperature at the friction surface can rise to 280 °C. Stanyl has clearly demonstrated its suitability for this demanding application.

Engine-management systems

Stanyl's heat resistance has led to the commercialisation of a number of devices for emission-control systems. These include secondary air supply (SAS) systems.

In integrated safety systems such as ABS, TCS (traction control system) and direct ignition, different kinds of housings, sensors, connectors and switches are used. For reasons of creep, fatigue and vibration resistance at high temperatures, Stanyl is often selected in these cases.

PA66 often fails to fulfill the high temperature requirements, whereas PPS has insufficient impact resistance and is more difficult to process. Compared with PES, Stanyl offers a superior price/performance ratio.

Under-the-bonnet applications are particularly demanding for plastics, with developments like Exhaust Gas Recirculation (EGR) reducing automotive emission levels but increasing operating temperatures in the air-intake manifold.

For air-intake manifolds Stanyl is used as an exceptionally strong engineering plastic to reduce weight and improve fuel efficiency. Considerably lighter than the aluminium parts it replaces, Stanyl high performance polyamide will support the key functions of the modern generation engine: reliability, durability and efficiency at competitive costs. For these applications the high stiffness of Stanyl up to 220 °C is crucial. This combines with easy injection

moulding, excellent flow characteristics and short cycle times to give a low final part price. Components made from Stanyl can, over short periods of time, withstand temperatures close to the material's melting temperature of 295 °C.

Stanyl is particularly suitable for new engine designs because of its high heat resistance, superior to standard materials like PA6 and PA66. As Stanyl has three to four times lower permeability to methanol-containing fuels than a material like PA66, it is also highly suitable for use in fuel systems, for components like fuel distributors and activated-carbon cartridges.

Sensors, switches and connectors

Stanyl sensors, switches and connectors are used in areas where high temperature resistance and toughness are required, for example in the vicinity of catalytic converters, the exhaust or the transmission.



Intercooler end-cap, Stanyl TW200F8.



Ignition connector. The ignition connector is mounted on top of the engine. Stanyl was chosen here for its heat stability in combination with its mechanical performance and chemical resistance.

Stanyl easily meets these requirements for sensors, switches and connectors. It resists constant temperatures of 150 to 160 °C for up to 4000 hours and peak temperatures of over 200 °C, even in combination with aggressive ATF oils. Besides general temperature, mechanical and chemical requirements, several specific requirements have to be met, namely temperature cycle tests, vibration tests at various temperatures and severe long-term tests for tightness against penetration of air, oil, dust and water at elevated pressures and temperatures.

Alternators, starters and small electric motors

Stanyl applications are also found in electric motors, alternators and starters. One application is the diode carrier in the



Radiator clips, Stanyl TW341.

alternator, which converts the alternating current (generated in the alternator) into a direct current. Diode carriers typically consist of a metal plate and PES inserts, overmoulded with PA66. These PES inserts are necessary because the local temperature is 200 °C, at which the creep resistance of PA66 is insufficient. Thanks to the use of Stanyl it is possible to integrate the PES and PA66 parts into one Stanyl part. The result is a lower final component price. Temperature requirements have also led to brush holders being manufactured in Stanyl instead of PA66.

Tubing

Stanyl TW363, a semi-flexible grade, can be extruded into thin vacuum tubing that can be used for actuation purposes under-the-bonnet. After metallization such tubing made from Stanyl has been extensively tested by automotive companies for 4.500 hours on light trucks and mini vans operating in desert climates and was found to be superior to the tubing previously used.



Cable channels, Stanyl TW200F6.

Conclusions

Stanyl is used in under-the-bonnet applications because of its excellent stiffness, long-term mechanical properties and wear resistance especially at high temperatures in aggressive automotive environments. At the same time Stanyl offers an economic advantage due to easy and fast processing in combination with longer life time expectancy of the parts. Stanyl also allows increased design freedom and part integration, leading to reduced handling costs.



Modern diesel engine, Stanyl TW341 chain tensioners exhibit a very low wear.

General




































































Electrical industry. Internal components of electrical applications sometimes encounter high temperatures. This results from the trend towards miniaturization or the increase in operating currents. Consequently there is an increasing demand for materials with:

- high heat resistance
- high stiffness at elevated temperatures
- low creep at elevated temperatures.

In applications such as electric motor parts, internal parts of circuit breakers, wire-wound components, e.g. bobbins and switches, Stanyl offers cost-effective solutions and can easily compete with materials such as PPS, PEI, PES, PPA, and LCP in terms of price/performance ratio. As a result of its outstanding intrinsic properties Stanyl has been successfully applied in the following applications and end-markets:

- connectors
- circuit breakers
- wire-wound components
- SMD components
- switches
- electric motor parts
- computers and peripherals
- telecommunications
- electrical and domestic appliances
- consumer electronics.

Table 5. Stanyl out performs well-known polymers such as LCP and PPS.

Resistance against IR reflow soldering*										
Material	Glass fibre reinforcement	UL94 classification	Maximum temperature (°C) of a standard IR reflow curve							
			250-260		260-270		270-280		280-290	
Stanyl TE250F6	30%	V-0								
Stanyl 46HF5040	40%	V-0								
PPS	40%	V-0								
PA 6T	30%	V-0								
PPA	33%	V-0								
PET	30%	V-0								
PCT	30%	V-0								
LCP	30%	V-0								
<div><div> No deformation</div><div> Slight deformation</div><div> Deformation</div></div>										
* Determined at thickness of 0.8 mm, dry as moulded										

Electronics industry. The continuing trend towards miniaturization of printed circuit boards leads to even smaller surface-mount devices (SMD) with further reduced wall thicknesses. These electronic components are more susceptible to the high peak temperatures involved in modern reflow-soldering techniques (see Table 5).

For these SMD applications, materials with a high heat distortion temperature must be used. Stanyl combines a heat distortion temperature (HDT) of 290 °C with excellent toughness and outstanding flow. It provides economical solutions and meets the latest design requirements for all kinds of end markets.

Stanyl® PA46 High Flow

Stanyl High Flow 46HF5040, a glass fibre reinforced, flame retardant polyamide 46, is the first grade of a new generation of Stanyl. This grade combines the high strength and toughness levels of the standard Stanyl flame retardant materials with excellent flow characteristics comparable or even superior to Liquid Crystal Polymer (LCP) (see Figure 4), a material often used for Information and Communication Technology (ICT) equipment. The Stanyl High Flow grade can replace LCP, resulting in cost savings of up to 50%.

RIMM connector.
Stanyl 46HF5040 (High Flow) is used for the new generation memory connectors. The optimal combination of “flow like LCP” and mechanical properties “better than LCP” enables a more cost-effective solution without giving-in on properties.



Stanyl High Flow 46HF5040 has an Underwriters Laboratories (UL) 94 V-0 rating at 0.8 mm for all colours, including a UL approval for 50-100% regrind use (UL yellow card file number for Stanyl is E119177 see Table 7). It offers high toughness, even in dry-as-moulded conditions. The weld-line strength of the new grade is significantly higher than that of LCP, enabling connector manufacturers to post-insert pins directly after injection moulding without the risk of cracking, thereby reducing reject levels.

Components made of Stanyl High Flow maintain their dimensional integrity during reflow soldering up to 280 °C due to the extreme high stiffness of the material at these temperatures. This is especially important for the new lead-free soldering techniques. While LCP is often specified for such components, the cost of LCP is significantly higher than that of Stanyl. This costly "overdesign" can now be eliminated because Stanyl's new High Flow series, specifically Stanyl 46HF5040, meets the end users' performance requirements and can reduce part costs by as much as 50%.

Figure 3. HDT versus solder temperatures.

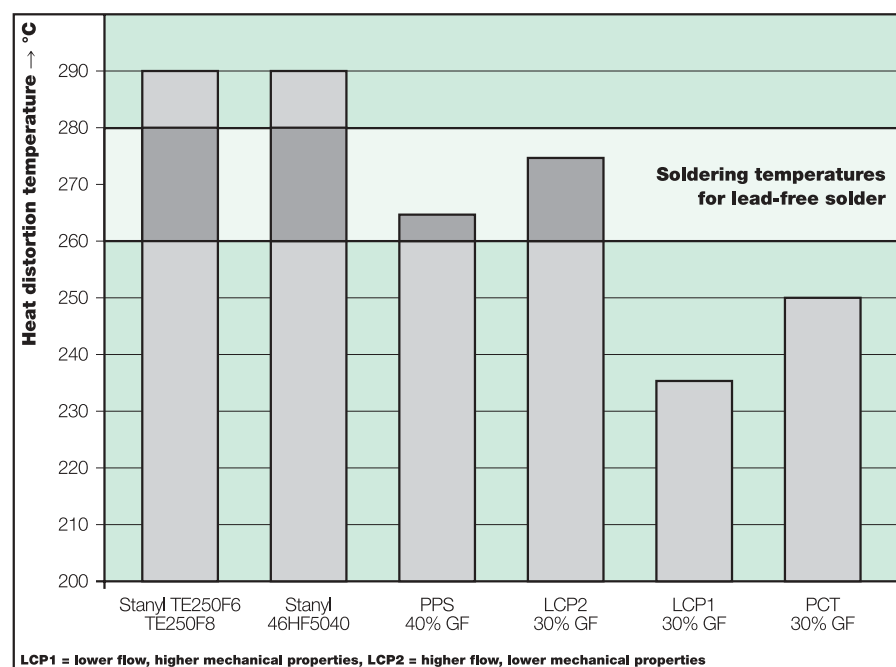
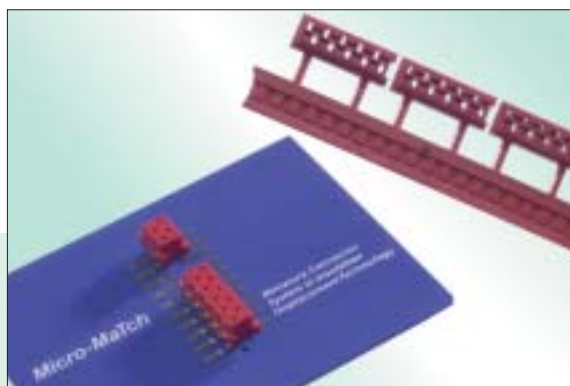
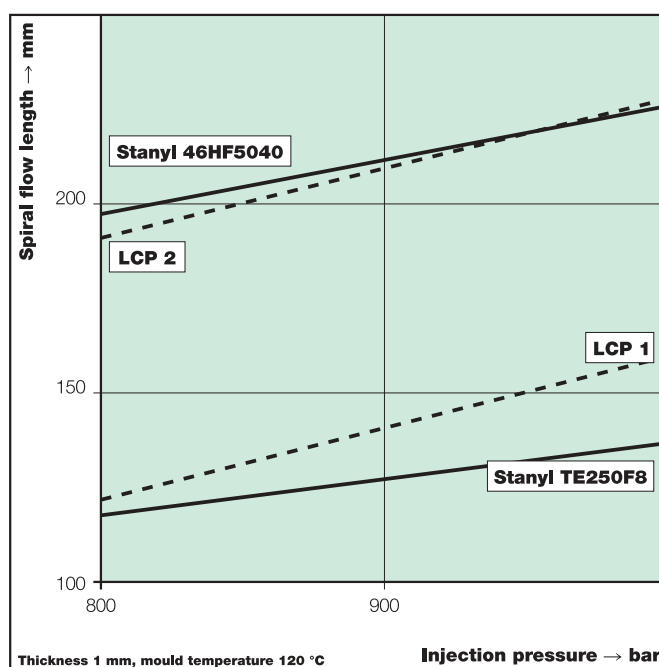


Figure 4. Flow improvement Stanyl High Flow grades.

LCP1 = lower flow, higher mechanical properties,
LCP2 = higher flow, lower mechanical properties.



Stanyl is being used for the SMD version of this appliance connector.

Challenges for the E/E industries

Increasing soldering temperatures. The use of lead-free solder will cause an increase in the temperature profile of the soldering ovens. A rise of approximately 20 °C can be expected, leading to peak temperatures in the solder process between 260 and 280 °C. Stanyl with its heat distortion temperature (HDT) of 290 °C (see Figure 3), will retain its dimensional integrity at soldering temperatures of 280 °C, which is higher than the HDT of most of the other high performance materials.

Connectors

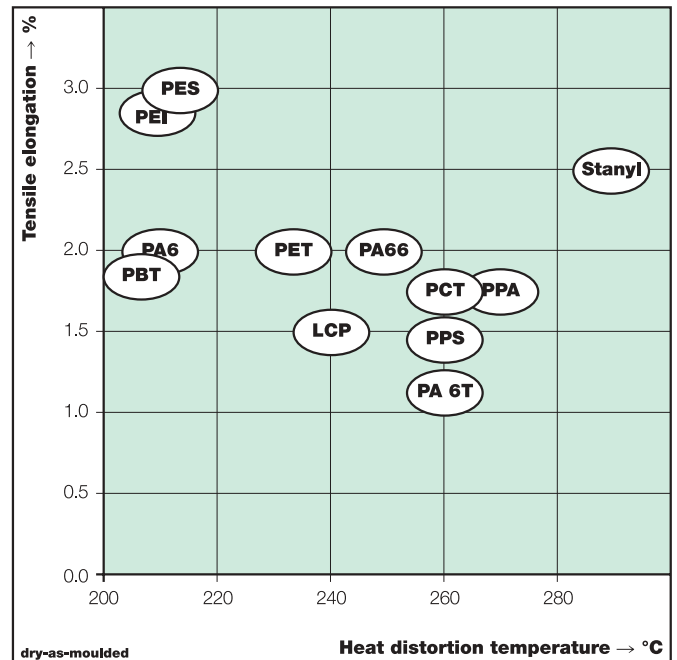
Stanyl meets the requirements for various connector designs such as modular jacks, shrouded headers, power connectors, fine-pitch connectors, breakaway connectors, sub-miniature D-connectors, memory-card connectors, edge-card connectors, ZIF-PGA connectors, memory module connectors (DIMM, DDR-DIMM, RIMM), and various telephone-handset connectors. All of these connectors can be made of Stanyl grades.

Cycle time. With Stanyl an overall cycle time reduction of up to 30% can be achieved compared to other polyamides and polyesters (including PCT), resulting in a clear economic advantage. Compared to LCP a similar cycle time can easily be achieved. It has been demonstrated that the cycle time of an edge-card connector, originally made from PPS, can be reduced by 50%, without any flash being produced and with dimensional specifications being met.

Pin headers.

Pin headers come in various lengths. The use of Stanyl enabled customers to produce all versions (some are up to 200 mm long) with the same high quality at competitive costs.

Figure 5.
Positioning of 30% glass fibre reinforced, flame retardant thermoplastics.



The shrinkage of Stanyl is close to that of commonly used polyesters and polyamides. Thus existing tools can be used without any adjustments.

The on-going miniaturization of connectors means that wall sections are becoming thinner and more complex. Stanyl's excellent flow enables sections as small as 0.1-0.2 mm to be filled without any problem.

Stanyl is specified in surface-mount fine-pitch connectors with pitches of 0.3 mm. These are used in products such as printers, video cameras, and lap-top computers.

Even the best-flowing grades of Stanyl show no flash, in contrast to many other high flow polymers, such as PPS.

Pin insertion and pin retention. Stanyl's combination of good weld-line strength (by far superior to LCP) and excellent tensile elongation (see Figure 5), prevents the introduction of micro-cracks during the pin insertion process even when this is performed directly after moulding. The absence of these micro-cracks and Stanyl's high stiffness at the soldering temperature, guarantees the best pin retention force, also after the soldering process.





Stanyl, a cost-effective solution for wire-wound components.

Snap-fits, latches and pegs. Stanyl's toughness allows designers greater freedom in the design of snap-fits, latches and pegs. In the case of high-current connectors, safe construction is needed to prevent accidental separation of mating connectors. Stanyl is chosen because it combines high stiffness with high toughness, especially in thin sections. This ensures excellent behaviour during repeated mating cycles.

Table 6. UL 1446 insulation system recognition for Stanyl.

UL 1446 classes		Stanyl grades
B	130 °C	TE350, TE250F6, TE250F8, TE250F9, TW250F6
F	155 °C	TE200F6, TE250F6, TE250F8, TE250F9, TW300, TW341, TW200F6, TW250F6
H	180 °C	TE200F6, TE250F6, TE250F8, TE250F9, TW200F6, TW250F6

Moisture absorption. Like all polyamides, Stanyl absorbs moisture from the environment. However, it offers grades with the required dimensional stability even when subjected to tropical environments. These grades meet even the stringent specifications required for DDR-DIMM sockets up to an overall length of 150 mm.

LCP mould. In practice LCP can be replaced without major modification of the existing moulds. The modest shrinkage of Stanyl in the flow direction will be compensated by the dimensional change due to moisture absorption. This, in combination with its SMD resistance and easy processing (good flow, low tool temperature, fast cycling), makes it an outstanding cost-effective alternative for LCP.

Wire-wound components

UL 1446. Stanyl's UL 1446 classification guarantees that systems with Stanyl as insulation material will withstand heat generated during both normal operation and overload conditions of an electric motor or bobbin (see Table 6). This system approval decreases the approval cost and time drastically.

Bobbins. Many different wire-wound components are used in transformers, filters, relays and electric motors. Bobbins are either of the standard pin-through-hole or the surface-mount type. Stanyl is chosen for these applications for reasons pertaining to the production process e.g. winding and dip soldering.

Winding. Stanyl's high stiffness and toughness improve the quality of the bobbin and diminish the reject level after winding. When thermosets or PPS are used the reject rate can be high due to the brittleness of these materials. Stanyl's superior creep performance makes it better than other polyamides and PPA's when it comes to with-standing heat-treatment procedures (such as encapsulation) on wire-wound components. For example, it shows a superior creep performance at 140 °C under a load of 20 MPa.



SIM connectors. The use of Stanyl instead of LCP in a SIM connectors created an interesting cost-saving of 30-70% on material cost, without giving-in on properties. Stanyl can often be used in tools cut for LCP.

Dip soldering. After winding, the wire is soldered to the connecting pin. This is done by passing the pin through a solder bath. The solder bath operates at temperatures between 380 °C and 500 °C. Although the plastic itself is not in direct contact with the heat source, heat conducted via the pins may soften the plastic and allow the pins to move. Stanyl performs better in this respect than the widely used PBT, PA66 or PC. PPS is too brittle and shows too much flash.

Eliminating wrapping film and potting. Before encapsulation, polyester film may be wrapped around the coil. Stanyl has enabled designers to leave out this extra production step by replacing the film by hinges which are integrated with the bobbin, with sections of less than 0.3 mm. The excellent flow of Stanyl enables the films of these thin flaps to be integrated in the bobbins.

Electric motors

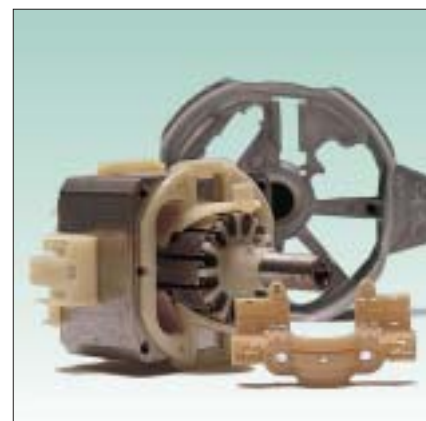
The trend in E-motors is to miniaturize. While power supply and capacity remain the same or increase, internal temperatures may rise significantly depending on the design. Overloading or blocked rotors can lead to temperatures rapidly exceeding 250 °C. Safety margins may be required for adequate functioning.

Stanyl can be found in various parts of an electric motor including end laminates, brush holders, gears and end brackets and (end) frames with incorporated brush holders.

End laminates. The winding process exerts a considerable stress on the end laminate. Brittle materials such as thermosets, polyesters and PPS need a highly controlled winding process to prevent cracking. Production costs are consequently high. The high toughness of Stanyl offers improved reliability and lower production costs.

After winding, the load on the end laminate can be permanent, requiring high creep resistance at elevated temperatures. In blocked-rotor situations, peak temperatures of more than 250 °C may occur. When combined with a load, these may result in deformation of the plastic, leading to malfunctioning of the motor. The high HDT of Stanyl (290 °C) prevents the occurrence of such deformations.

Brush holders. The use of brushes leads to significant power loss at high currents. In combination with internal friction between the brushes and the commutator, this can result in temperatures exceeding 220 °C. Only a limited number of materials can withstand these conditions. Initially thermosets were used, but high production costs led to the search for alternative thermoplastic materials. PPS was found to be too brittle. Stanyl offers an ideal combination of high stiffness at elevated temperatures and toughness, giving greater reliability at lower cost.



End laminates: Stanyl is used in vacuum cleaners, lawn mowers and washing machine motors for end laminates.

Stanyl® PA46 in circuit breakers

Stanyl has successfully replaced metal, thermosets and more expensive materials such as PEI, PES and PPS for several internal parts of circuit breakers. For these applications, a high heat resistance, low creep at high temperatures and outstanding mechanical properties (toughness) are required. The high peak temperature resistance of Stanyl is an additional advantage in Miniature Circuit Breakers (MCB) parts that are exposed to the high temperature switching arc.

Due to its good balance of strength and ductility, flame retardant Stanyl is also being used as enclosure material for MCB's and Residual Current Devices (RCD's), especially in high performance

Mobile phone connectors. Stanyl (TE250F6, 46HF5040) is the material for a cost-effective solution in mobile phones.



applications where other polyamides fail to pass the final short circuit tests. In high current switches, Stanyl is used in parts that are subject to high mechanical shock during switching operations, where zero failure after several thousands of switching cycles is required.



Earth leakage circuit breakers. Stanyl offers an excellent balance of flow and mechanical properties at very low warpage levels.



Industrial high current circuit breaker. Stanyl has succeeded in replacing thermosets in this demanding application, where other thermoplastic materials fail to meet the requirements.

UL recognitions

Table 7. Underwriters Laboratories yellow card file E 119177 for Stanyl grades.

Description	Grade designation	Colour	Minimum thickness mm	UL 94	RTI °C ¹⁾			H W I ¹⁾	H A I ¹⁾	H V T R ¹⁾	D 4 9 5 ¹⁾	C T I ¹⁾
					EI	WI	WOI					
Unreinforced	TE300	NC	0.9	V-2	130	-	-	3	0	0	5	0
	TE341	NC, BK	0.75	V-2	130	-	-	3	0	-	-	0
	TW300	NC	0.75	V-2	150	115	130	3	0	1	6	1
	TW341	NC, BK	0.75	V-2	150	115	130	3	0	1	6	2
	TW371	NC	1.5	HB	-	-	-	-	-	-	-	-
	TW441	NC	0.75	V-2	-	-	-	-	-	-	-	-
Flame retardant	TE350	NC, BK	0.75	V-0	130	110	120	1	0	1	7	2
Glass reinforced	TE200F6	NC	0.9	HB	-	-	-	0	0	0	5	1
	TW200F6	NC	0.9	HB	140	140	140	0	0	0	5	2
	TW241F10	BK	0.75	HB	-	-	-	-	-	-	-	-
	TW271F6	NC, BK	0.75	HB	-	-	-	0	0	3	-	2
Glass reinforced, Flame retardant	46HF5040 ²⁾	All	0.75	V-0	140	130	130	0	0	1	7	2
	TE250F3	NC, BK	0.9	V-0	130	110	120	1	0	1	7	3
	TE250F6 ²⁾	All	0.35	V-0	140	130	130	0	0	1	6	2
	TE250F8 ²⁾	All	0.75	V-0	140	130	130	0	0	0	7	2
	TE250F9 ²⁾	All	0.75	V-0	140	130	130	0	0	0	7	2
	TW250F6	NC, BK	0.75	V-0	140	140	140	0	0	1	7	3
Glass reinforced, Mineral reinforced	TS250FK33	NC, BK	0.75	V-0	-	-	-	-	-	-	-	-

1) These data are for 3 mm thickness

2) Recognitions for regrinds are available (up to 100%)

Detailed and up-to-date UL-data can be found on the internet website of Underwriters Laboratories Inc.
<http://data.ul.com>

Consumer durables and other applications

The clear advantages over other plastics that Stanyl offers in personal care products, kitchen and household appliances, power tools and garden appliances are:

- resistance to high temperatures
- high stiffness at elevated temperatures
- excellent fatigue resistance at elevated temperatures
- toughness
- high wear resistance
- low friction.

Kitchen appliances

Metal or wooden kitchen spatulas are increasingly being replaced by plastics, for greater design freedom and for bacteriological reasons. If the temperature requirement is not too high, PA66 is used. However, in hot oil PA66 meets its limitations. Stanyl shows no deformation up to 280 °C. Stanyl TE grades comply with the food-approval legislation of most European countries.

The safety controls in electric kettles and ovens are based on a thermostat combined with a switch. During operation, temperatures surrounding the bi-metal may exceed 275 °C. As a result of its high heat distortion temperature, combined with the absence of flash and good toughness for snap-fits, Stanyl outperforms PPS in this application.

For applications where not only heat resistance but also "cosmetic" appearance (visible parts) are important, e.g. oven knobs and toaster parts, unreinforced Stanyl is the best solution.

Kitchen spatulas, Stanyl TE300.



Gas curler, Stanyl TW200F6.



Engine grid for small petrol engines (e.g. trimmers, chain saws).



Thermostatic control for water kettle, Stanyl TE250F6.



Crank shaft saddle, Stanyl TW200F6.

Power tools and garden appliances

Stanyl's high stiffness at elevated temperatures allows the replacement of metal components. This, combined with parts integration, gives a considerable weight reduction. Examples of applications are: electric motor parts, crank shafts, grid covers and heat shields.

Other applications

Stanyl has been chosen for office chair seat adjusters because of stiffness, toughness, wear and low friction. Grids of electric fan heaters require stiffness at high temperatures and toughness. The trend is to design more compact heaters with higher heating capacities. Stanyl outperforms the other high heat resistant thermoplastics.



Typical shrinkage values

Shrinkage values parallel and perpendicular to the flow for common Stanyl grades are given in Table 8.

Often the exact shrinkage levels cannot be predicted. For precision articles, it is advisable to start with a prototype mould. If this is not possible, the tool cavity should be under- or oversized so that later corrective adjustments are easier to make.
Three major factors have to be considered:

Part dimensions

- Dimensional aspects
- mould manufacturing tolerances
 - thermal linear expansion of the mould between 23 °C and the moulding temperature Tm.
- Processing
- mould shrinkage
 - post-shrinkage
- Operation conditions
- water uptake
 - thermal linear expansion of the moulded part.

Shrinkage of mouldings

The level of shrinkage depends on several factors and varies with the grade of Stanyl. In general the shrinkage behaviour of Stanyl is similar to that of PA66.

- Processing shrinkage. The level of shrinkage is mainly determined by:
- grade of Stanyl
 - holding pressure
 - holding time
 - mould temperature
 - gate position
 - glass fibre orientation.

The holding pressure (see Figure 6) in combination with holding time has the greatest influence on mould shrinkage.

Table 8. Typical shrinkage values.

Grades	Shrinkage (%)	2 mm wall thickness
flow direction	//	⊥
unreinforced	2	2
flame retardant unreinforced	2	2
glass fibre reinforced (30 %)	0.3-0.5	0.9-1.3
flame retardant glass fibre reinforced	0.2-0.4	0.7-0.9

Figure 6. Influence of holding pressure on shrinkage¹⁾.

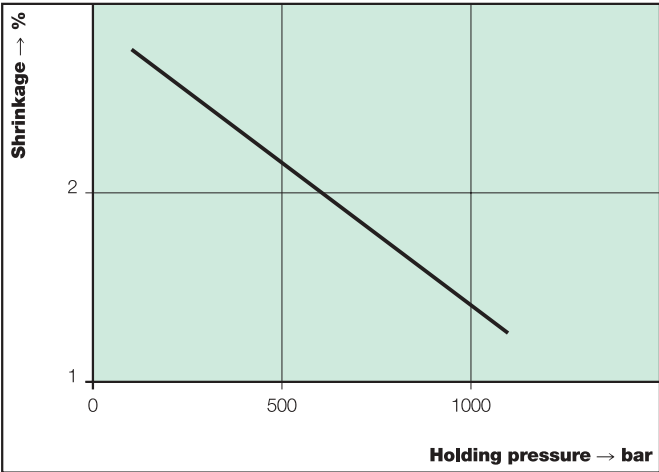
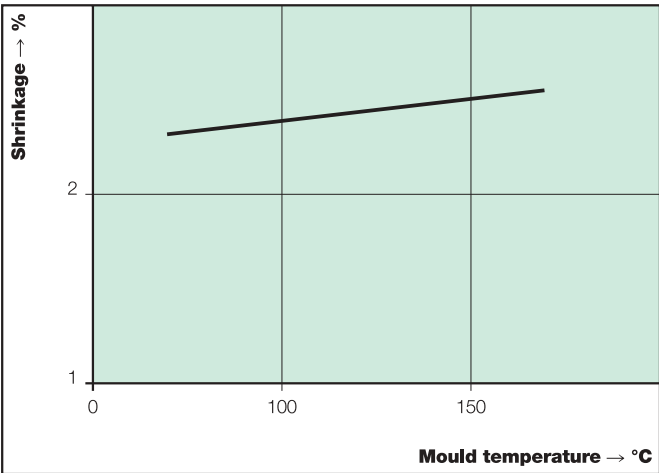


Figure 7. Influence of mould temperature on shrinkage¹⁾.



1) Unreinforced Stanyl (UF), after 14 days storage dry as moulded:
- mould dimensions 80x80x2 mm
- mould temperature 80 °C
- cooling time 30 s
- holding pressure 325 bar.

By varying these, dimension corrections are possible, but internal stresses may be introduced. This has a negative influence on aspects such as fatigue. Internal stresses can be reduced by using a “stepped” holding pressure profile. Depending on the shape of the article and the gate, optimizing the holding pressure is very important. Control parameters are weight and dimensions.

Increase of the mould temperature (see Figure 7) shows a small increase of the shrinkage level and reduction of post-shrinkage. The influence of cooling time (see Figure 8) on Stanyl's shrinkage level is small.

Mould design variables. Design variables are:

- length and diameter of sprue runner and gate
- position and type of gate
- wall thickness of the moulding.

In general, smaller gates and runners result in higher mould shrinkage. This is because the premature freeze-off of the material in the gate prevents further pressurisation necessary to compensate for mould shrinkage. Thicker walls give higher shrinkage. The influence of wall thickness on shrinkage (mould- and post-shrinkage together after 14 days, dry as moulded) is shown in Figure 9.

Warpage

Like any other semi-crystalline thermoplastic, Stanyl has a higher tendency to warp compared to amorphous materials. The combination of the anisotropy (injection moulding induced orientation) and shrinkage results in a higher warp sensitivity.

Figure 8. Influence of cooling time on shrinkage ¹⁾.

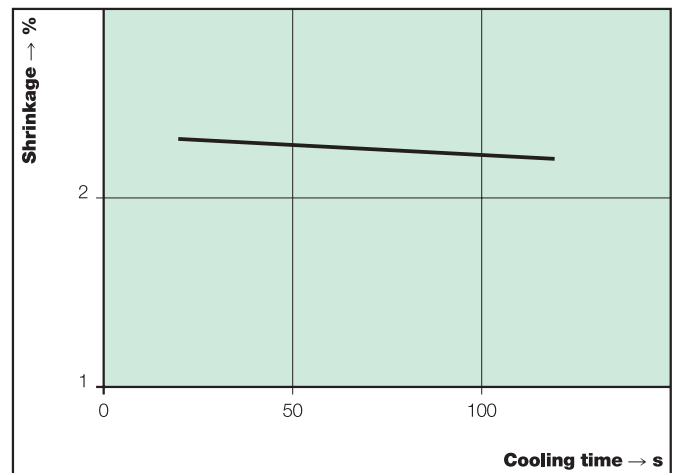
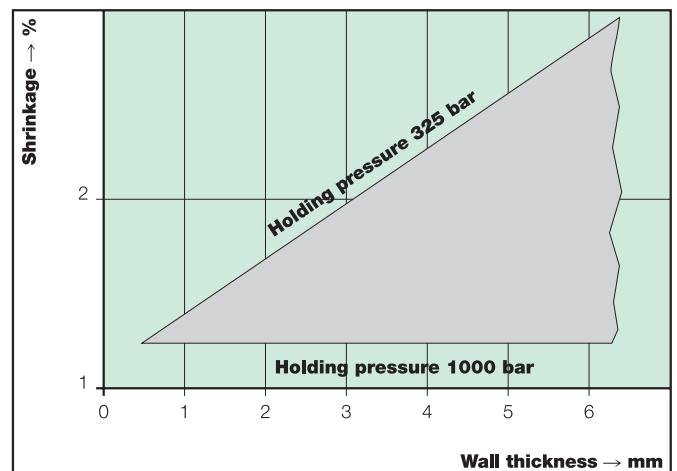


Figure 9. Influence of wall thickness on total shrinkage ²⁾.



2) Unreinforced Stanyl (UF), free shrinkage test plate, mould temperature 80 °C.

Two major mechanisms cause warpage:

- differences in cooling rate
- anisotropy (crystallinity, reinforcement).

Major factors decreasing warpage are:

- balanced cooling
- more isotropic materials
- symmetrical part design (wall thickness, ribs, etc.)
- cavity balance and gating (gate locations and dimensions).



Modular fuel pump and sender assemblies.

Conditioning of Stanyl® PA46 components

To accelerate the realisation of the specified dimensions or to achieve increased toughness, it may be necessary to condition the components.

Water absorption. The equilibrium water content at 23 °C/50% RH is:

- 3.7% for unreinforced Stanyl grades and
- 2.6% for 30% glass fibre reinforced grades.

There are several conditioning methods for accelerating water absorption:

- the ISO 1110 (1987) standard indicates that accelerated conditioning at 70 °C/62% RH results in the same water content as equilibrium moisture content at room temperature/50% RH
- a simple method is immersion of the components in water (50-80 °C) until they have reached the equilibrium content determined by weight at 23 °C/50% RH followed by at least 2 days conditioning.
- the components can be packed in PE bags, with 3.7% respectively 2.6% (by weight) of water added and the bags sealed. This method is more time-consuming.

Influence of moisture uptake on dimensions. Although Stanyl absorbs more moisture than PA66, the resulting dimensional change at equilibrium is of a similar order (see Figure 10). Due to the effect of water absorption, the dimensions will increase (see Figure 11). These effects should be taken into consideration when designing the mould.

More detailed information about design guidelines can be found in the brochure "Designing with DSM Engineering Plastics".

Figure 10.
Dimensional change in length direction due to moisture absorption.

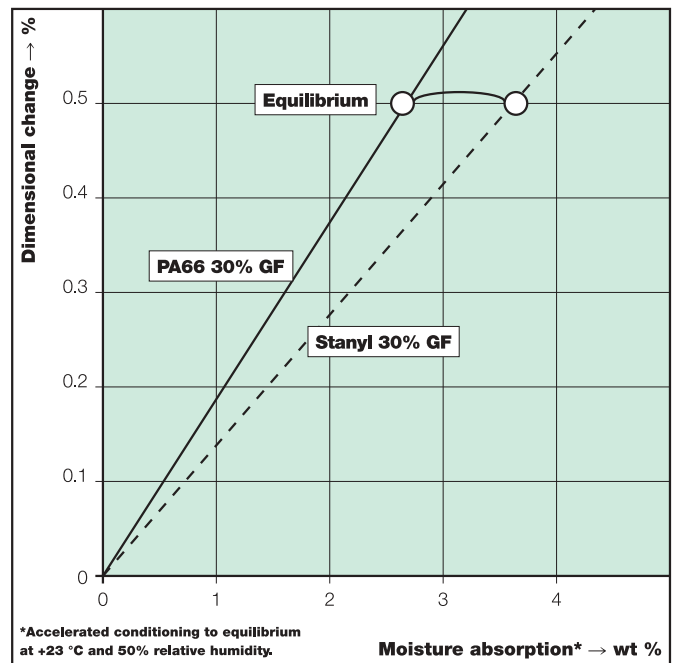
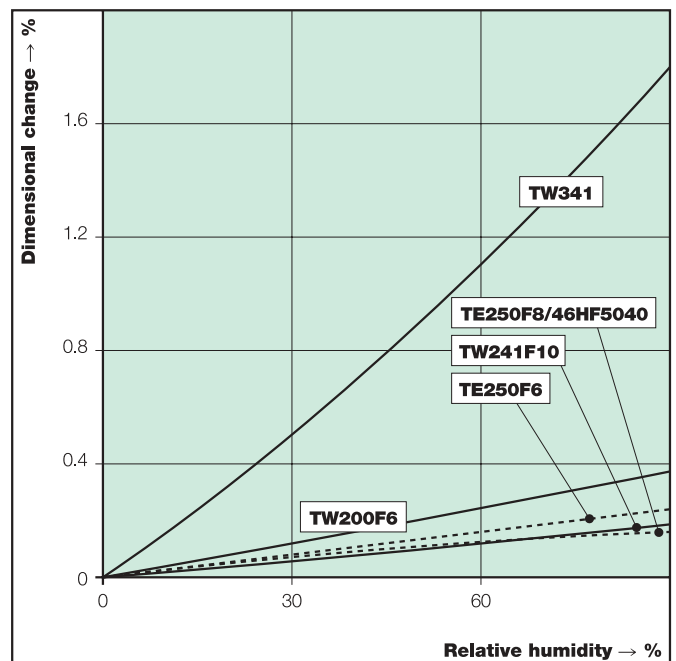


Figure 11.
Dimensional change in flow direction versus relative humidity.



Equipment

Injection moulding machine

Stanyl can be processed on standard reciprocating screw injection moulding machines.

Injection unit. For best results, the preferred shot weight should be between 50 and 65% of the maximum plasticizing capacity. The capacity of the heater bands should be sufficient (4-5 W/cm² of the outside barrel surface) to ensure enough heat is transferred into the material.

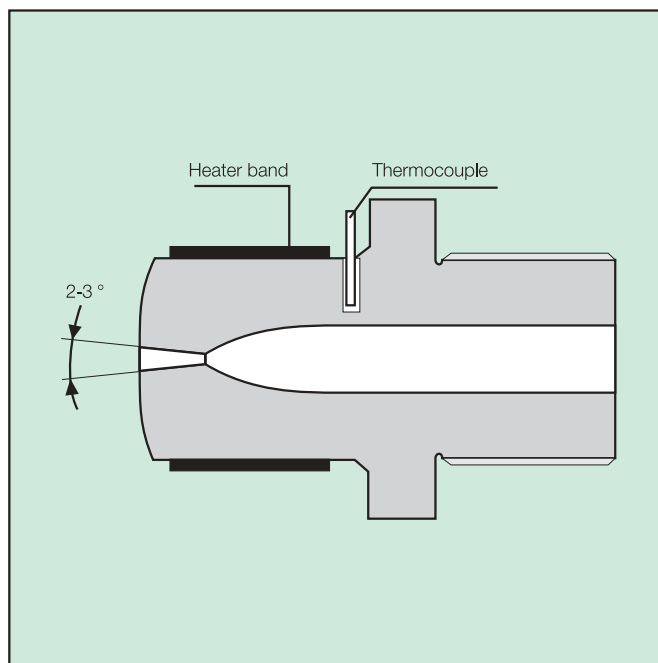
Screw geometry. The feed performance and the plasticizing of the granules are, to a high degree, determined by the screw geometry. A three zone screw, with non-return valve, of the following geometry, is recommended:

- a L/D ratio of at least 20;
- a channel depth ratio from 1:2 to 1:2.5;
- a channel depth, in the metering zone, of 0.06-0.07 D;
- a constant pitch of 1 D;
- feeding compression and metering zone lengths of 0.6 L, 0.2 L and 0.2 L respectively.

Screws that are too short have insufficient melting and homogenising capacity. This will cause high pressure in the compression zone, resulting in excessive wear and shear and screw stall, and may lead to unmolten particles in the end product.

Non-return valve. The non-return valve plays an important role in controlling the pressure and must be completely closed in order to maintain pressure throughout the moulding phase.

Figure 12.
Nozzle design.



A worn valve is always apparent from the screw's tendency to continue to move forward during the holding pressure stage. A badly worn or broken valve should be replaced promptly. It is important when reinforced Stanyl is moulded to keep a regular check on the function of the valve.

Nozzle design. Open nozzles have the advantage of no flow restrictions which could damage the glass fibre length of reinforced grades. The absence of dead spots is also an advantage. The design and temperature control should, however, be of a high standard to avoid freeze-off or drooling (see Figure 12). If necessary, different types of shut-off nozzles can be used.

However, pressure losses during mould filling and packing and degradation of the material are encountered.

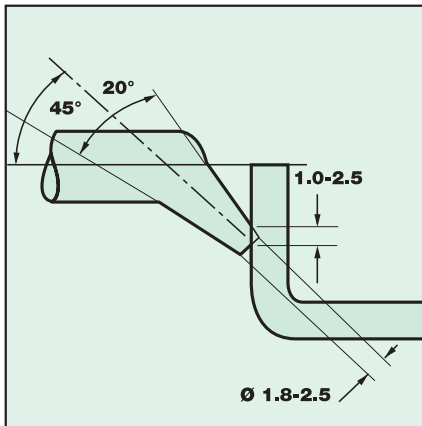
To minimize such losses use a hydraulically operated shut-off type nozzle.

Important design features is a large surface area, completely covered with heater bands of sufficient output. These heater bands should be controlled via a thermocouple placed near the tip of the nozzle because the aim is to have an accurate temperature control of the nozzle tip. The temperatures should be set at a level where the material just freezes off when the nozzle retracts from the mould. The conical tapered opening facilitates withdrawal of the frozen sprue-end from the nozzle.



Bus bar connector. This connector is used in power supply. Stanyl TE250F6 has been chosen for its right combination of properties: high toughness for the locking system; V-0 and a long term thermal stability at 160 °C.

Figure 13. Tunnel gate.



Screw/barrel steel. Processing of glass fibre reinforced and/or flame retardant engineering plastics on standard screw and barrel assemblies can cause considerable wear and corrosion.

Manufacturers of injection moulding equipment recommend the use of ion nitrided steels when glass fibre and/or flame retardant engineering plastics are being processed.

For GF/FR Stanyl this wear can be reduced to acceptable limits by using coated screws/barrels and non-return valves.

Moulds

General features. Moulds used for Stanyl are designed in a similar manner as those used for other thermoplastics. Stanyl is processable in existing moulds designed for PA, PPA, PPS, PET, PBT. If an existing mould is used, make sure this mould is suitable for operating with the necessary temperatures (with regard to slides, cores, etc.) and differences in shrinkage. Whenever possible, section thicknesses should be uniform throughout the component in order to give uniform cooling shrinkage, stress distribution and packing. Avoid internal sharp corners to reduce high stress concentrations and subsequent weaknesses. The dimensional tolerances mentioned in DIN16901 for aliphatic polyamides are applicable to Stanyl. Compared to this DIN norm, experience indicates that the tolerance of 0.15% can be reduced to 0.05%, within the size limits of 10-100 mm. This, however, requires accurate manufacturing of the mould and optimal and reproducible processing.

Injection

Sprues. Sprues have to be tapered to prevent sticking in the bushing. The total draft angle should be between 2° and 3°. Sprue extractors should be tapered in the opposite direction (5°). The length of the sprue extractor should be approximately equal to its diameter.

Runners. As processing temperatures are not far above the crystallisation temperature, runners and gates must be of adequate size to prevent solidification of the material before reaching the cavity. The diameter of the runners can be empirically estimated from maximum thickness of the part plus 1.5 mm. A more accurate result can be obtained using flow simulation programs.

Gating. The position and sectional area of the gate must always be carefully located from the point of view of the final properties of the part rather than simply ease of construction.

When possible, gates should be positioned at the thickest section of the component. The gating is normally placed at a line of symmetry of the product. Be aware of the fact that weldlines should not occur where loads are involved. If the gate is too small and the material freezes prematurely, it will not be possible to pressurize the mould cavity further, resulting both in mould filling problems as well as stresses in the area of the gate.

The gate diameter should therefore be at least 50% of the component wall thickness, with a short land length to help overcome void formation, sinking and poor dimensional stability. For tunnel gates (see Figure 13) the minimum recommended diameter is 1.0-2.5 mm (approx. 75% of the wall thickness).

Hot runners. When for instance long flow paths are involved, a hot runner system could be used. When using a hot runner system, an open, externally heated system with a small front torpedo or shut-off valves is recommended. The hot runner design should be streamlined to avoid dead spots.



Ignition connector, Stanyl TW200F6.

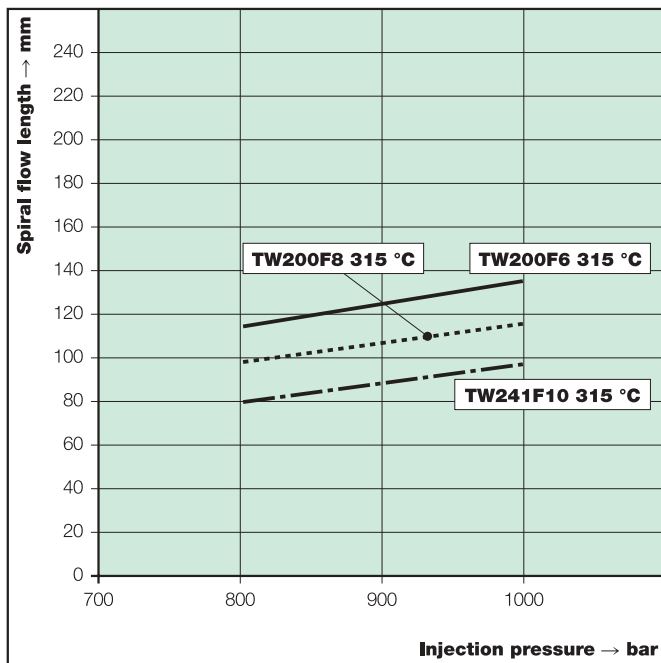


Figure 14.
Spiral flow length
of Stanyl GF
grades; spiral
thickness 1 mm,
mould temperature
80 °C (influence of
glass content).

It is important that good thermal control is assured throughout the runner system, particularly at the nozzle gates to avoid nozzle stringing or freezing. Each nozzle tip should be controlled by a separate temperature control device to ensure smooth production. To provide even temperatures, the manifold block needs enough heating power and separate heating circuits.

Venting. Ideally, the mould should have venting at several points around the cavity. The minimum requirement is to have adequate venting at the end of the flow path. Due to the low viscosity combined with the high rate of crystallization of Stanyl, a depth of 0.01-0.02 mm for the venting channels is sufficient. To improve the venting the channels should be enlarged after 2-3 mm.

Ejector-pins, moving cores and mould inserts can be produced with a clearance of 0.01-0.02 mm so that optimum venting is guaranteed. For multi-cavity moulds with a conventional runner lay-out, it is preferred to vent also the end of the runner in the mould parting line (depth 0.1 mm, length 3 mm).

Flow behaviour. A material's flow behaviour depends on several factors:

- melt temperature
- mould pressure
- melt viscosity
- injection pressure and injection rate
- runner and gate dimensions.

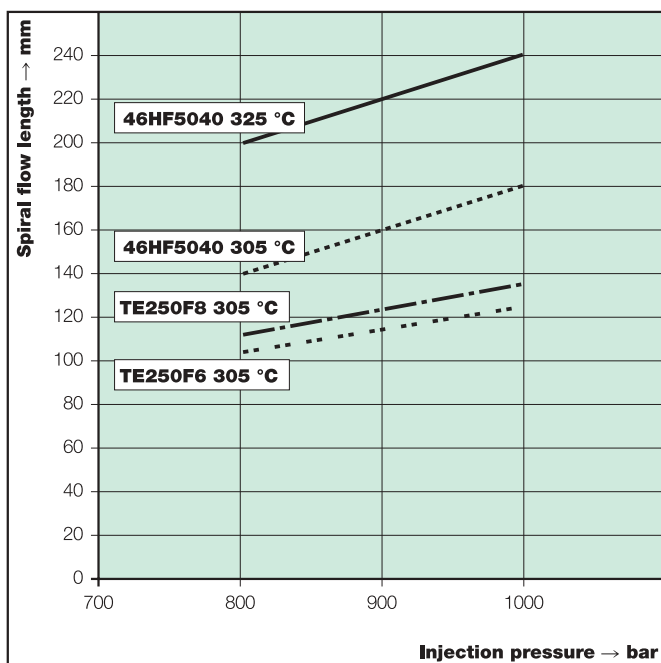


Figure 15.
Spiral flow length
of Stanyl GF FR
grades, spiral
thickness 1 mm,
mould temperature
120 °C (influence
of glass content
and melt
temperature).

End laminate in electro motors.



Stanyl has very good flow properties. It will readily fill moulds with long or complicated flow paths with good replication of the mould surface details. However, because it has a high rate of crystallization, it solidifies rapidly and fast injection rates are necessary.

The effect of injection pressure and melt temperature on flow length is illustrated in Figures 14, 15. Figure 16 shows the influence of wall thickness.

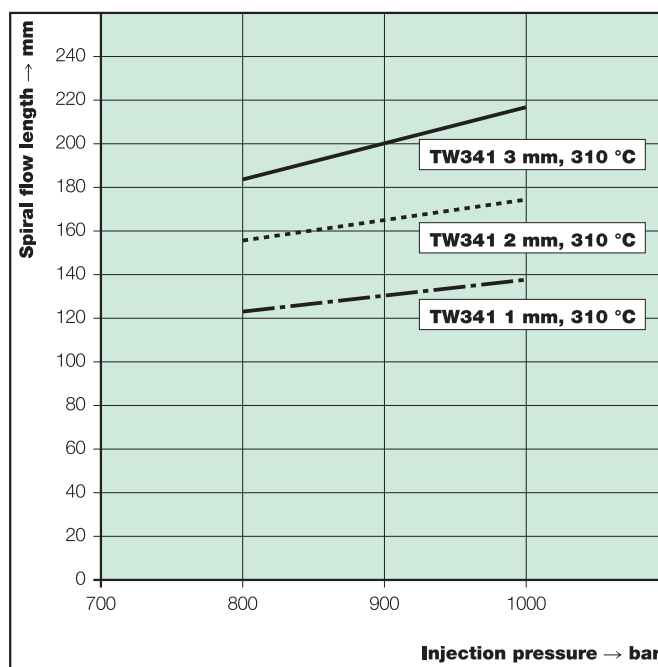
Ejection. Stanyl does not stick to the mould surface and has good ejection properties. The component should have tapered walls and ribs with a 1° taper for Stanyl UF and 0°-30° for Stanyl GF. Parts with less draft angle can be moulded from Stanyl if the mould is provided with extra ejectors.

Temperature control. The quality of the components and the degree to which their properties can be reproduced, depends amongst others, on a uniform cavity wall temperature distribution.

Mould insulation plates are recommended to prevent heat transfer from the heated mould to the injection machine. The use of such plates offers more precise mould temperatures and in addition energy savings.



Figure 16.
Spiral flow length of
Stanyl UF as
function of wall
thickness; mould
temperature 120 °C.



Mould steels. Stanyl without flame retardant additives can be processed in moulds made of standard tool grades. For flame retarded Stanyl grades, it is necessary to use steel containing at least 12% free chromium.

For reinforced Stanyl grades hardened steel prevents wear. Required hardness: 56-60 HRC.

Inserts

Use of metal inserts. Metal inserts can be overmoulded with Stanyl. Larger inserts require preheating to 80-120 °C to avoid the creation of local stresses which can lead to cracks or brittle fracture. If cracking occurs, the wall thickness surrounding the metal insert should be increased to absorb the stresses. The inserts should be clean, free of oil and grease and without sharp edges.

Safety

Under normal conditions, Stanyl does not present a toxic hazard through skin contact or inhalation. During processing, contact with the polymer melt and inhalation of the fumes should be avoided. A Material Safety Data Sheet can be requested from the DSM product administration department.

Chain guides and tensioners, Stanyl TW341 and TW241F10 (base).

Material handling

Packaging

Stanyl is supplied in sealed, airtight, multi-layer 25 kg bags or 1000 kg in octapacks. Bags are supplied on complete pallets of 1375 kg and are wrapped in plastic. The bags should only be opened immediately prior to processing.

Storage. When the material is stored in a relatively cold warehouse, it is recommended to condition the material by placing the bags near the processing unit 24 hours prior to its use. This will prevent moisture condensing on the granules after the bag is opened. The hopper should not be filled with more material than is sufficient for four hours of production.

When a bag has been opened and the content has not been used completely, the bag should be closed and sealed carefully to prevent contamination and moisture pick up.

Drying

Every batch of Stanyl is tested for moisture content and viscosity. A certificate with the relevant batch data can be delivered with the materials. Stanyl is packed at a maximum moisture content level of 0.1%. For critical applications, the recommended moisture content is 0.05% or less. Higher levels can have an adverse effect on both flow and mechanical properties. When bags have been opened, or have been damaged, it may be necessary to pre-dry the material to a moisture level of less than 0.1% (see Figure 17). It is advisable to dry Stanyl with dehumidified air dryers according to

Figure 17. Drying of wet Stanyl grades ³⁾⁴⁾

- 3) Drying in a pre-heated air circulated oven (dew point ≤ -30 °C).
- 4) After conditioning for 42 days at + 23 °C and 50% relative humidity (= starting point curve).

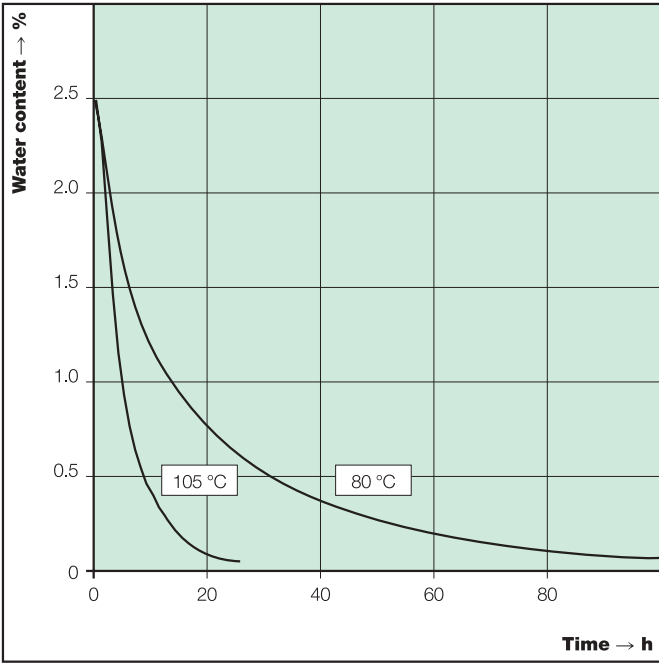


Table 9. Moisture content and advised drying conditions.

Moisture content	Pre-drying of Stanyl ³⁾ :	
	time	temperature
0.05-0.2%	2-4 h	80 °C
0.2-0.5%	4-8 h	80 °C
> 0.5%	24 h	105 °C
	100 h	80 °C

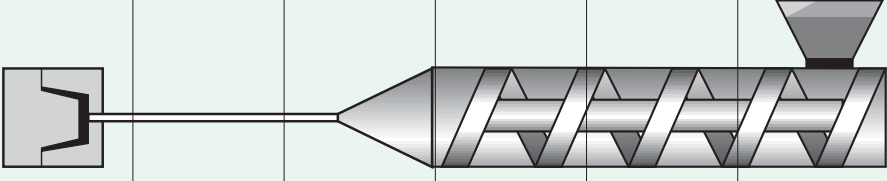
Table 9. The key requirement of the dryer, however, is its ability to maintain a dew point between -40 and -30 °C. Dew points above this level do not facilitate drying.

Vented barrel. At high temperatures or long residence times, wet material can degrade due to hydrolysis, which will lead to a drop in molecular weight. A vented barrel does not effectively reduce a high moisture content in Stanyl. For this reason, we do not recommend vented cylinders for processing moist Stanyl.



The packline where the final Stanyl product is packed in 1000 kg octabins for shipment to customers.

Figure 18. Standard moulding temperatures.

							
Stanyl	Mould	Melt	Nozzle	Front	Center	Rear	
Standard grades	80-120	305-320	280-300	300-320	300-320	280-320	°C
High Flow grades	60-120	315-330	280-300	315-330	310-325	280-310	°C

Use of regrind

The standard practices using regrind, also apply to Stanyl:

- clean, non-contaminated regrind
- low dust content (use sieves to remove dust)
- no thermally degraded material
- pre-dried material, moisture content < 0.05%
- no mixtures of different types of Stanyl.

To avoid moisture pick up, it is advisable to regrind the sprue immediately after processing, mix it with virgin material and feed it back into the hopper.

Critical applications should be produced without regrind.

"Parts shall not be moulded from material that contains more than 25% thermoplastic regrind by weight, unless the result of a separate investigation indicates acceptable performance for the specific part." (Underwriters Laboratories Inc. UL746D).

Regrind can cause colour changes and the flow characteristics of the material can also be affected.

Production start up

Start production with a clean injection moulding unit. Cleaning can best be carried out by purging with HDPE (MFI 0.2).

To start the injection moulding process, the following procedure should be used:

- set the cylinder temperatures as recommended in Figure 18. Make sure the injection unit has reached these temperatures, to prevent high torque loads on the screw. Recommended hopper base temperature is 30-80 °C
- set mould temperatures to 80-120 °C
- make sure the hopper is clean and filled with dry Stanyl
- start the injection cycle with a short shot and optimize the conditions.

Plasticizing

See also page 28 for Stanyl High Flow grades.

Melt temperature/residence time.

In order to establish the optimum processing temperatures, one should be aware of the upper and lower temperature and time limitations for processing Stanyl. Like other polyamides, Stanyl shows severe degradation at melt temperatures above 330 °C, also at short residence times. At lower temperatures, the allowable residence time depends on the temperature (see Figure 19). To generate completely molten materials, the melt temperature should always be above 300 °C. Optimum mechanical properties, are achieved when Stanyl is processed with a melt temperature between 310-320 °C, for High Flow grades 315-330 °C and a residence time of less than 6 minutes.

A non-homogeneous melt may affect the properties of the material negatively, especially its toughness and fatigue behaviour.

The melt temperature depends on the cylinder temperatures settings, the screw configuration, the screw speed and the back pressure. Therefore, it is essential to measure the actual melt temperature after the injection moulding process has been running on automatic cycle for some time and the processing conditions have stabilized.

The residence time is defined as the time that the material needs to get from the hopper through the injection moulding machine and into the part.

Cylinder temperatures. Semi-crystalline materials require additional energy compared to amorphous materials in order to fully melt their crystalline structure.

Due to its high melting point and high crystallinity, Stanyl needs a relatively long feeding zone. In order to compensate for this on screws which have a short feeding zone (1/3L) the following steps can be taken:

- an almost uniform temperature profile with, in extreme cases, a higher temperature setting near the hopper than the nozzle temperature
- pre-heat the material in the hopper (max. 80 °C and use pre-dried air)
- limit the cooling at the hopper base, 30-80 °C.

Starting temperatures as shown in Figure 18 are recommended.

Plasticizing problems. When problems occur, such as unmolten granules or a grinding noise is heard during plasticizing, it may be necessary to increase the temperature settings at the feeding zone. The addition of no more than 0.1% of a lubricant based on PE, can be beneficial when irregular plasticizing occurs. The use of stearates (for example Ca-stearate or Zn-stearate) is not advised since the molecular weight of Stanyl may drop during processing.

Screw rotation speed. Like most aliphatic polyamides, Stanyl has excellent flow properties due to its relatively low melt viscosity. For Stanyl a screw rotation speed should be selected to give a plasticizing time that is just within the cooling time.

In Figure 20 the limits of the screw rotation speed are shown in relation to the diameter of the screw. The circumferential speed of the screw should not exceed 0.25 m/s for small screws and 0.20 m/s for larger diameters.

With glass reinforced grades, care should be taken to prevent the reduction of the glass fibre length.

Back pressure. A back pressure of 50-75 bar effective (10-25 bar for High Flow grades) is recommended for processing Stanyl to homogenise the melt and to prevent air or gas entrapment in the melt, which would otherwise cause voids or streaks. A too high back pressure (± 200 bar effective pressure) can cause an increase in plasticizing time (usually resulting in a longer cycle time), unnecessary nozzle drool and a reduction of the glass fibre length.

Figure 19.
Processing window
for standard Stanyl
grades.

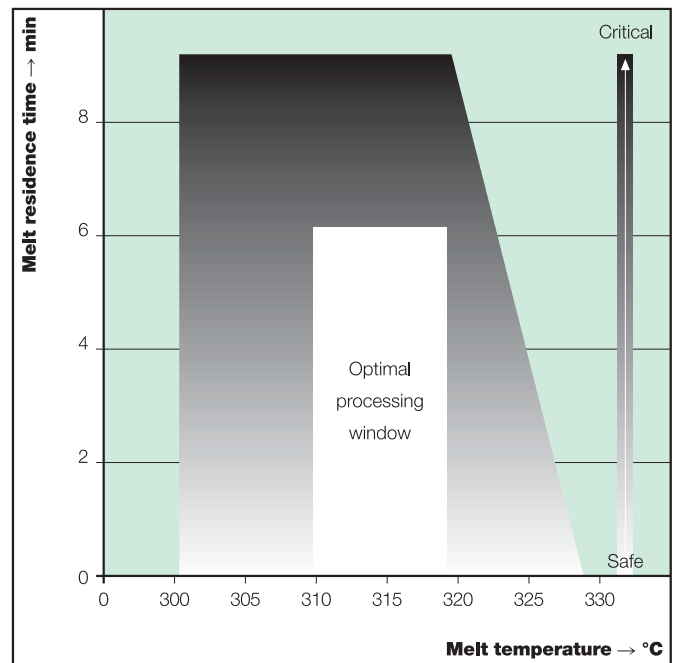
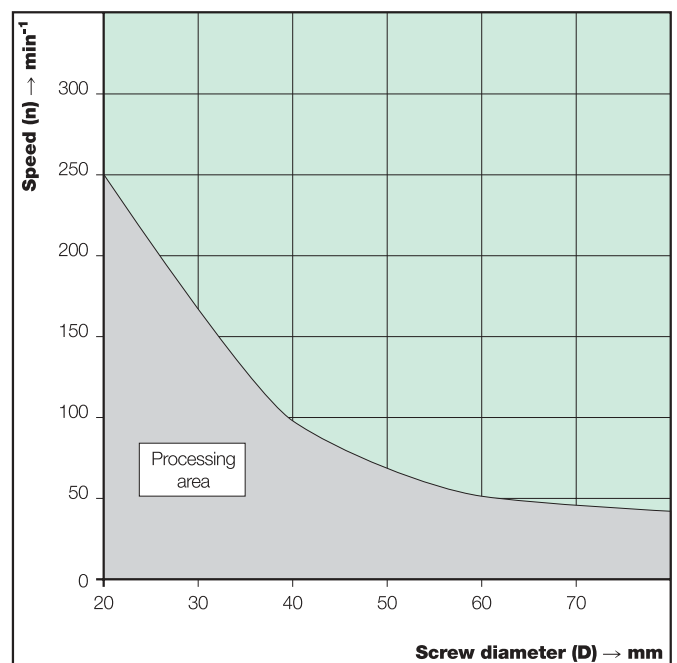


Figure 20.
Screw speed for
standard Stanyl
grades.



Processing Stanyl® PA46 High Flow

Due to its high flow character, Stanyl High Flow (46HF5040) is less sensitive to shear heating and should be processed differently from the standard Stanyl grades. The best results, both for mechanical properties and flow, have been obtained using actual melt temperatures around 325 °C. Due to the low shear heating, this can only be achieved by increasing the barrel temperature settings in the compression and metering zone. As for regular Stanyl grades, high injection pressures give better end-product performance.

An example of settings used for 46HF5040 (using an injection moulding machine with a 22 mm screw diameter):

- temperature profile from hopper to nozzle: 290-295-305-315-315-315 °C (or 325-330 °C in compression/metering zone)
- back pressure: 25 bar specific
- rotation speed: max. 340 rpm
- injection speed: max 100 mm/s
- holding pressure: < 350 bar specific.

As a result of its high flow, injection pressures will be reduced up to 50% and less warpage will occur (less built-in stresses).

Problems that may be encountered when using standard Stanyl settings for High Flow grades are:

- a large variation in dosing time
- variations in injection pressure
- drooling from nozzle
- low melt temperatures (< 300 °C).

The variations in dosing time and injection pressure can be overcome by decreasing the back pressure, decreasing the temperature of the feeding zone and increasing the screw speed compared to standard Stanyl settings. Because of the reduced shear, the final melt temperature will be lower using the same barrel settings. When the melt temperature decreases below a critical level (300 °C), it may result in poor mechanical properties caused by an inhomogeneous melt. To avoid this, the temperature setting of the compression and metering zone should be increased. Drooling from the nozzle can be adjusted by lowering the nozzle temperature. Beware not to lower the nozzle temperature too much as it again may lead to an inconsistent dosing behaviour or premature freezing of the melt.

Injection phase

As Stanyl sets up fast in the tool, high injection speeds are required in order to obtain a good surface finish. Adequate mould venting is necessary to avoid burning (due to self-ignition) at the end of the flow path.

Since Stanyl is an easy flowing polymer, high injection speeds can be achieved with relatively low injection pressures. An injection speed up to 80% of the maximum speed will give good results.

Cooling phase

Holding pressure/holding time.

For optimum appearance, quality and dimensional control, holding time plays an important role. In general the holding time of Stanyl is very short compared to other engineering plastics, since it solidifies rapidly.

Sink marks and voids caused by shrinkage can be reduced by applying an adequate holding pressure. However, the holding pressure should not be so high that stresses are induced. One method of determining the correct level is by increasing the holding pressure until no sink marks are visible. After completely cooling down, the component is then cut open at its thickest section and inspected for voids. If necessary the holding pressure is increased. Another method to determine the holding time is to weigh the components (without sprue) and increase the holding time until a constant weight is achieved.

A more sophisticated method is by using pressure transducers in the cavity to determine the exact moment of freeze-off. An example of a 3.2 mm UL bar shows that Stanyl needs only half the holding time compared to PA66 (see Figure 21). In combination with higher mould ejection temperatures, this explains the very short cycle times compared to other engineering plastics.



SIM connectors. The use of Stanyl instead of LCP in a SIM connector created an interesting cost-saving of 30-70% on material cost, without giving-in on properties. Stanyl can often be used in tools cut for LCP.

Mould temperature and cooling time. In addition to holding pressure and holding time, cooling time and mould temperature are also important. Because Stanyl solidifies rapidly, the cooling time is very short. For this reason, the plasticizing time is the determining step the cycle time. In general, mould temperatures of 80 °C are recommended for good dimensional stability and flow properties. To reduce post-shrinkage, increase toughness, improve the surface appearance or achieve maximum crystallinity mould temperatures may be increased up to 120 °C and sometimes even higher, especially for Stanyl UF. In some specific cases a mould temperature lower than 80 °C has advantages. A practical example is metallization, where an etched surface results in a better adhesion of the metal. Furthermore, good cooling is necessary to reduce warpage. For optimum cooling the positioning of the cooling channels is very important.

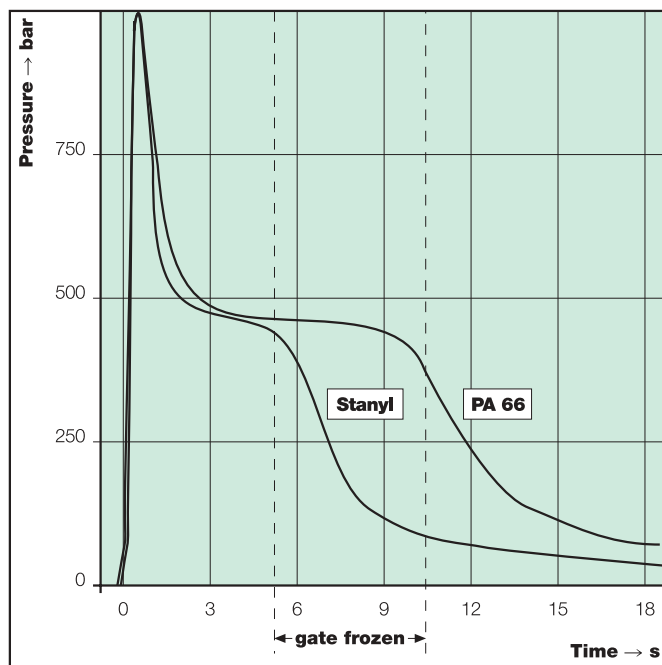
Mould ejection. Stanyl does not stick to the mould surface and has good ejection properties. Due to the high crystallisation rate, the surface solidifies very fast and exhibits a high stiffness at high temperatures, so that Stanyl can be ejected at relatively high temperatures (T_{wall} 200 °C) resulting in short cycle times (20 - 30% faster than PA66).

Breaks during production

Take care that the nozzle does not freeze off when production is interrupted.

Figure 21.
Determination of
gate freeze-off ⁵⁾

5) Test piece UL-bar
3.2 mm, Injection
temperature 270 (PA66)
and 310 °C (PA46),
mould temperature
80 °C, holding pressure
450 bar.



This can cause a backward moving melt front when production is started again.

Short breaks. When a break during production is expected, the hopper should be closed, the screw emptied and the screw put into the forward position. The cylinder temperatures can be maintained. When starting up, purge with fresh material.

Production breaks of 1-2 hours. Empty the hopper (to prevent material from absorbing moisture), empty the screw, put the screw into the forward position and lower the cylinder temperatures to 260 °C.

When starting up, first purge with fresh material.

For flame retardant grades always purge the cylinder with HDPE.

Cleaning the injection unit

When production with Stanyl is finished, empty the hopper and the screw and purge with a high melt viscosity grade of HDPE (MFI 0.2) such as Stamylan HD7625 (DSM). Lower the cylinder temperatures during purging to the required level of the polymer to be processed.

Injection system. TDI-Pump-Nozzle assembly used in the latest range Turbo-Diesel-Injection engines of VW Passat/ Bora/Golf (4 cylinder) and Lupo. Also in Audi A3/A4 and A6. The pump-nozzle cable-assembly is water/oil proof and connects outside engine management with inside engine cylinder head injection pump system. Stanyl has been selected because of its heat- and oil resistance (> 2000 hrs/150 °C).



Characteristics properties of Stanyl

General

Stanyl is a high performance polyamide which is used in demanding applications in the automotive and electrical/electronics industry and in other applications where a combination of high heat resistance, excellent flow, high mechanical properties or outstanding wear and friction behaviour is required. Stanyl's high number of amide groups per given chain length and the highly symmetrical chain structure (see also Introduction) result in a high melting temperature (295 °C), a high crystallinity and fast crystallization. Stanyl's high crystallinity (approximately 70%), results in a high heat distortion temperature (190 °C for unreinforced Stanyl and 290 °C for glass fibre reinforced Stanyl), excellent creep behaviour (especially at elevated temperatures), high oxidative stability and excellent abrasion resistance. The high crystallization rate of Stanyl results in the formation of many small spherulites. This explains the superior toughness of Stanyl compared to other engineering plastics, resulting in a unique combination of toughness and high heat resistance (see Figure 5 page 13 and Figure 22). The combination of high crystallinity and many small spherulites results in excellent fatigue behaviour. In addition, the high crystallization rate of Stanyl enables faster cooling and thus short cycle times.

Due to its unique combination of excellent mechanical properties and high heat resistance (see Figure 23), Stanyl bridges the gap between conventional engineering plastics such as PA6, PA66 and polyesters and more exotic materials such as LCP, PPS, PSU, PEEK and PES, PEI.

Figure 22. Impact versus heat resistance of Stanyl and other engineering plastics.

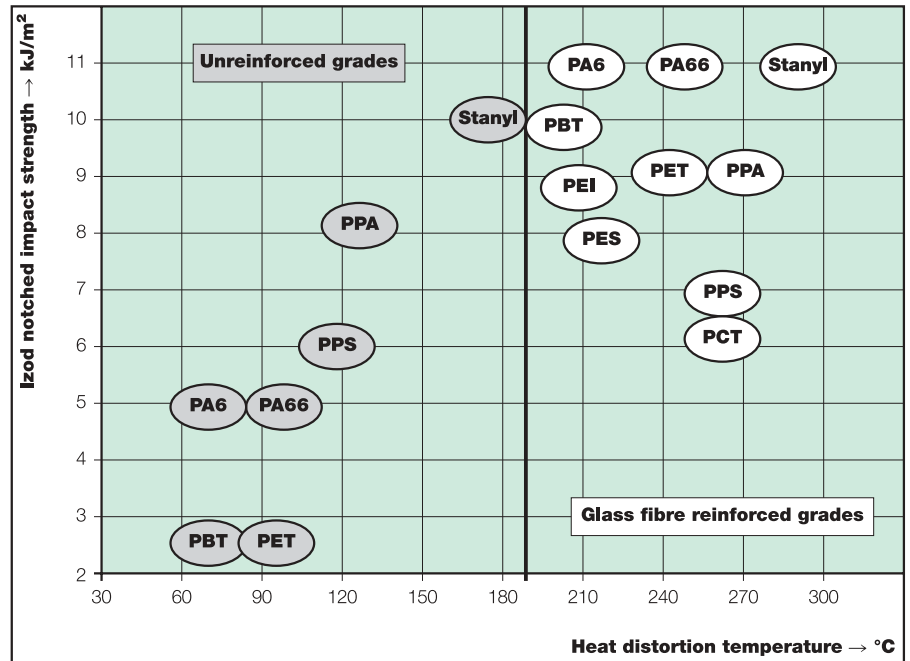
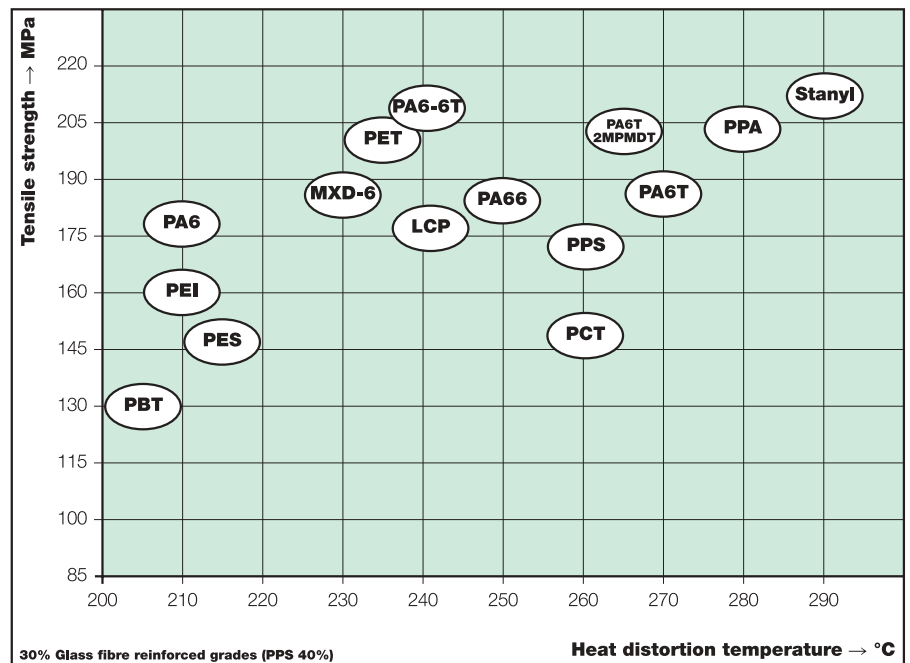


Figure 23. Tensile strength versus heat resistance of Stanyl and other engineering plastics.



Stanyl's high performance leads to important advantages for the customer including cost reduction, longer lifetime and higher reliability due to:

- excellent short-term and long-term heat resistance
- high stiffness at elevated temperatures
- high creep resistance, especially at elevated temperatures
- outstanding toughness
- excellent fatigue behaviour
- superb wear and friction properties
- excellent flow
- good resistance to chemicals
- high level of electrical properties combined with V-0 UL flammability listings for flame retardant grades
- high productivity due to short cycle times and low reject levels
- no flash.

Temperature Performance.

The temperature performance of every engineering plastic can be described by:

- a peak temperature resistance or short term temperature resistance, as indicated by the melting point, Vicat or a Heat Distortion Temperature and a certain level of stiffness and strength at a certain elevated temperature
- a resistance to long-term exposure at elevated temperatures with or without a load applied (with load: creep resistance, without load: Absolute Real Operating-value, see page 34).

Short Term Heat Performance

In today's high tech world, the performance of engineering plastics over a wide temperature range is often of critical importance. An indication of the short term temperature performance of a material is its stiffness and strength at elevated temperatures (for instance between 100 °C and 280 °C).

Figure 24a.
Shear modulus of unreinforced polyamides.

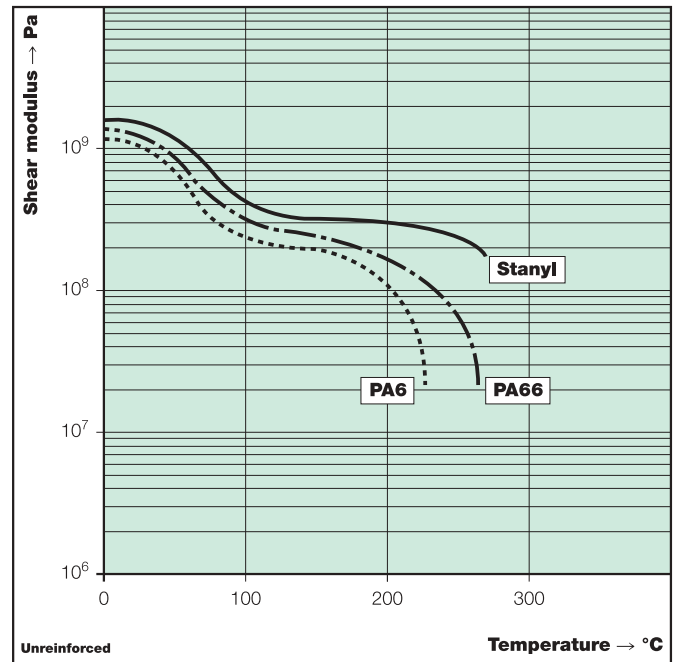
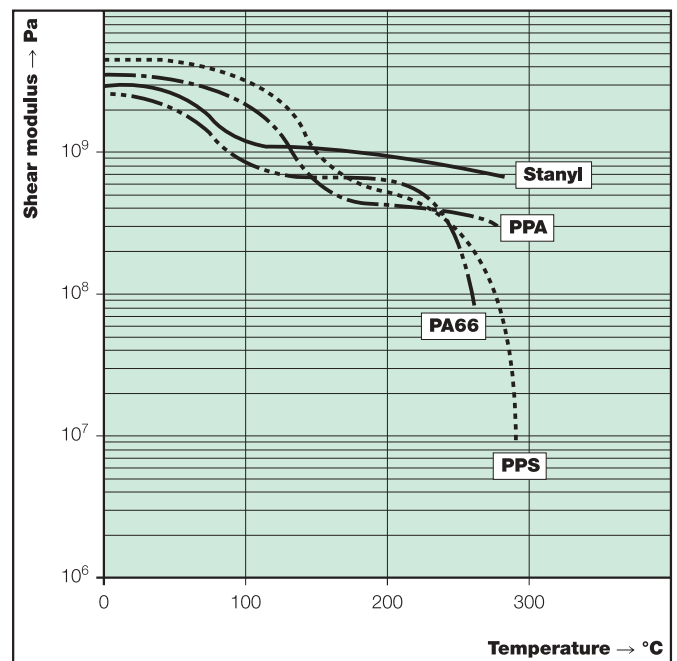


Figure 24b.
Shear modulus of 30% (PPS 40%) glass fibre reinforced engineering plastics.



This stiffness/strength level at elevated temperatures should be considered as the critical level to design for, since measurements at room temperature are in general much higher (even after moisture absorption).

The shear modulus offers a way of comparing the stiffness of thermoplastics at different temperatures. Due to its high level of crystallinity.

Stanyl retains its stiffness to a great extent at elevated temperatures close to its melting point 295 °C (see Figures 24a, b, c), which ensures a wider safety margin for critical applications in comparison to competitive materials such as polyesters, PA6 and PA66 and PPAs. PPA and PPS have a very high modulus at room temperature but show a significant drop in stiffness at temperatures above 100 °C (see Figure 24b). In practice, Stanyl has the highest stiffness at temperatures higher than 120 °C, when compared to competitive materials with the same level of reinforcement.

The superior stiffness also allows Stanyl to be used in applications exposed to high peak or high operating temperatures where other thermoplastics fail (see connector and automotive applications). By adding reinforcers, stiffness can be further increased (see Figure 24c).

Other indicators of the stiffness, which are more suitable as a design criterion than the shear modulus, are the tensile and the flexural moduli; for polyamides these properties (and other mechanical properties like tensile or flexural strength) merely depend on ambient temperatures, moisture content, heat exposure, the type and amount of reinforcement or other additives (lubricants, pigments) used, see Table 10. This table again shows Stanyl's superior strength and stiffness at elevated temperatures compared to competitive high performance thermoplastics.

Figure 24c.
Shear modulus of
some Stanyl grades.

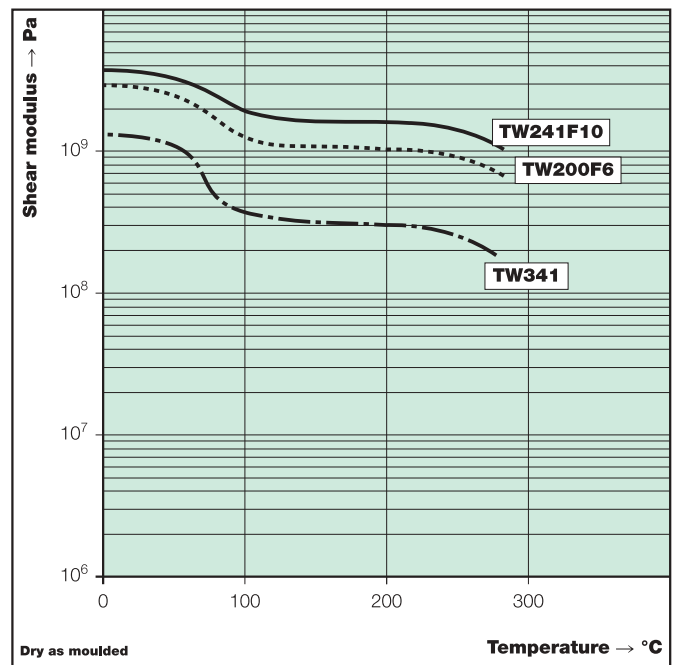


Table 10. Stiffness at various conditions and various GF reinforcements levels.

Polymer	Stanyl	PA66	PPS	PPA
Tmelt (°C)	295	260	285	315
Tg (°C)	80	65	90	120
HDT 1.8 MPa (°C)	290	250	265	280
E-Modulus (MPa)	30% GF reinforced	30% GF reinforced	30% GF reinforced	30% GF reinforced
23 °C	10000	9500	11700	12800
23 °C/50% RH	6500	6500	11700	12800
120 °C	5500	4400		7200
140 °C	5300	4100		4000
160 °C	5000	3800		3600
E-Modulus (MPa)	40% GF reinforced	40% GF reinforced	40% GF reinforced	40% GF reinforced
23 °C	13000	12500	16300	16200
23 °C/50% RH	8000	8500	16300	16200
120 °C	6600	5600	7900	9000
140 °C	6300	5200	7100	5000
160 °C	6000	4800	6000	4400
Tensile strength (MPa)	30% GF reinforced	30% GF reinforced	40% GF reinforced	30% GF reinforced
23 °C	210	180	170	200
23 °C/50% RH	115	140	170	170
120 °C	105	85	95	100
140 °C	100	80	80	70
160 °C	90	65	65	60

Figure 25a. Creep modulus of unreinforced polyamides.

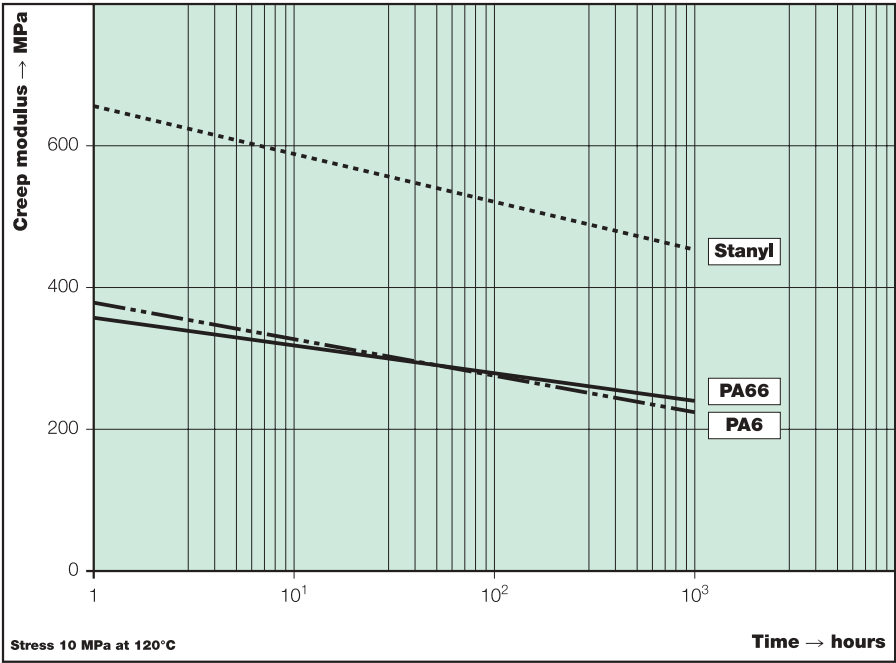
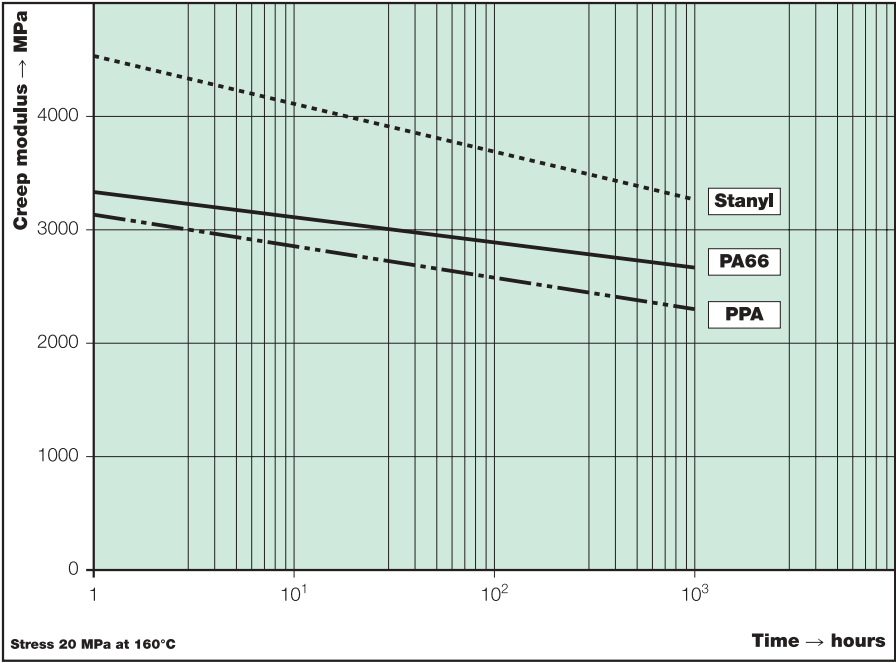


Figure 25b. Creep modulus of glass fibre reinforced (30 or 33%) engineering plastics.



The **melting point** in combination with the **Heat Distortion Temperature (HDT)** gives a good impression of the peak temperature resistance under load. The HDT is defined as the temperature at which a test bar is deformed to a given extent at a given applied load; this is related to a certain level of stiffness at the elevated temperature. Due to its excellent retention of stiffness at higher temperatures, the HDT-rating of Stanyl (190 °C for unreinforced and 290 °C for 30% glass fibre reinforced grades) is higher than that of other engineering plastics (see Figure 23).

Long Term Heat Performance

Creep resistance. For optimum performance and maximum lifetimes, engineering plastics which are subjected to long-term loading must have a high creep resistance (i.e. low plastic deformation under load).

Stanyl's high crystallinity results in an excellent stiffness retention at elevated temperatures (above 100 °C) and hence in creep resistance, which is superior to that of most engineering plastics and heat-resistant materials (see Figure 25a and 25b).

Figure 25c shows the effect of glass fibre reinforcement on the creep modulus of Stanyl at 140 °C. Creep behaviour could be one of the factors that limits the maximum application temperature of a material.

Heat ageing in air

For designers it is crucial to know the performance level of the end-product and therefore of the material at the end of its lifetime, which often means after exposure for thousands of hours to heat in an oxygen containing environment. This performance (heat or air ageing resistance) can be expressed in various ways: different parameters like strength, stiffness, impact resistance, elongation at break (measured either at room temperature or at the elevated temperatures) can be selected to monitor the performance after heat ageing over time. The results of these measurements can again be displayed in various ways: in a relative way via retention levels or via relative characteristics e.g. Continuous Use Temperature and Relative Temperature Index, or in an absolute way as in the recently introduced **Absolute Real Operating (ARO) Value** concept. This concept shows the strength measured at the absolute real operating temperature e.g. of 150 °C after ageing at 150 °C.



Figure 25c. Creep modulus of some Stanyl grades (GF = glass fibre reinforced)

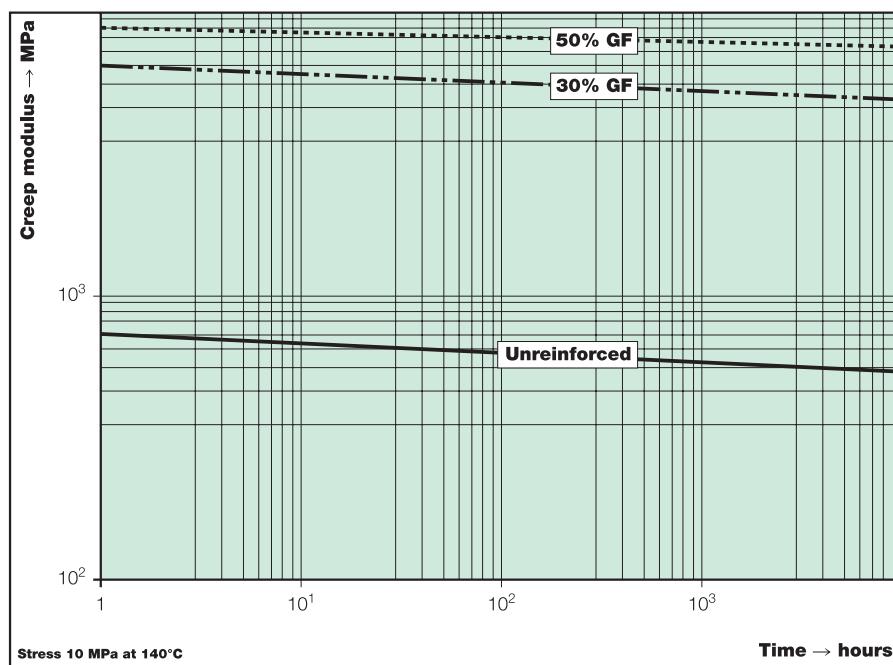
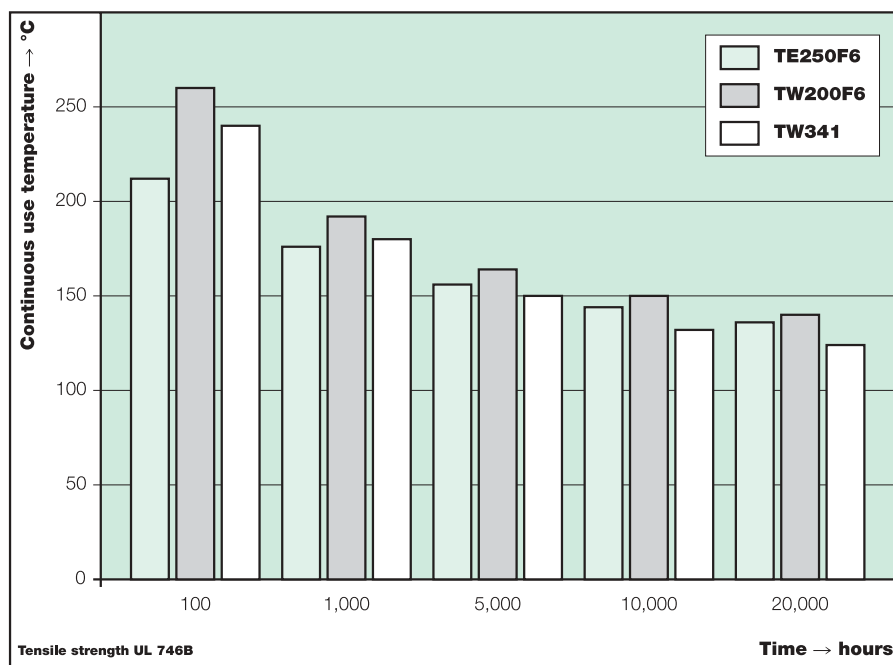


Figure 26. Continuous use temperatures of some Stanyl grades.



Diode carrier.

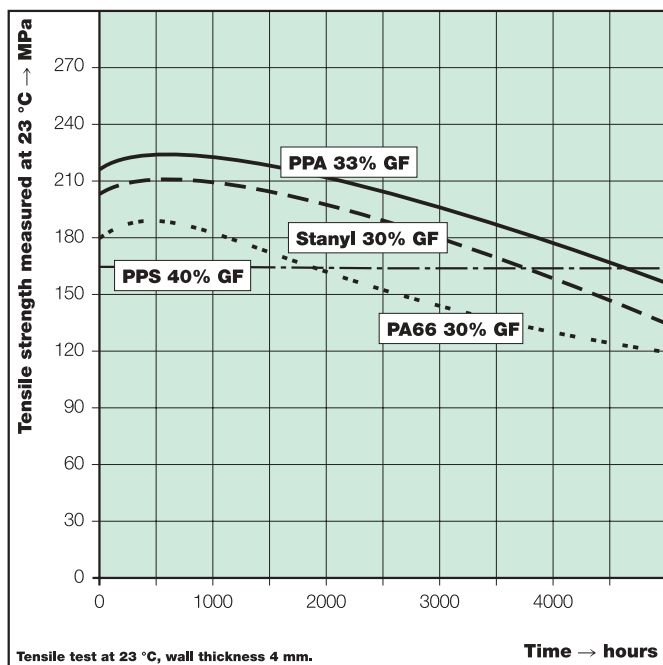


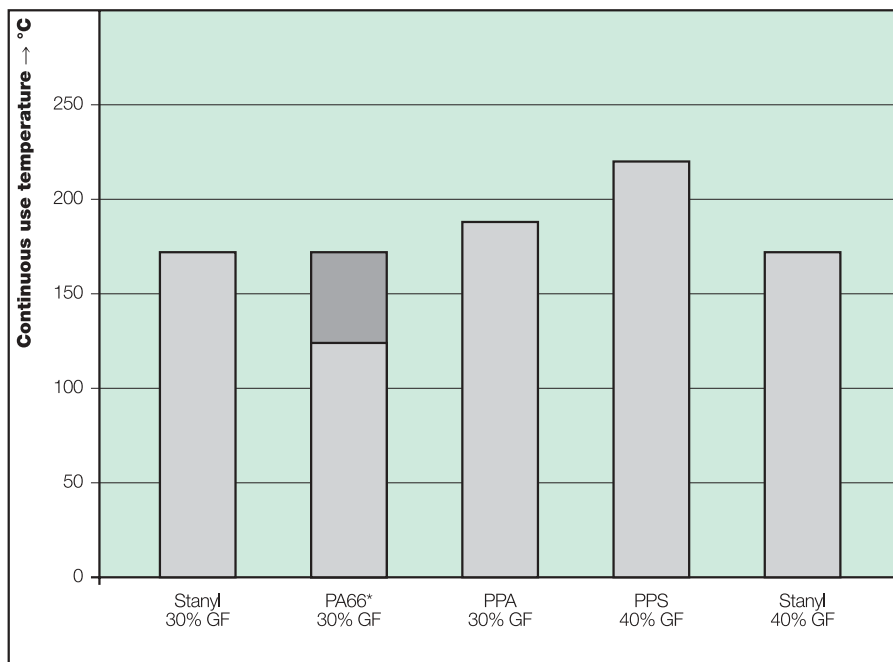
Figure 27. Absolute level of tensile strength at 23 °C after heat ageing at 150 °C for Stanyl and competitive thermoplastics.

The Continuous Use Temperature (CUT), frequently used in the automotive industry as a selection criterion, is defined as the temperature at which a given mechanical property (usually tensile strength or impact resistance) **measured at 23 °C decreases by 50% within a certain period of time** (usually 500, 1000, 5000, 10000 or 20000 hours). From Figure 26 it follows that the CUT of 30% glass fibre reinforced Stanyl TW200F6 at 5000 hours is 170 °C (after 5000 hours of ageing at 170 °C the drop in tensile strength is 50%). The different CUTs for different ageing times are also summarized in Figure 26.

The Relative Temperature Index, frequently used in the E&E industry, as given by UL (see Table 7 UL recognitions, chapter E&E) can be considered to a certain extent as a CUT for very long half-life times ranging between 60000 and 100000 hours: the RTI of heat stabilized Stanyl 30% GF is 140 °C.

The recently introduced concept of the **Absolute Real Operating Value** after heat ageing, gives designers more realistic comparisons between the various materials. It overcomes the major drawbacks of the CUT- and RTI- concepts, namely that these concepts only consider the retention of properties and measure these properties only at room temperature, after heat ageing.

Figure 28. CUT at 5000 hours for Stanyl and competitive materials.



* depending on the exact heat stabilizer package and content used.

Certain materials which start at very low levels but retain this level to a high degree (as for instance PPS, see Figure 27 and 29) are rated better in CUT-terms than other materials which start at a higher level and show a stronger reduction. However, the last materials can in absolute values still outperform the former materials after the heat ageing exposure. Additionally the CUT-concept is based on measurements of properties at room temperature, whilst the **more critical design levels are to be expected in the elevated temperature range**. The ARO concept is demonstrated in Figures 29 and 30 and Table 11, which show the superiority of Stanyl in comparison with PA66, PPA and PPS after heat ageing at 150 °C and 170 °C.

Comparing Figures 28 and 30 clearly show how misleading CUT can be when positioning engineering plastics for their heat ageing performance: the ARO value results in a much more realistic positioning.

Figure 29. Absolute level of tensile strength at real operating temperature (150 °C) after heat ageing at 150 °C for Stanyl and competitive thermoplastics.

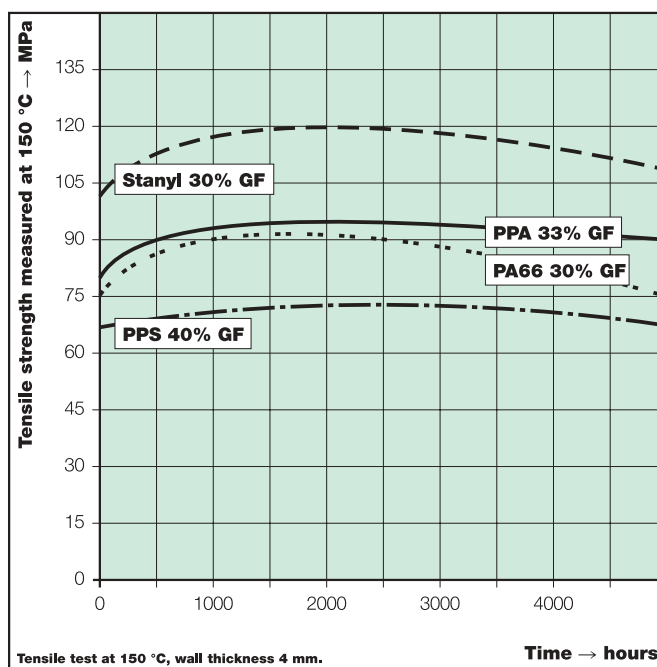
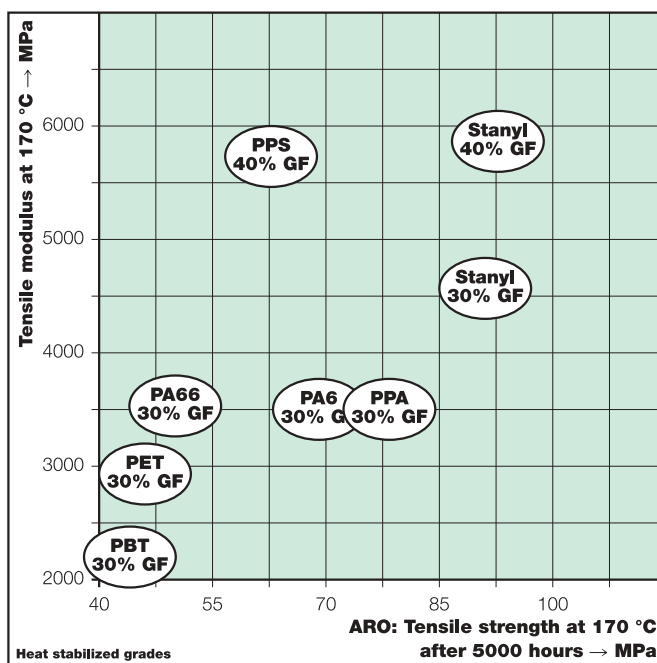


Figure 30. Positioning of thermoplastics according to ARO-concept.



Locking spring of a mobile phone connector (Stanyl TW341).

Table 11. Heat ageing resistance as expressed by the CUT and ARO-concept and stiffness at elevated temperatures for Stanyl and competitive polyamides (30% GF reinforced).

Properties	Stanyl	PPA	PA66
ARO 5000 hrs Strength at high temp. (MPa) after ageing at high temp.			
150 °C	110	90	70
170 °C	90	80	50
CUT 5000 hrs (°C)	170	185	130-170*
E-modulus (MPa)			
150 °C	5200	4000	4000
170 °C	4700	3500	3500

* Depending on the exact heat stabilizer package and content used.

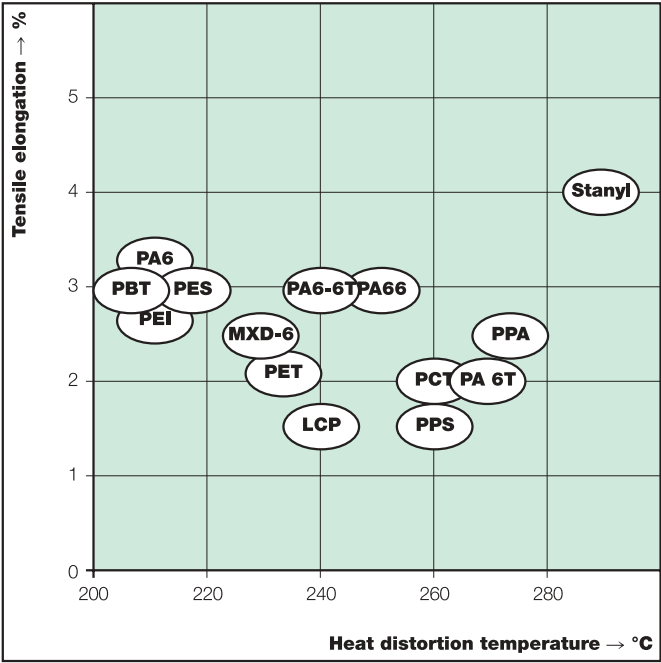


Figure 31. Tensile and temperature behaviour of 30% glass fibre reinforced engineering plastics.

Toughness, fatigue and wear properties. Whilst tensile and flexural strength decrease with increasing temperature, toughness, as measured by elongation at break and impact resistance, increases. Therefore the critical factor is usually the toughness performance at lower temperatures. Due to its fine crystalline structure, unreinforced Stanyl exhibits extraordinary impact resistance in comparison with many other engineering plastics (see Figure 22). Notched impact values remain at a high level even at temperatures below 0 °C.

The effect of different amounts of glass fibre reinforcement is different for both toughness parameters. With increasing reinforcement percentages, the elongation at break decreases whilst the notched impact resistance increases.

The notched Izod impact resistance of glass fibre reinforced Stanyl is unmatched (see Figure 22). This makes Stanyl the material of choice for demanding applications and facilitates further assembly steps, for instance using inserts and snap-fits.

Since this is combined with a very high elongation at break (see Figure 31), Stanyl offers the best solution for thin-walled parts, snap-fits, film hinges and insert moulding of gears, pulleys and dip switches.



Hall sensor, Stanyl TW200F6.

The high crystallinity and fine crystalline structure of Stanyl lead to a fatigue resistance superior to that of most other engineering and heat resistant plastics, (see Figure 32). The fatigue resistance of Stanyl is much better than that of PPA, PPS and PA66. Fatigue resistance is particularly important for gears and chain tensioners.

Stanyl also has excellent abrasion (or wear) resistance and outperforms many other engineering plastics under most conditions.

Figure 33 shows a comparison between Stanyl, PA66 and POM according to the Taber Abrasion test (ASTM D1044). Although the coefficients of friction of standard grades of these materials are quite similar, Stanyl outperforms its competitors. The main reason is its higher pressure velocity (PV) rating, which permits higher pressures or velocities to be used (see Figure 34).

Modified Stanyl grades with even better wear properties, are available in unreinforced (e.g. TW371) as well as in glass fibre reinforced (e.g. TW271F6; 30% GF) form. Its smooth and tough surface, combined with its stiffness at elevated temperatures, makes Stanyl an ideal material for sliding parts. These include valve lifter guides, chain tensioners, bearings and thrust washers.

Figure 32. Fatigue resistance at 140 °C of glass fibre reinforced engineering plastics.

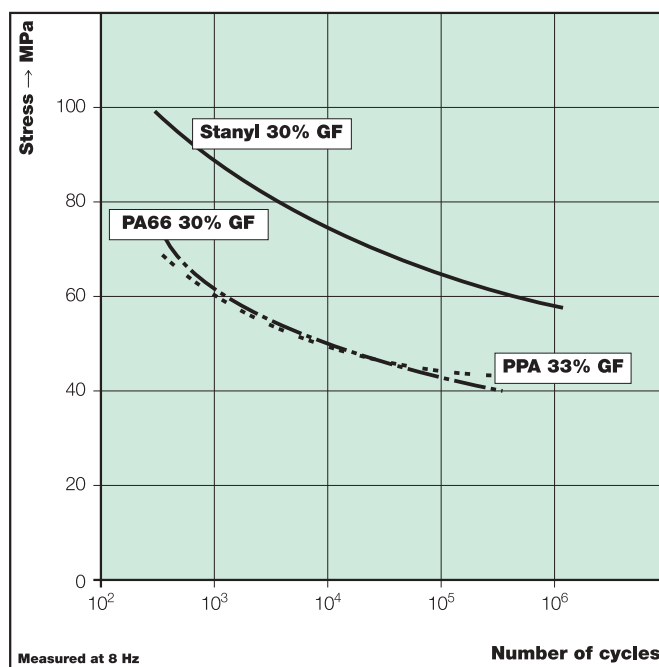
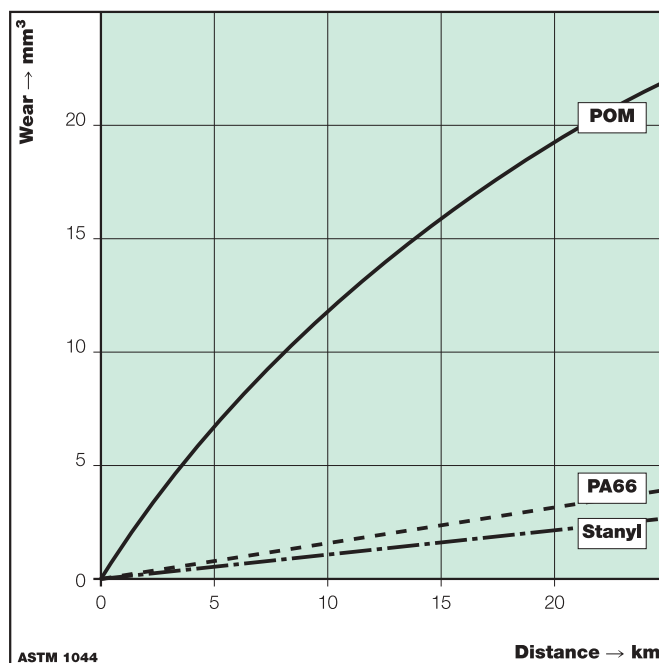


Figure 33. Taber abrasion resistance.



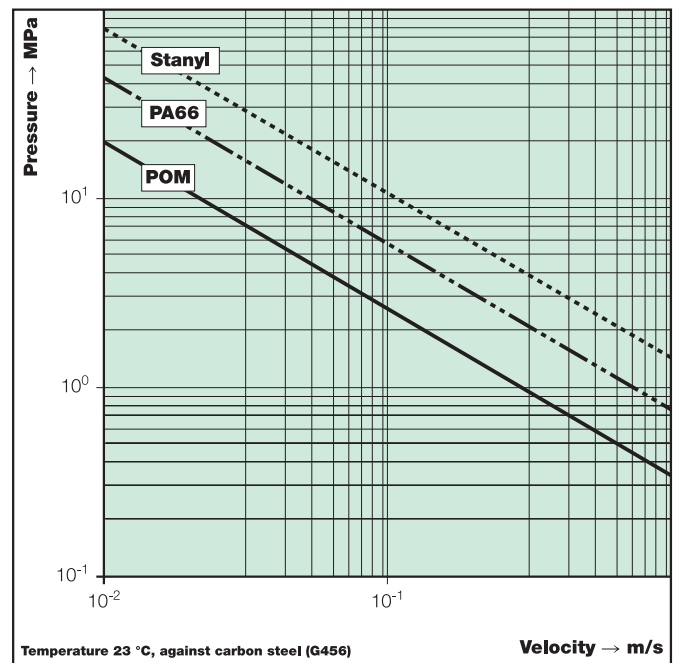
Stanyl provides toughness for recycable oil filter housings, Stanyl TW200F6.

Flow

One of Stanyl's key features has always been its excellent flow during processing. This allows Stanyl to be used in its applications with very narrow wall sections, as in different types of connectors used in Information and Communication Technology (ICT). This combined with a high level of mechanical properties and short cycle times (lower processing costs) has led the use of Stanyl in many applications such as memory connectors, fine pitch connectors, mobile phone and ZIF-PGA connectors (see also chapter E&E applications). Trends in this market are towards higher speeds and larger outputs. This implies a further demand on increased flowability for the thermoplastic materials used. DSM Engineering Plastics has developed a new generation of Stanyl: the Stanyl High Flow series. The first commercial grade in this series is a 40% glass fibre reinforced, flame retardant material: 46HF5040. This material clearly has an even higher flow than the standard Stanyl types otherwise used for these applications (TE250F6, F8 and F9). It also outperforms many competitive materials, even LCPs, which are known for their excellent flow.

This outstanding flow is combined with the usual high level of mechanical properties (high modulus, high toughness), high HDT and high melting point of standard Stanyl grades, clearly creating a product with a unique property-flow balance (see Figure 35).

Figure 34.
PV Diagram.



Charge air-intercooler, Stanyl TW200F6.

Figure 35. Spiral flow versus tensile strength.

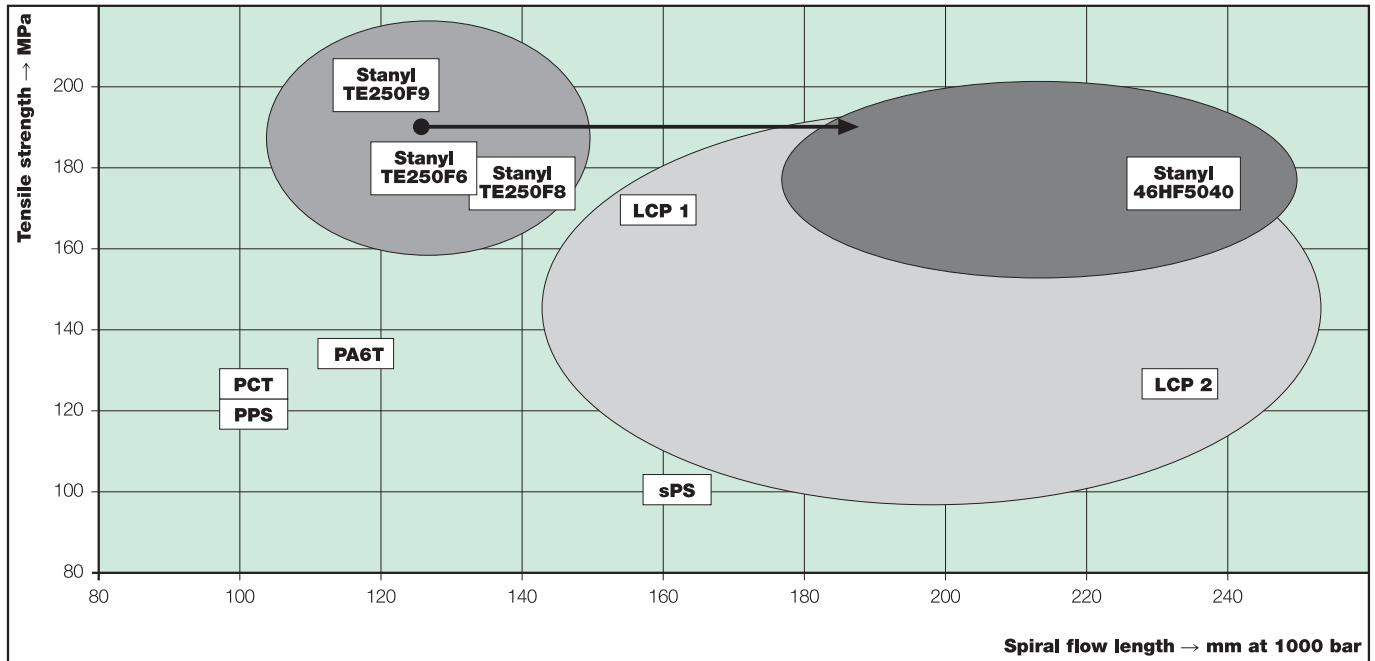


Table 12.
Dimensional change
as a function of
moisture uptake of
non-flame-retardant
grades.

Dimensional change (%) in flow/perp. to flow	Stanyl UF	Stanyl 30% GF	PA66 30% GF	PPA 30% GF	Stanyl 50% GF
50% RH - oriented part	0.7/0.7	0.15/0.6-0.9	0.1/0.4	0.1/0.3-0.4	0.1/0.5-0.8
50% RH - not oriented	0.8/0.8	0.3/0.6-0.9	0.15/0.4	0.15/0.3-0.4	0.3/0.3-0.6
90% RH - oriented part	1.8/1.9	0.35/1.4	0.2/1.0	0.2/0.5	0.2/1.2
90% RH - not oriented	2.2/2.2	0.5/1.5	0.4/0.9	0.2/0.3	0.8/0.8

The high mechanical properties assure good pin retention and low reject levels during pin insertion. Stanyl 46HF5040. The fast crystallization of Stanyl 46HF5040, once again results in short cycle times during injection moulding, offering a cost-effective solution for the most demanding applications. Stanyl 46HF5040 is less sensitive to shear heating and can be processed at higher melt temperatures.

Increasing the melt temperature from 305 °C (as used for standard flame retardant Stanyl grades) to 325 °C results in a further increase in flow (see Figure 15) and an increase in mechanical properties. The lower sensitivity, to shear heating, requires that High Flow grades be processed differently from the standard flame retardant Stanyl grades (see processing of Stanyl High Flow page 28).

Stanyl 46HF5040 is already used in the new generation of memory connectors (DDR-DIMM, RIMM) and ZIF-PGA and ZIF-BGA sockets. The outstanding flow results in lower injection pressures during injection moulding, a lower level of built-in-stresses and consequently, lower warpage.

Stanyl 46HF5040 has a V-0 UL-94 listing at 0.8 mm. This grade is the first one in the new High Flow series.

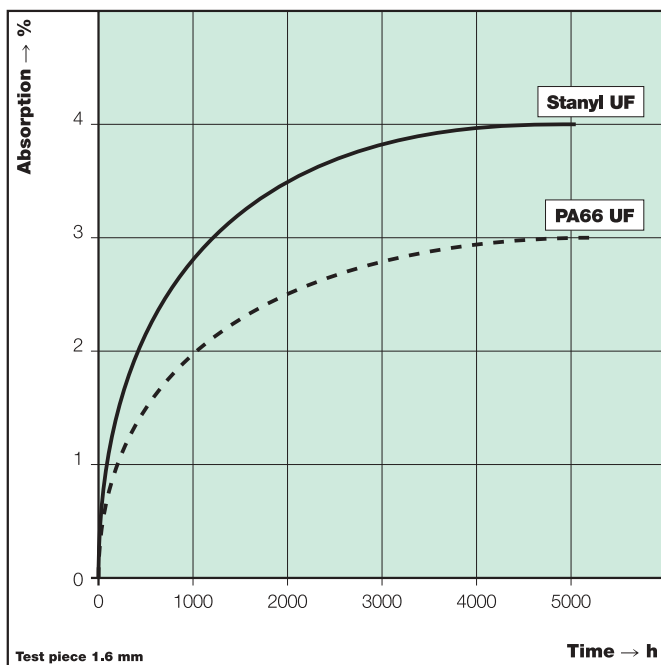


Figure 36.
Water absorption
23 °C in air 65% RH.

Water absorption and hydrolysis resistance

Like all polyamides, Stanyl reversibly absorbs moisture from the environment until it reaches an equilibrium (see Figure 36). Although Stanyl absorbs more moisture than PA66, the resulting dimensional change at equilibrium is of a similar order (see Figure 10 Chapter Processing). This can be explained by the higher crystallinity level of Stanyl.

When dealing with applications with very tight tolerances with respect to dimensions, the use of polyamides is not recommended. Note however that for many applications (even for connectors with very narrow tolerances, see chapter E&E applications) the dimensional stability of Stanyl matches these stringent specifications (see Table 12).

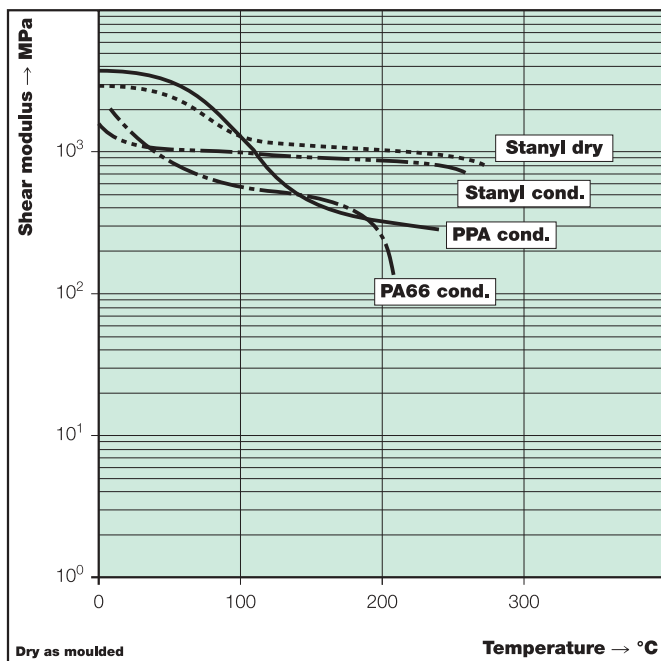


Figure 37.
Influence of moisture uptake on shear modulus of glass fibre reinforced polyamides.

At room temperature, moisture absorption will lower stiffness and strength while increasing toughness. At temperatures above 80 °C (the glass transition temperature of Stanyl) the effect of moisture absorption on Stanyl's stiffness is negligible (see Figure 37). In the case of materials like PA66 and PPA the effect of moisture absorption is more pronounced. Their stiffness drops more sharply at elevated temperatures due to their lower crystallinity when compared to Stanyl.



Fasteners.

In the case of conditioned PPA, the drop in stiffness already takes place around 100 °C. This means that in practice the stiffness and creep of Stanyl is superior to that of PPA at temperatures above 100 °C.

Chemical Resistance. Polyamides are well known for their resistance to a wide range of chemicals. Stanyl is no exception.

Its resistance to oils and greases is excellent especially at higher temperatures (see Figures 38 and 39). Stanyl is therefore an ideal material for under-the-bonnet applications in the automotive industry and for other industrial applications such as gears and bearings.

Liker all other polyamides, Stanyl is attacked by strong mineral acids and absorbs polar solvents. Information concerning the resistance of Stanyl to various chemicals and solvents is available on request from your local DSM sales office.

Figure 38. Influence of immersion in oil* on flexural strength of 30% glass fibre reinforced polyamides.

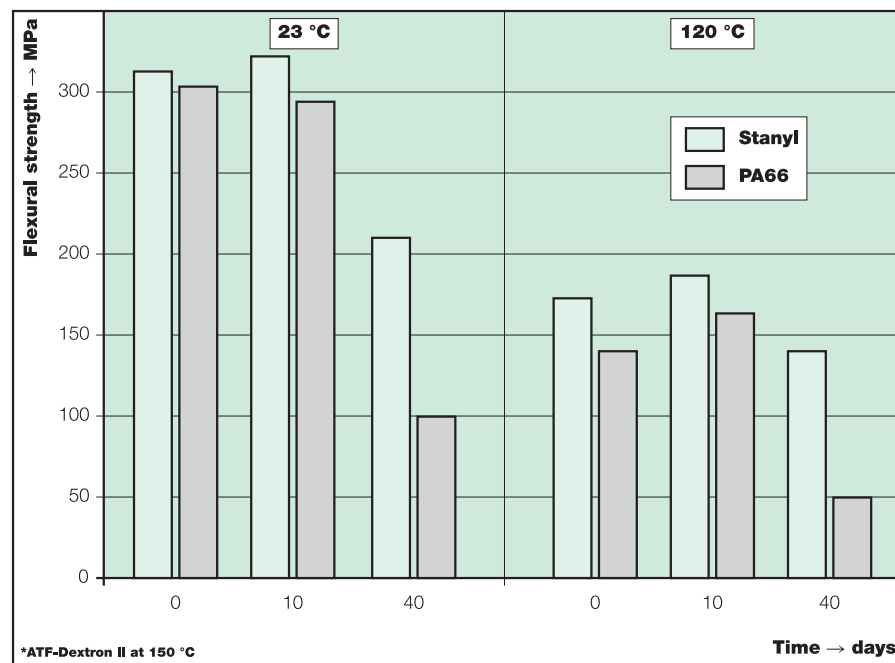
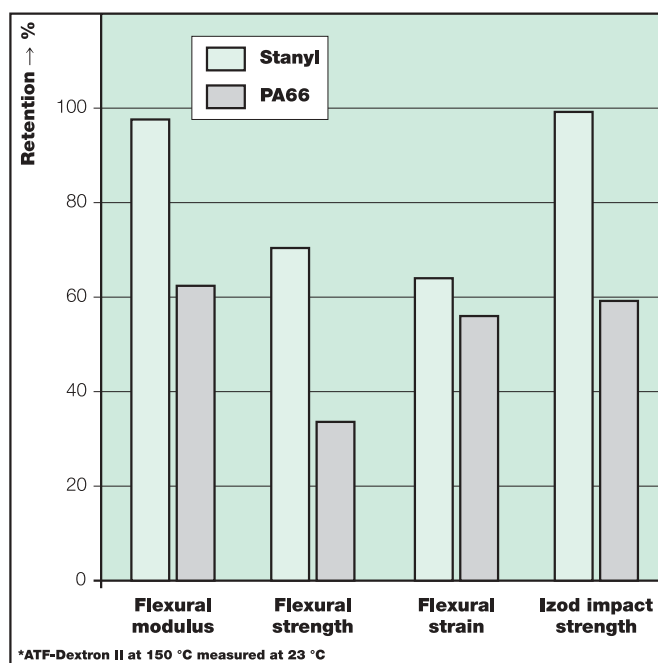


Figure 39. Retention of mechanical properties (of 30% glass fibre reinforced polyamides) after 1000 hours immersion in oil*.



SMD-resistant DIN connectors.

Electrical properties, flammability and UL classifications

Stanyl exhibits high levels of surface and volume resistivity, dielectric strength and comparative tracking resistance. The exact levels of these properties depend on the specific grade, temperature and moisture content. In general these properties are sufficiently retained at elevated temperatures to fulfil critical applicational requirements. This fact, in combination with its very high peak temperature resistance and its high toughness level, makes Stanyl an excellent choice for components which have to be soldered onto printed-circuit boards (PCB's).

A number of flame retardant grades have been developed and are rated V-0 according to the Underwriters Laboratories UL 94 classification (some even at 0.35 mm).

The unmodified, unreinforced Stanyl grades are rated V-2 and the glass fibre reinforced grades without flame retardant are rated HB.

Other classifications according to a number of UL standards have been obtained for different Stanyl grades. In Table 6 and 7 the most important ratings according to UL have been summarized. The class H (180 °C) rating according to UL 1446 for Stanyl glass fibre reinforced grades is worth noting.

A complete overview of the total system rating is also available at your local DSM sales office or at UL's website <http://data.ul.com>

After-treatments

Plastic parts are often subjected to a finishing operation after the actual moulding step. This can be a functional operation such as machining, glueing, welding, screwing or snap-fitting, or a decorative treatment, such as vacuum metallization, electroplating, lacquering, printing or laser marking.

Although Stanyl is generally used in parts which primarily have to fulfil highly technical requirements, decorative finishing techniques are sometimes applied for reasons of product identification (laser marking) or functionality (metallization). The same coating systems and techniques which are used for PA66 are applicable to Stanyl.

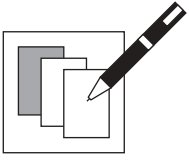
With regard to these after-treatments Stanyl will show a better adhesion behaviour, due to its higher polarity, when the finishing technique is applied to "dry-as-moulded" parts.

Since high-temperature-resistant glues are not available, welding and snap-fitting are the preferred bonding techniques for Stanyl. Welding should be performed on "dry-as-moulded" parts in order to achieve maximum weld strengths.

More detailed information can be obtained through your local DSM sales office.

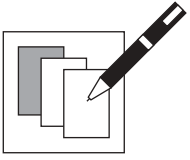


View at the lower part of the Stanyl reactor.



DSM Engineering Plastics product portfolio

Stanyl® PA46 46 polyamide	High temperature polyamide which bridges the price-performance gap between traditional polyamides and high-performance materials.
Stanyl® PA46 High Flow™ 46 polyamide	An innovative PA46 which combines excellent mechanical performance with (LCP-like) high flow and low warpage resulting in cost-savings for demanding high-end applications.
Akulon® polyamides	Polyamide 6 and 66 in both unreinforced and reinforced grades, including flame retardant products.
Akulon® Ultraflow™ polyamide	Polyamide 6 reinforced grades, easy flowing, lower processing temperatures, faster crystallization speed, shorter injection and holding time, reduced cycle time.
Arnite® thermoplastic polyester	PBT and PET based materials, including unreinforced, reinforced, and flame retardant grades, offering excellent dimensional stability and low creep with good chemical resistance.
Arnitel® copolyester elastomers	High performance elastomers based on polyester.
Stamylan® UH ultra high molecular weight polyethylene	A high performance polymer having outstanding abrasion resistance in combination with excellent impact and chemical resistance, low coefficient of friction and very good electric and dielectric properties.
Stapron® PC/ABS-blend PC/PET-blend	Unreinforced and reinforced PC-blends. Flame retardant grades based on halogen free systems.
Xantar® polycarbonate	Unreinforced, reinforced, and flame retardant grades with outstanding impact resistance, dimensional stability, and high heat deflection temperature.
Xantar® C PC/ABS-blend	A new generation PC/ABS-blend providing improved flow, simultaneously increasing impact and stress-crack resistance, while optical appearance and stability are on a very high and consistent level.
Yparex® adhesive resin	This family of extrudable adhesive resins consists of polyolefins with incorporated functional groups, which provide the necessary bond between polyolefins and polar materials (e.g. PA, EVOH, glass) or metals (e.g. steel, aluminium, brass, copper).



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