Ultraform® (POM)

Product Brochure

Ultraform® in the web:
www.plasticsportal.eu/ultraform

BASF
The Chemical Company

Ultraform®

is the trade name for BASF's product line of thermoplastically processable copolymeric polyoxymethylenes. The Ultraform® family encompasses engineering plastics with different characteristics suitable for use in complex and highly durable components. Ultraform meets the requirements made of a technical material especially well. It combines high stiffness and strength with outstanding resilience, favorable sliding friction behavior and excellent dimensional stability, even under the effect of mechanical forces, in contact with numerous chemicals, fuels and other media as well as at elevated temperatures.

ULTRAFORM® – THE MATERIAL OF CHOICE …

THE PROPERTIES OF ULTRAFORM

THE PROCESSING OF ULTRAFORM

GENERAL INFORMATION

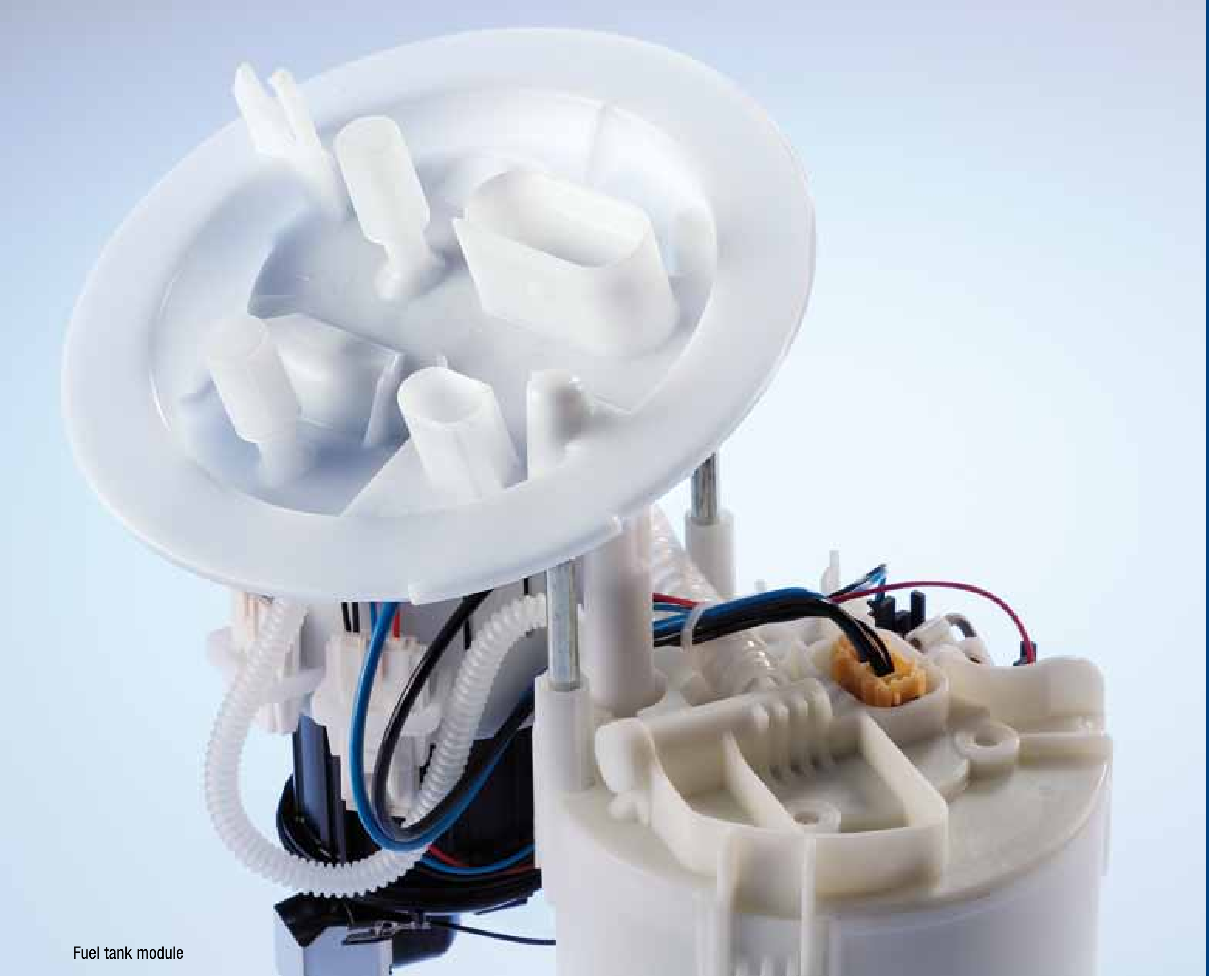
Ultraform® in automotive construction

Ultraform® gives designers an engineering plastic that shows many of the properties required in the automotive industry. Ultraform® offers excellent fuel and chemical resistance, low swelling, good long-term thermal stability and electrical insulation capacity.

Roll-over valve

Ultraform® has long been successfully used in numerous applications in the automotive industry, for instance,

- in the fuel system for tank caps, in components of fuel-carrying modules (flanges, fuel pumps, filter housings, swirl pots), for level gauges, in tank venting systems (roll-over valves);
- for the steering and controls of torque roll restrictors, ball cups, levers, linkages, sensor components;
- in the interior for loudspeaker grids, clips, fastening and spring elements, pushbuttons, deflection fittings and mechanical parts in safety belts;
- in doors and windows, for example, for components to raise and lower windows and for the cranks of sliding sunroofs;
- in the exterior, for clips and elements for fastening add-on parts, for windshield wiper clips, windshield washer nozzles, mechanical and electrical adjustment mechanisms for mirrors and headlights (for example, electromechanical, with a bowden cable);
- in the engine compartment for clips located away from the engine and for fastening elements;
- in the electrical & electronic area for clips, fastening elements and plug-in connectors.



Fuel tank module

Loudspeaker grills

Ultraform® for home and recreation

Ultraform® has been showing what it is made of for many years, also in the household and recreation realms.

Thanks to its outstanding mechanical properties at elevated temperatures and its superior resistance to hot water, Ultraform® has stood the test in millions of espresso and coffee-making machines.

Sprinkler nozzle

Other applications:

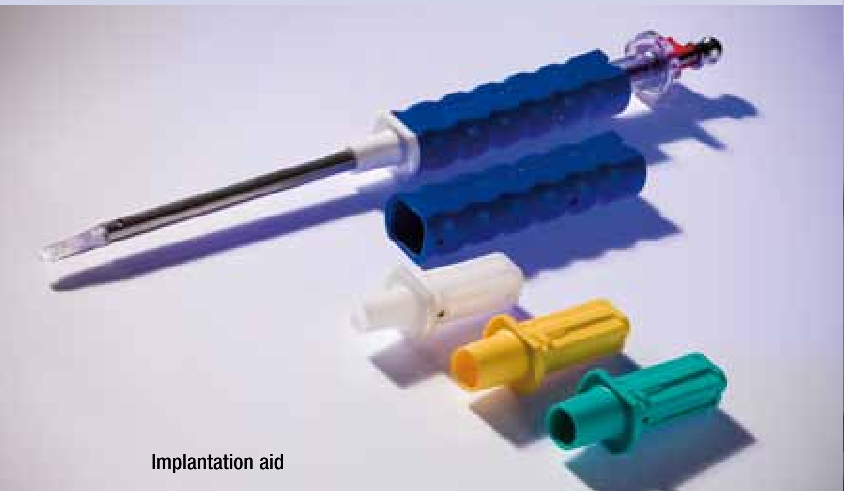
- parts of plumbing fixtures and inserts for showerheads
- components in watering and irrigation systems
- gas meters
- sliding and fastening parts for curtains
- functional parts in the hardware of doors and windows
- clasps, clips and fastening elements in sports and recreation
- zippers
- shock-absorbing elements in washing machines
- functional parts and inserts in dishwashers
- components in vacuum cleaners
- tablet dispensers
- functional parts in toys: springs, clamps, gear wheels, motor and gear modules, sliding elements

Toy dragon

Shower head

Ultraform® in industrial applications

Owing to its extremely versatile and tailor-made properties as well as its high reliability even under demanding conditions, Ultraform® is used in numerous industrial applications.



Implantation aid

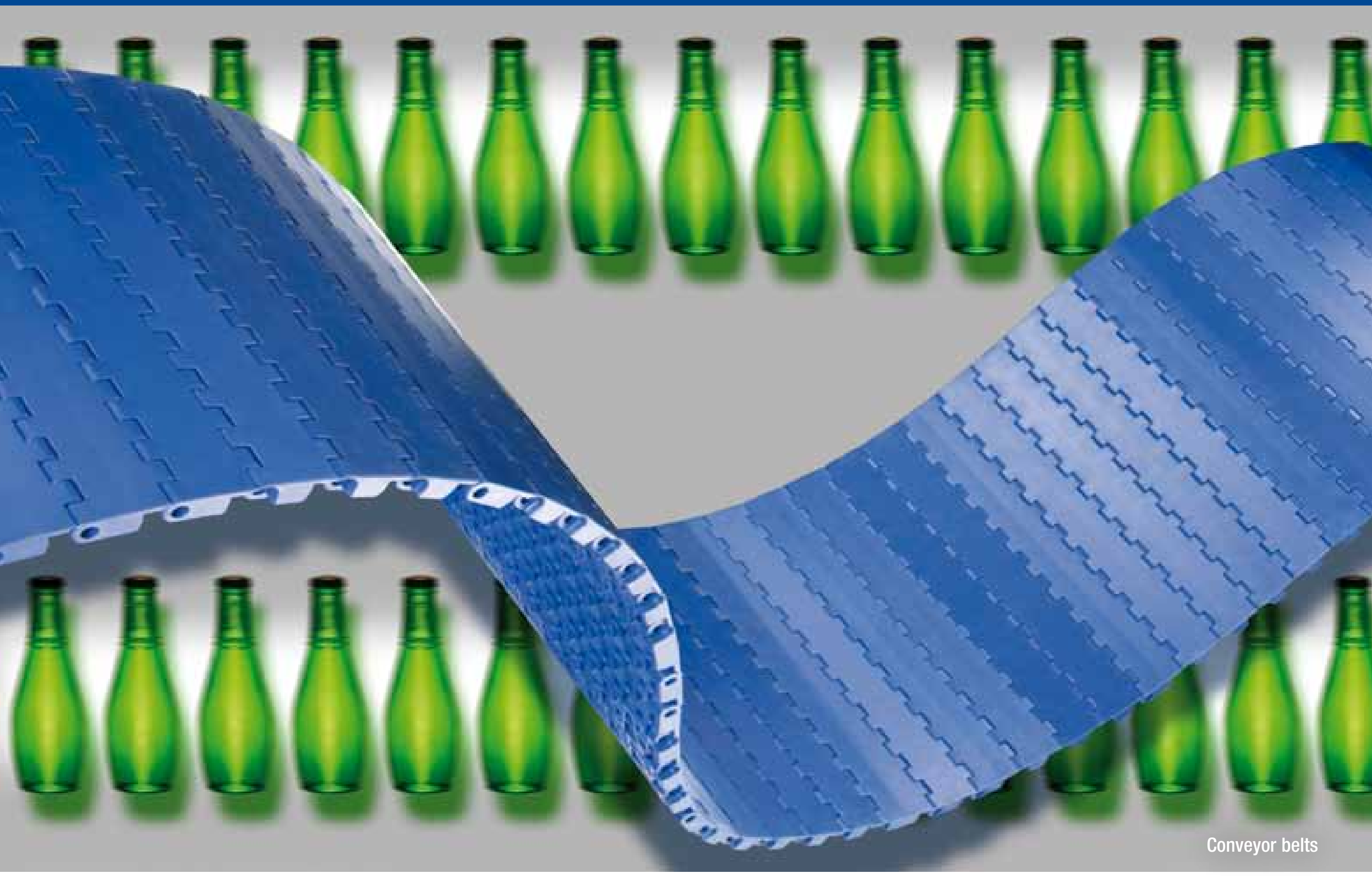
Applications for machine and plant construction as well as precision engineering:
Fastening elements, ball bearings and roller bearings, gear wheels, gear parts, valves, impellers, deflection rollers, thread guides for textile machines, links and connecting elements in conveyor chains and belts.

The two grades Ultraform® S2320 003 PRO and W2320 003 PRO are adapted specifically for the requirements and needs of the medical industry. The suffix PRO (**P**rofile covered **R**aw materials **O**nly) expresses the claim that only very specific raw materials that are subject to strict controls are used, and points to an expanded service package for medical technology. The Ultraform® PRO service package offers evidence of and compliance with relevant international standards and tests regulating the use of plastics in medical technology. Among other things, these comprise:

- EU Pharmacopeia (EP 5th Edition, Chapter 3.2.2 "Plastic Containers and Closures for Pharmaceutical Use")
- Japanese Pharmacopeia (14th Edition, General Information, "11. Plastic Containers for Pharmaceutical Products").
- Proof of biocompatibility
- US Pharmacopeia (USP Biological Reliability Test Class VI)
- ISO 10993-5 (Cytotoxicity)
- Suitability for food in accordance with the US Food and Drug Administration (21 CFR Food Additive Regulation)
- Lodging of the Drug Master File (DMF) with the FDA

From BASF, there is the documented intention not to change the plastic formulation which is lodged in the drug master file. Exceptions only exist if there are external constraints, for example amendments to the

and medical technology



Conveyor belts

general legal framework. In addition, BASF guarantees that it will notify customers at least 36 months in advance if changes to formulations should be necessary after all. At the same time, dedicated suppliers are obliged to keep the formulation of their products.

Ultraform® PRO is ideal for use with functional components such as

- valves
- metering systems
- springs and sliding elements in e.g. insulin pens, inhalers

The properties of Ultraform®

In view of its property profile, Ultraform® belongs to the engineering plastics. It can be thermoplastically processed and has a partially crystalline structure with a high degree of crystallization. Ultraform® is produced by the copolymerization of trioxan and another monomer. It consists of linear chains in which the co-monomers are firmly incorporated in a statistically distributed manner. These co-monomer units account for the high stability of Ultraform® during processing and when exposed to long-term heat and to chemicals. It surpasses by far the resistance of homopolymeric polyoxymethylene.

Mechanical properties

The special aspect of Ultraform® is its ideal combination of strength, stiffness and toughness, all of which can be ascribed to the structure of the product. Owing to its high crystallinity, Ultraform® is stiffer and stronger than other engineering plastics, especially within the temperature range from 50 °C to 120 °C. Ultraform® does not undergo any transitions between the low glass-transition temperature of approximately -65 °C and the melting temperature of approximately 170 °C. This translates into relatively constant mechanical properties over a fairly wide temperature range that is very attractive from a technical point of view (Fig. 1).

At room temperature, Ultraform® has a pronounced yield point at about 8-12% strain. Below this limit, Ultraform® exhibits good resilience, even under repeated loading, and is therefore especially suitable for elastic elements.

In addition, it has high creep strength and a low tendency to creep (see Fig. 2).

This combination of characteristics in association with good tribological properties makes it very suitable for engineering applications.

Ultraform® absorbs very little water: approx. 0.2 % under normal conditions (DIN 50014-23/50-2) and only approx. 0.8 % on complete saturation with water at 23 °C. Its physical properties are so slightly affected by this that it is of little importance for practical purposes.

The mechanical properties can be widely varied by employing suitable elastomeric additives, mineral fillers and glass fibers. Elastomer-modified Ultraform® grades largely retain their POM-like properties but exhibit a substantially higher level of impact resistance and a higher energy absorption capacity. Depending on the degree of modification, the rigidity and hardness of these grades is reduced.

Mineral-filled and especially fiberglass-reinforced Ultraform® grades, in contrast, exhibit increased strength, stiffness and hardness.

Fig. 7 shows a plot of impact strength versus rigidity for this and other selected grades.

Behavior under long-term static loading

The tensile creep test in accordance with ISO 899-1 and the stress relaxation test in accordance with DIN 53441 provide information about extension, mechanical strength and stress relaxation behavior under sustained loading.

The results are illustrated as creep modulus plots (Fig. 2) and creep curves (Fig. 3).

Figs. 4 and 5 show the isochronous stress-strain curves for standard and glass-fiber reinforced Ultraform®.

The graphs reproduced here are just a selection from our extensive collection of test results. Further values and diagrams for different temperature and atmospheric conditions can either be obtained from the Ultraplaste-Infopoint or from the plastics materials database “Campus” on the internet.

Design data obtained from uniaxial tensile loading tests can also be used to assess a material’s behavior under multiaxial loads.

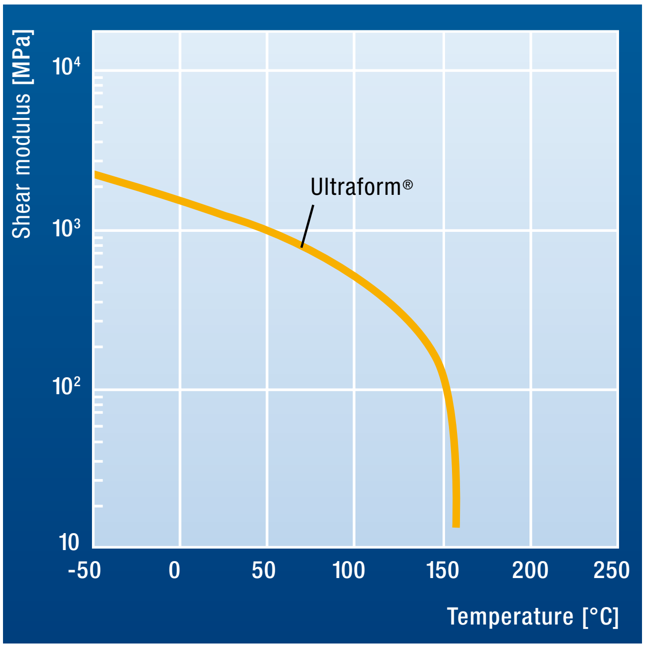


Fig. 1: Shear modulus as a function of the temperature (measured according to ISO 6721)

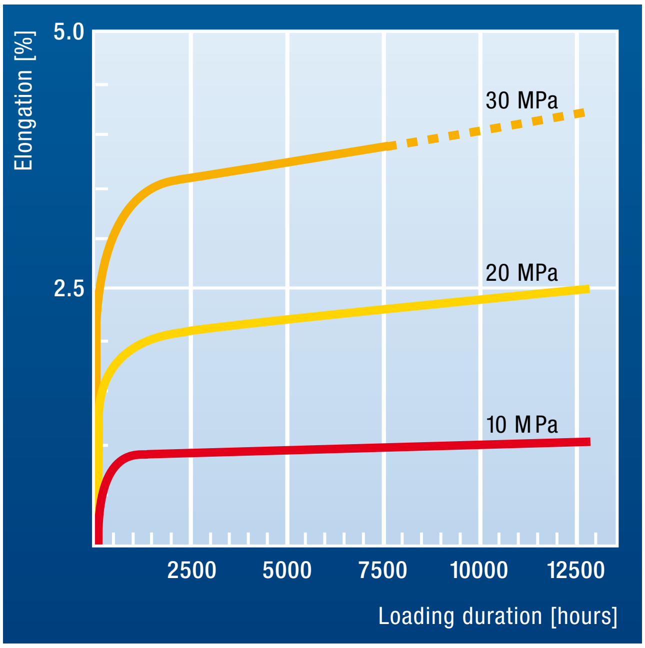


Fig. 3: Creep curves for Ultraform® N2320 003 at 23 °C, measured in accordance with ISO 899-1

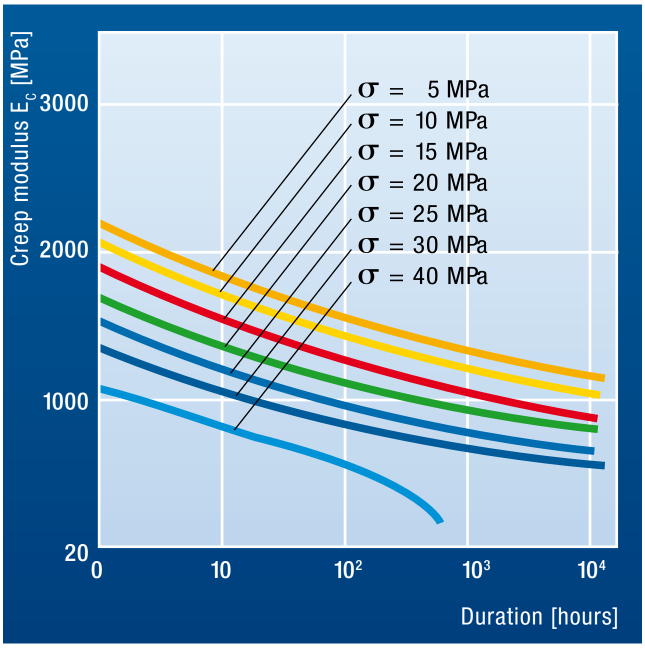


Fig. 2: Creep modulus E_c of Ultraform® N2320 003 as a function of loading duration (measured in accordance with ISO 899-1 under standard climatic conditions, 23 °C/50 % r.h.)

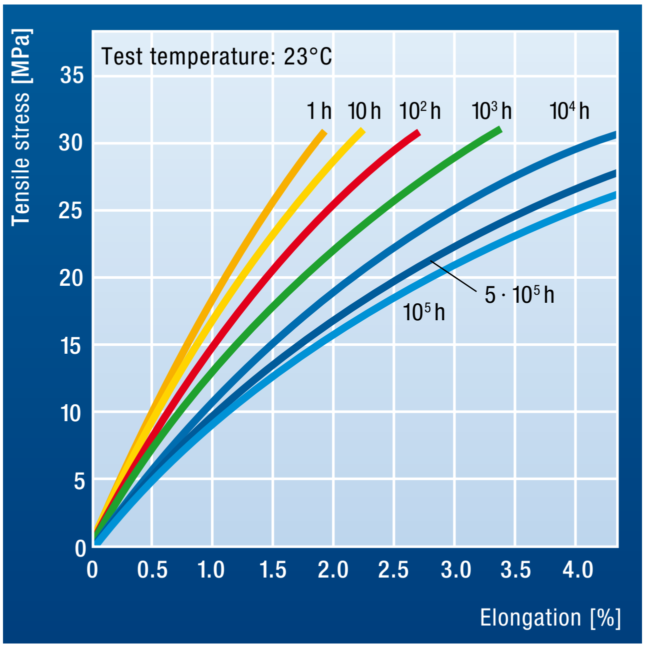


Fig. 4: Isochronous stress-strain curves for Ultraform® N2320 003, measured in accordance with ISO 899-1

The properties of Ultraform®

The PC programs “Snaps”, “Screws” and “Beams” developed by BASF can be used for the analysis of construction elements such as snap and screw connections and beams subjected to flexural stresses.

The creep strength values determined for pipes made from Ultraform® reflect a multiaxial stress condition and the allround action of water (see Fig. 6).

Impact strength
Parts made from Ultraform® stay impact-resistant over a wide range of temperatures. Due to its very low glass transition temperature (about -65 °C) Ultraform® still exhibits outstanding impact resistance and adequate notched impact resistance at temperatures as low as -30 °C.

Impact-resistant grades with graduated modification are available for applications with high demands on toughness. Fig. 7 shows a plot of impact strength versus rigidity for these and other grades. A substantial gain in impact strength is obtained at the expense of a moderate loss in rigidity.

Behavior under cyclic loads, flexural fatigue strength
Engineering parts are frequently subjected to stress by dynamic forces, especially alternating or cyclic loads, which act periodically in the same manner on the structural part. The behavior of a material under such loads is determined in fatigue tests in flat bending or rotating bending tests (DIN 50 100) up to very high load-cycle rates. The results are presented in what are known as Wöhler diagrams obtained by plotting the applied stress against the load-cycle rate achieved in each case (see Fig. 8). The flexural fatigue strength is defined as the stress level a sample can withstand for at least 10^7 cycles.

It can be gathered from the graph that in the case of Ultraform® N2320 003 the stress remains practically constant above about 10^7 load cycles.

When the test results are applied in practice, it has to be taken into account that at high load alternation frequencies, the workpieces may heat up considerably due to internal friction. In such cases, just as at higher operating temperatures, lower flexural fatigue strength values have to be expected.

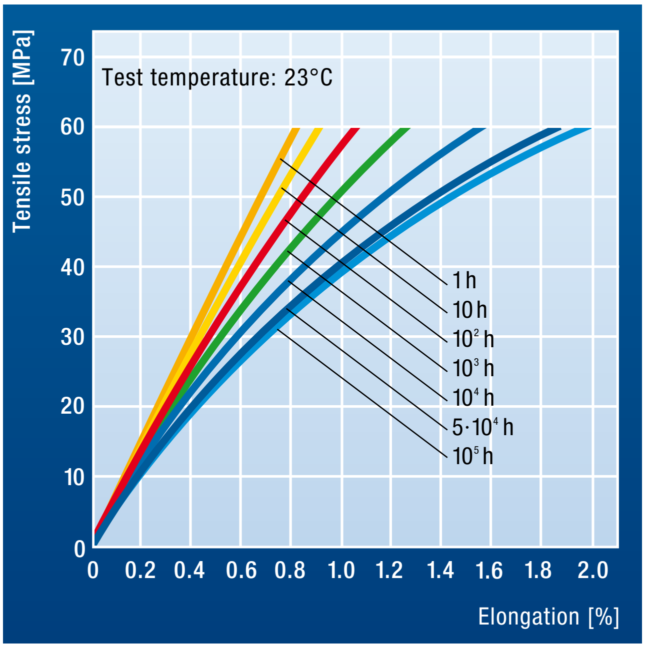


Fig. 5: Isochronous stress-strain curves for Ultraform® N2200 G53, measured in accordance with ISO 899-1

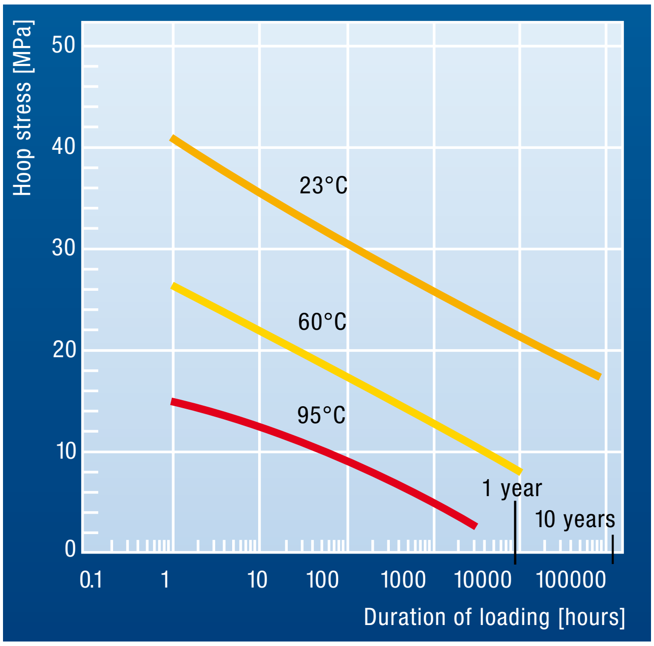


Fig. 6: Creep strength of pipes made from Ultraform® H4320 at various temperatures, with water inside and outside

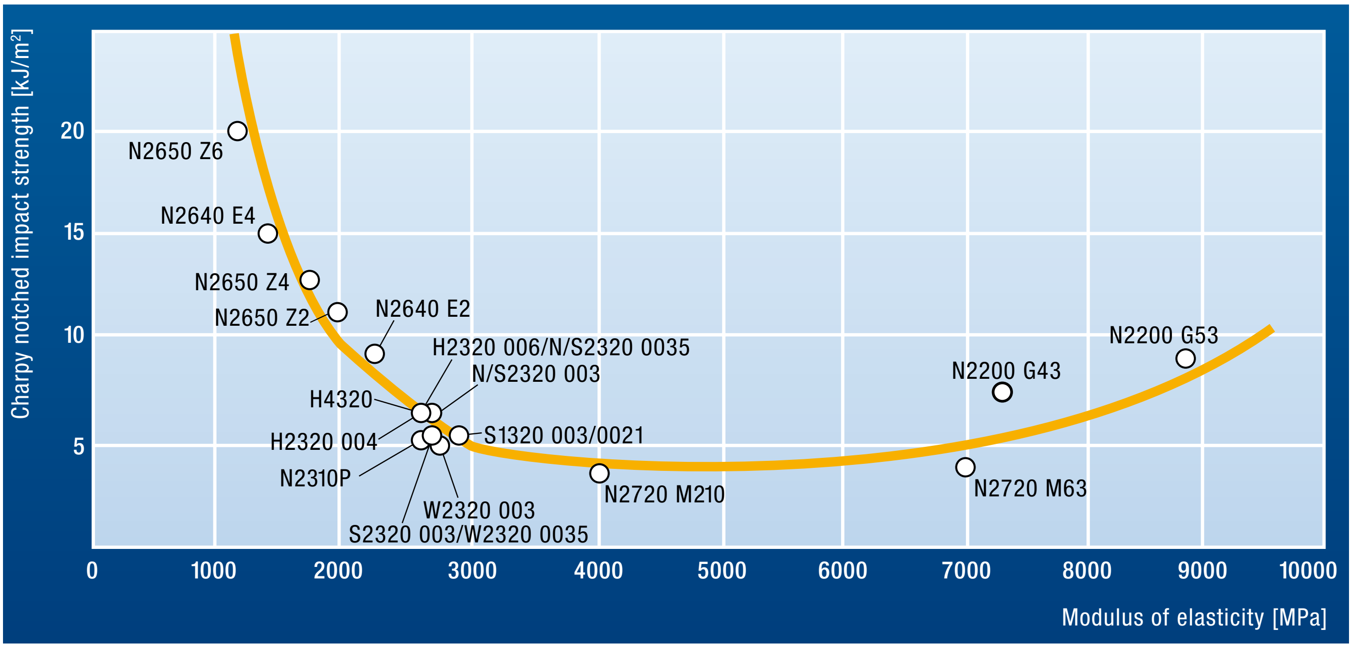


Fig. 7: Impact strength vs. stiffness for selected Ultraform® grades

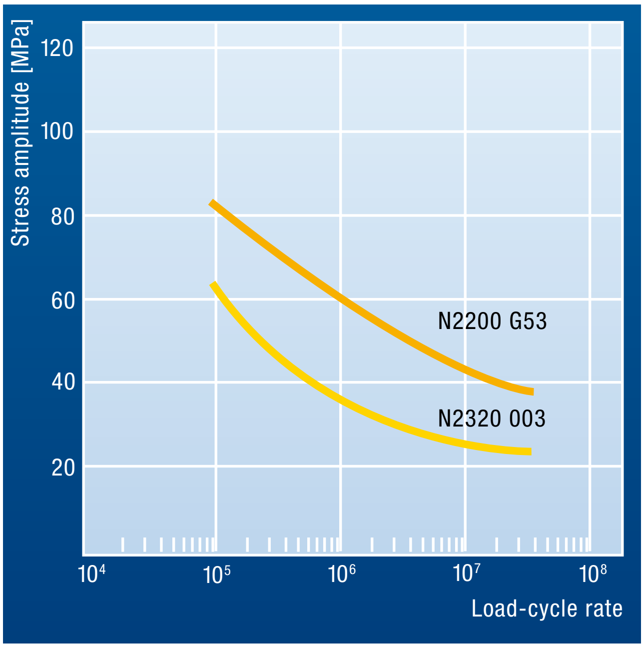


Abb. 8: Wöhler diagram for unreinforced and reinforced Ultraform® determined in the flexural fatique tests in accordance with DIN 50 100. Normal climatic conditions 23/50 in accordance with DIN 50 014, load cycle frequency: 10 Hz

Tribological properties

The smooth, hard surface and highly crystalline structure of this material allow its application for functional parts subjected to sliding friction. Even in the case of solid friction only slight wear is to be expected at the coefficients of sliding friction likely to be in operation. The coefficient of sliding friction of Ultraform® becomes smaller as the surface roughness of the paired material increases, but wear caused by sliding friction will increase.

The special grades of Ultraform® N2310 P, N2770 K and N2720 M210 display a marked improvement in their sliding and abrasion behavior. N2720 M210 exhibits optimal properties, even at elevated surface pressures or greater roughness of the sliding counterpart. Generally speaking, N2310 P and N2770 K are best suited for applications in precision mechanics.

The properties of Ultraform®

Figure 9 shows the coefficient of sliding friction and the rate of wear due to sliding friction of Ultraform® N2320 003 and N2310 P as a function of the average roughness height. The properties of Ultraform® N2310 P prove to be particularly favorable at low roughness heights of the sliding counterpart (Figure 10).

Wear and friction are system properties which depend on many parameters such as the nature of the paired materials, temperature, speed, loading, etc. While results obtained from tests allow some assessment of tribological properties, they are no substitute for performance testing carried out under practical conditions on the pair of materials actually planned.

Thermal properties

The standard Ultraform® grades have a narrow melting range of approx. 164 °C to 168 °C. Up to the neighborhood of this melting range Ultraform® moldings can be briefly subjected to thermal stresses without the material being damaged.

Figures 11 and 12 show the influence exerted by temperature on the strength-related properties of this material. At a temperature of 80 °C, for instance, Ultraform® N2320 003 still displays the strength of high-density polyethylene at room temperature. The advantage of fiberglass-reinforced products such as Ultraform® N2200 G53 in terms of stiffness and strength is retained, even at an elevated temperature.

The long-term thermal stability of Ultraform® in air is also exceptionally high, as 12-month storage tests at 100 °C and 120 °C have shown (see Fig. 13). From these a maximum long-term service temperature of approximately 100 °C can be derived.

Parts made from glass-fiber reinforced Ultraform® can withstand prolonged exposure to temperatures of up to 120 °C without deterioration in material properties due to heat aging (see Fig. 14).

It has to be expected that sustained exposures to temperatures above 110 °C will eventually cause discoloration. Ultraform® also exhibits good long-term thermal stability in the presence of water, neutral oils, greases, fuels and many solvents.

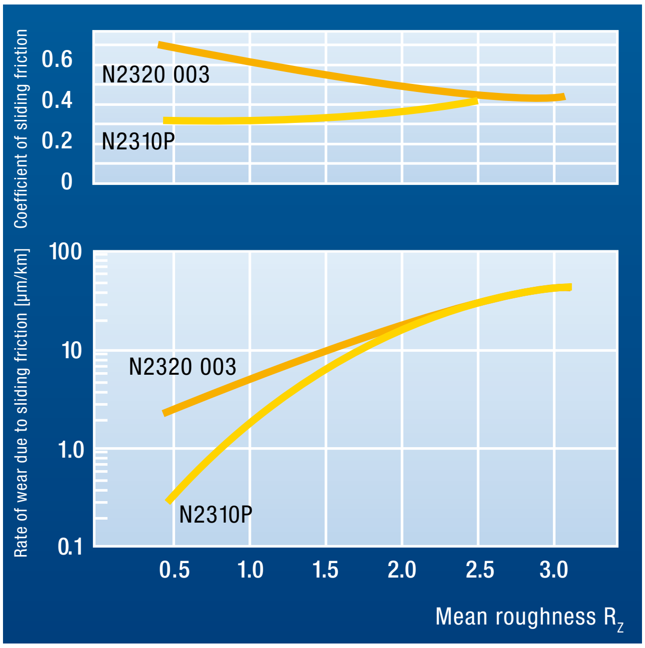


Fig. 9: Coefficient of sliding friction and rate of wear due to sliding friction of Ultraform® N2320 003 and N2310 P as a function of the average roughness height. Sample technically dry. Sliding counterpart: steel disk, HRC 54 to 56, 40 °C, p = 1 MPa, v = 0.5 m/s

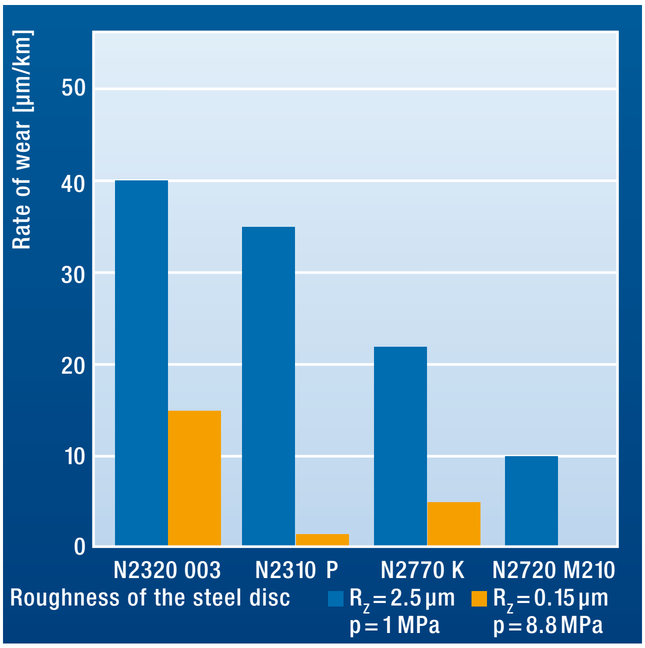


Fig. 10: Rate of wear of modified grades as a function of the roughness of the sliding counterpart (steel disk); v = 0.5 m/s; max. 40 °C

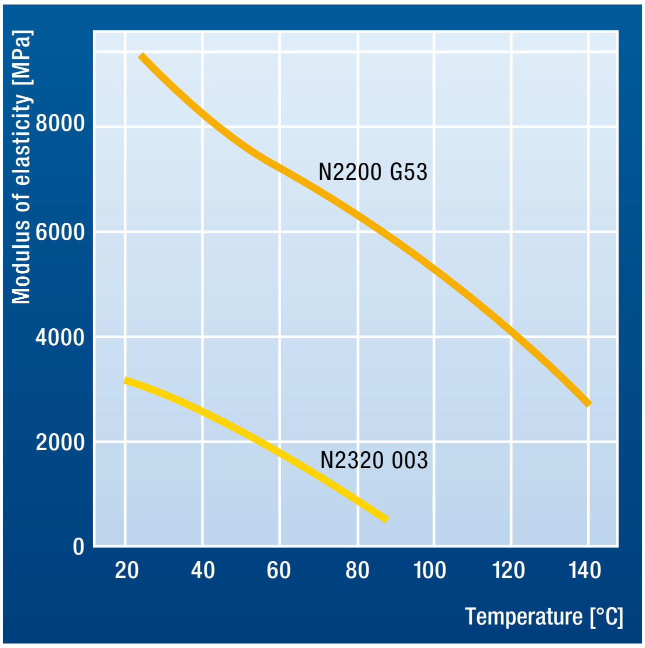


Fig. 11: Modulus of elasticity of unreinforced and reinforced Ultraform® measured in accordance with ISO 527 as a function of temperature

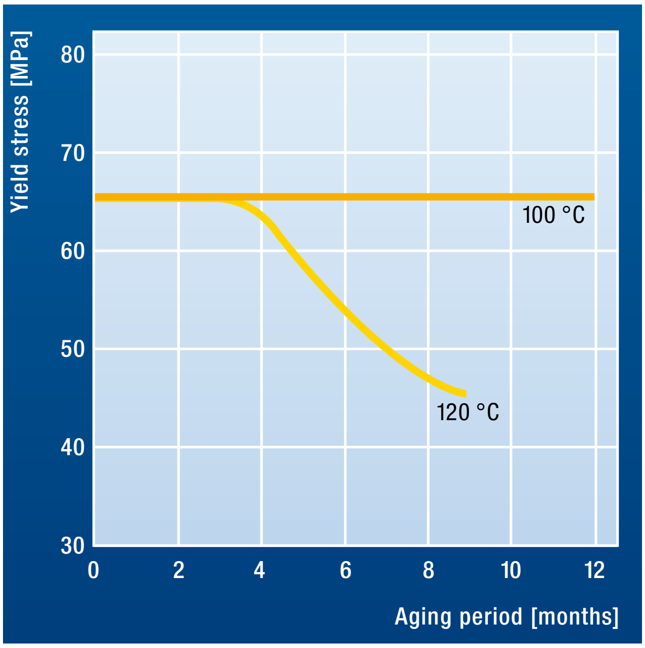


Fig. 13: Storage in air at 100 °C and 120 °C. Yield stress of Ultraform® N2320 003 as a function of the aging period (measured in accordance with ISO 527, v = 50 mm/min.)

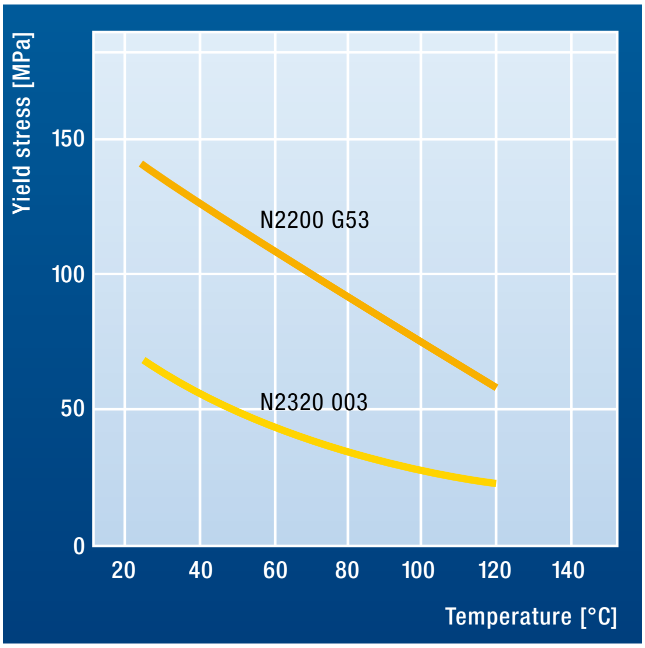


Fig. 12: Yield stress or tensile strength of unreinforced and reinforced Ultraform® measured in accordance with ISO 527 as a function of temperature

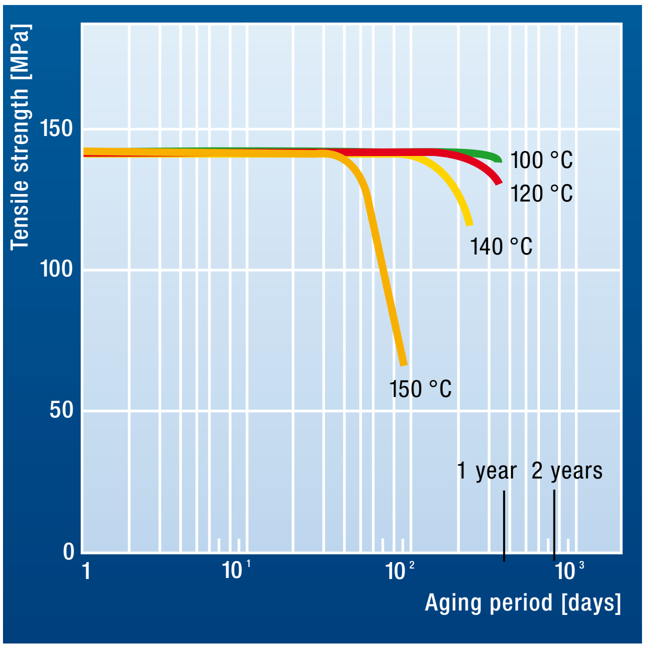


Fig. 14: Tensile strength of Ultraform® N2200 G53 measured in accordance with ISO 527 as a function of the aging period at 100 °C, 120 °C, 140 °C and 150 °C

The properties of Ultraform®

Behavior on exposure to light and weather

When POM is used in the open air, the general sensitivity to UV radiation has to be borne in mind. After prolonged exposure to the action of sunlight the parts lose their surface gloss and become brittle. Treatment with UV stabilizers, as in Ultraform® N2320 U035 for example, approximately doubles the service life. Certain pigments e.g. carbon black can also provide additional protection.

Resistance to water, fuels and chemicals

A polymeric thermoplastic material is chemically resistant to certain ambient conditions if the surrounding medium does not cause any degradation, that is to say, a reduction of the molecular weight or a shortening of the polymer molecules. The chemical resistance depends on the concentration, on the duration of exposure and on the temperature of the medium. The swelling (reversible absorption and release of a substance, for example, a solvent) and the stress crack formation (disentanglement of convoluted polymer molecules without chemical degradation) have to be distinguished from the chemical resistance.

Ultraform® displays good to very good long-term chemical resistance against the following media: water, washing liquors, aqueous solutions of salts and most of the commonly employed organic solvents (such as alcohols, esters, ketones, aliphatic and aromatic hydrocarbons), fuels (also those containing ethanol and methanol, for example, M15, CM15, CM15A, $CM15_AP$, E85, FAM-B, biodiesel) as well as against fats and oils, braking fluids and coolants, even at elevated temperatures.

Some solvents and fuel components, particularly short-chain alcohols like ethanol and methanol, cause a slight (reversible) swelling.

There are only a few solvents that are known to dissolve Ultraform®, and this usually only takes place at elevated temperatures.

Stress cracking formation due to solvents or other chemicals is not known to occur in Ultraform®.

Figures 15 to 18 show the often superior resistance of Ultraform® in comparison to similar homopolymeric or copolymeric competitive products when exposed to hot water and fuels. This advantage makes Ultraform® suitable for many applications, for example, in the plumbing sector, in espresso and coffee-making machines, in dishwashers as well as in vehicle fuel systems.

Ultraform® is attacked by oxidizing agents and organic and inorganic acids ($pH < 4$).

Contact with strong acids (e.g. hydrochloric acid, sulfuric acid) should be avoided at all costs. On the other hand alkalis have no effect, even at elevated temperatures.

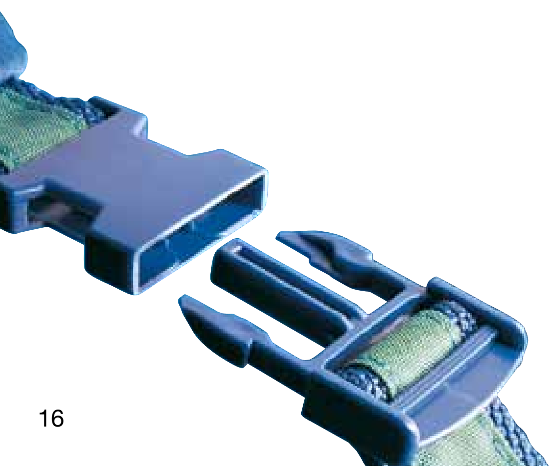
Detailed information may be found in the Technical Information leaflet "Resistance of Ultramid®, Ultraform® and Ultradur® to chemicals" and can also be obtained at the Ultraplaste-Infopoint or from the Application Engineering experts.

Sterilization

Properly and flawlessly manufactured parts made of Ultraform® can be sterilized in hot steam at 121 °C and, with some limitations, even at 134 °C, over the course of many cycles, whereby the high-molecular grades perform best. Plasma sterilization is also a good option.

Repeated sterilization in ethylene oxide can be carried out at room temperature without problems employing familiar methods, but this hardly plays a role any more because of the absorption and subsequent release of toxic ethylene oxide.

Great caution is advisable in case of sterilization using ionizing radiation. Chemical disinfection is not recommended.



Detachable snap-in connection

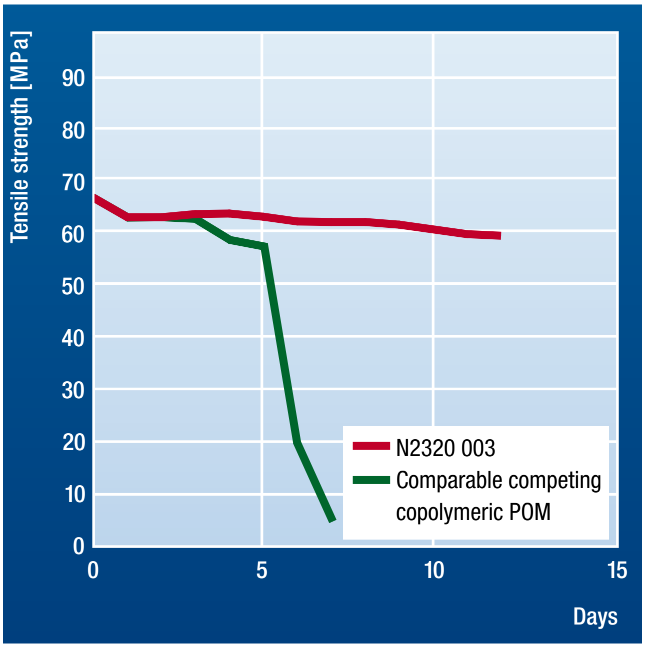


Fig. 15: Hot water storage of tensile bars at 130 °C in an autoclave

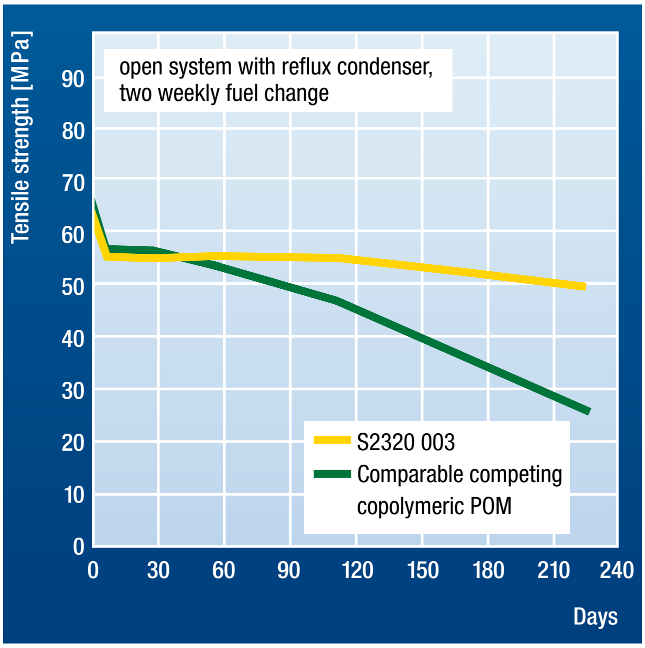


Fig. 17: Storage of Ultraform® S2320 003 in fuel $CM15_AP$ (peroxide number 50) at +60 °C

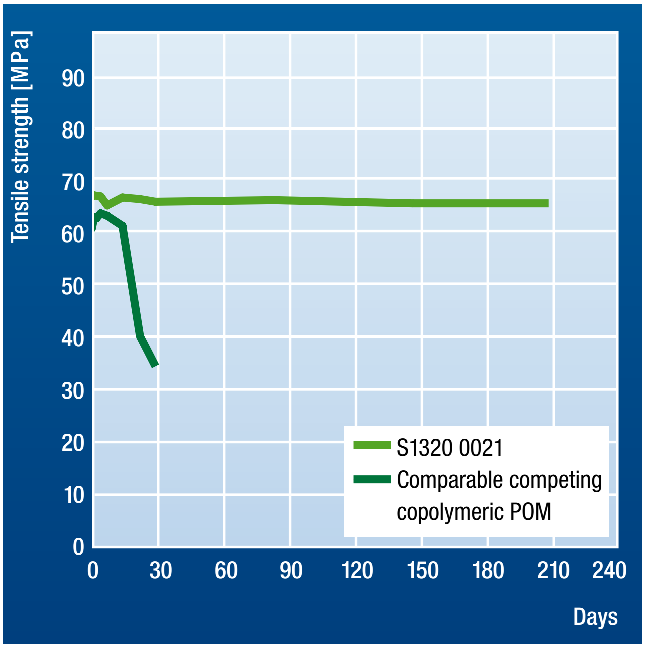


Fig. 16: Storage of hot diesel stabilized Ultraform® S1320 0021 in biodiesel DIN EN 14214 at +140 °C

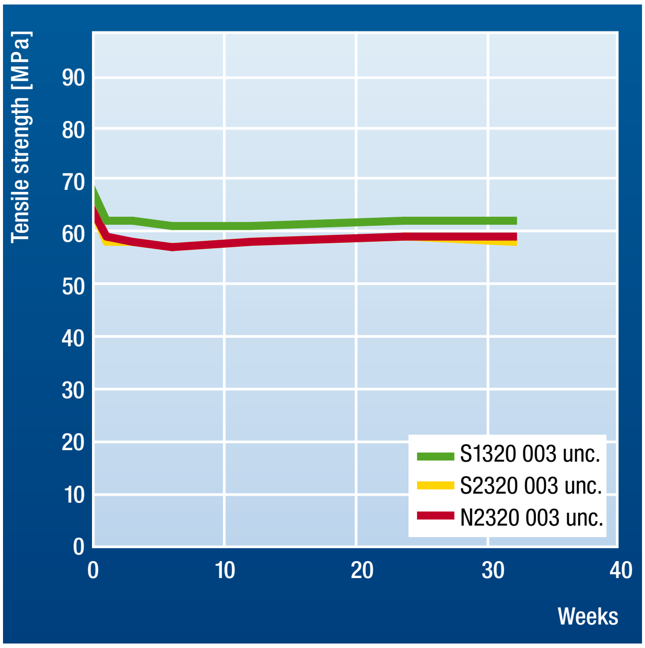


Fig. 18: Storage of Ultraform® in fuel $CE85_A$ at +65 °C (85 % ethanol, with aggressive additives)

The properties of Ultraform®

Behavior on exposure to high-energy radiation

Polyacetals are only moderately resistant to electron and gamma rays. Ultraform® behaves fundamentally in the same way with respect to these two types of radiation. Depending on the total radiation dose, a more or less pronounced degradation occurs, along with brittleness. A total dose of 25 kGy (2.5 Mrad) can already affect the mechanical properties and the color of the parts.

Fire behavior

Polyoxymethylenes ignite on exposure to flame and continue to burn after the ignition source has been removed. A flame-retardant treatment is not offered.

Ultraform® has a UL 94 flammability rating of "HB".

The combustion rate required by FMVSS 302 of < 100 mm/min is met by Ultraform® test specimens having a thickness of 1.0 mm and over.

Electrical properties

Ultraform® has good electrical insulation properties and high dielectric strength. The very low moisture absorption of the material does not impair this property, making parts made from Ultraform® highly suitable for use in consumer electronics and telecommunications.

In the field of electric power engineering, Ultraform® is widely used for functional and drive parts which are not used directly as supports for current-carrying parts.

Electrically conductive special grades such as, for example, Ultraform® N2520 L, are available for applications that call for low electric surface resistance.

Product line

The Ultraform® product line encompasses grades for processing by means of extrusion and injection molding. The following product groups exist:

Grades with a high melt strength and high molecular weight
for the extrusion of thin-walled as well as thick-walled tubes and panels, hollow profiles and semi-finished products having wall thicknesses of up to 50 mm and more. These are made into gear wheels, bearings and other machine elements by means of non-cutting procedures.

The grades are likewise suitable for blow molding and for the injection molding of thick-walled molded parts with few voids.

Standard injection-molding grades
in various viscosity classes. As a rule, they can be processed rapidly, without deposits and are also easy to demold.

Impact-modified injection-molding grades
for applications that make particularly high demands in terms of the toughness. There are TPU-modified grades as well as grades containing rubber, each with differing contents of impact modifiers. The products containing rubber exhibit a number of advantages for processing technology such as, for instance, high weld line strength.

Mineral-filled injection-molding grades
with differing mineral contents for low-warpage and dimensionally stable molded parts that display increased stiffness, hardness and heat distortion resistance.

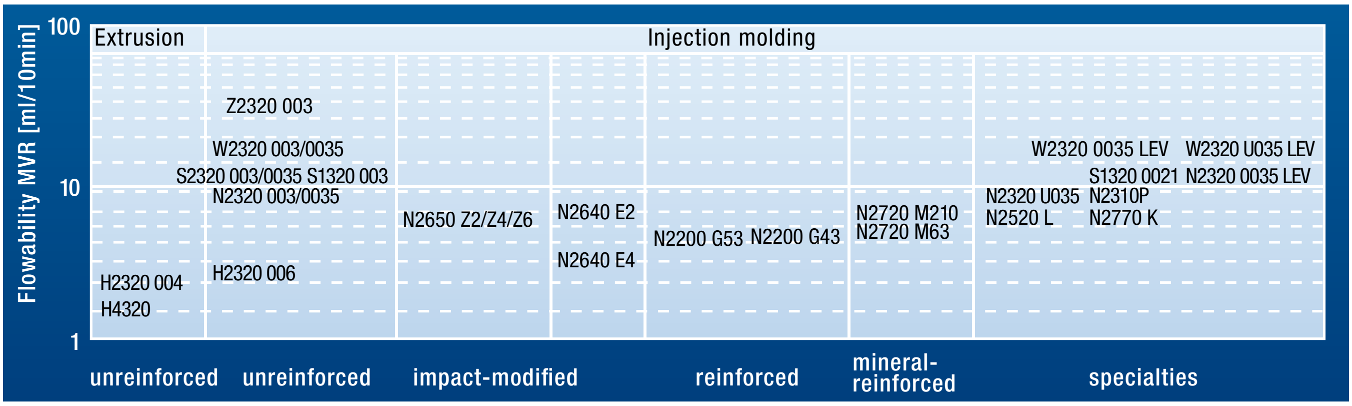


Fig. 19: Selection of grades from the Ultraform® range

Fiberglass-reinforced injection-molding grades
with differing fiberglass contents for applications entailing very high demands in terms of strength, stiffness, hardness, creep resistance and dimensional stability under heat.

Grades with special treatment for purposes of

- improving light resistance, UV resistance and weathering resistance,
- optimizing sliding and abrasion characteristics,
- achieving a certain electrical surface conductivity or volume conductivity, for instance, to reliably and permanently prevent static charging,
- enhancing the fatigue strength against diesel fuel at high temperatures,
- increasing the contrast for printing by means of an Nd:YAG laser,
- producing especially low-odor parts, e.g. for the interior of vehicles.

A detailed overview of the product line can be requested from the Ultraplaste-Infopoint.

Gears for
postage meters

The processing of Ultraform®

Ultraform® can be processed by all methods suitable for thermoplastics. The most important methods are injection molding and extrusion. Injection molding allows even the most complicated moldings to be mass-produced very economically.

The extrusion process is used to manufacture rods, pipes, profile sections and sheet, most of which are further machined by cutting tools to form finished parts.

General notes

Preliminary treatment

The granules or pellets in their original packaging can generally be processed without any special preliminary treatment. However, granules or pellets which have become moist due to prolonged or incorrect storage must be dried in suitable dryers, e.g. dehumidifying dryers, for approx. 3 hours at about 100 °C to 110 °C.

Start-up and shutdown

The processing machine containing Ultraform® is started up in the usual manner for thermoplastics. The barrel and nozzle heaters are set to achieve melt temperatures of 180 °C to 220 °C.

After this the optimum processing conditions must be determined in trials. See also “Safety notes”.

When there are relatively long work stoppages or on shutdown the machine should if possible be run until it is empty and the barrel temperature lowered. When the processing machine is re-started, care should be taken to ensure that the die is first heated up to about 200 °C. This measure prevents blockage of the barrel by a cold plug of material.

Self-coloring

Ultraform® can be colored during processing. The following should be observed in this context:

- Only colorants and auxiliaries that do not affect the thermal stability of Ultraform® and that are themselves stable under the prevailing processing conditions can be utilized to color Ultraform®.
- In actual practice, coloring systems on the basis of powdered pigments, liquid colors and masterbatches (polyolefin or preferably POM substrate material) are successfully employed. Uniformity of the color distribution can usually be achieved by means of elevated back pressure and a low screw speed.
- The presence of pigments (type and amount) as well as the presence of a masterbatch support material alter the mechanical and tribological properties as well as shrinkage and warpage behavior of Ultraform® by comparison with the uncolored material. Tests on finished parts will provide information as to whether the demands made of the parts are being met.
- In most cases, good results can already be obtained with conventionally configured processing installations to which a colorant metering unit has simply been added. If very high demands are being made, it is recommended that special mixing elements be employed.
- If self-colored parts are used in contact with food, the special provisions of food legislation must be observed (see “Safety notes”).

Additional information can be found in the brochure “Self-coloring of Ultraform®”.

Toys with functional parts made from Ultraform®

Re-processing

Ground-up waste material consisting of sprues, rejects and the like can be recovered by mixing it back in. However, they must not be dirty or damaged during the preceding processing. Factors that can influence the material decomposition are:

- severe shearing (high screw speeds, gates that are too small, etc.),
- temperature too high or residence time too long,
- incompatible pigments used in self-coloring,
- foreign matter or other impurities,
- moisture.

The grinding procedure can also damage the plastic. Mills running at a low speed have proven their worth for the grinding operation; any adhering dust should be removed. Prior to the re-processing, it is recommended to dry any ground-up material that has been stored for a prolonged period of time. In actual practice, 10 to 15 percent, occasionally even up to 30 percent of ground-up material, is admixed.

In the case of fiberglass-reinforced products, the glass fibers can be shortened during the processing and also during the grinding. If large quantities of such a type of ground-up material are admixed to the new material, then the shrinkage, the warpage and especially the mechanical properties can be affected.

The addition of ground material to the original granules can adversely affect the normal feed behavior. For that reason it should only be added to a production run if it is certain that it will not disturb the processing conditions or impair the properties (e.g. impact strength) of the finished parts.

The processing of Ultraform®

Compatibility with other thermoplastics

The Ultraform® brands can be mixed with one another and with other polyoxymethylenes. Due to the limited homogenizing action of the processing machine, excessively large differences in viscosity must be avoided. Ultraform® is immiscible with most other thermoplastics. Even small amounts of such extraneous materials become evident in the form of a laminate structure, particularly in the vicinity of the sprue. The result is the well known flaky pastry effect.

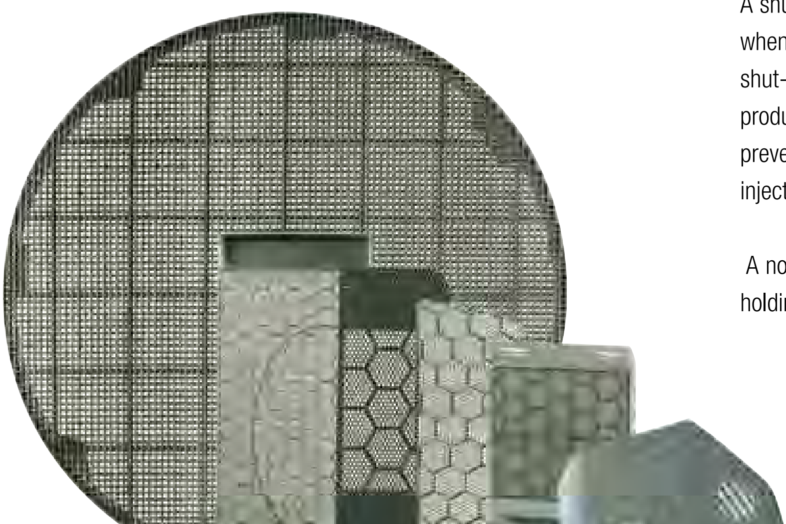
Contamination of Ultraform® by thermoplastics exercising a destructive effect on POM, e.g. PVC, must be avoided without fail. Mixtures with thermoplastics containing halogen-based flame retardants must also be excluded. Even small amounts can bring about uncontrolled and rapid decomposition of Ultraform® during processing.

When ground material is added, it is therefore important to take special care that the material is clean, free of dust and homogeneous.

When changing over to other thermoplastics or from other thermoplastics to Ultraform®, it is advisable to purge the barrel with a granular PE or PP material or suitable cleaning compounds.

In general, once the required temperatures have been set, production can be resumed, the first few moldings being rejected. When changing over from PVC to Ultraform® and vice versa it is essential to purge the processing machine thoroughly and then clean it mechanically.

Loudspeaker grids



Injection molding

Injection molding is the most important method for processing Ultraform®. Ultraform® can be processed on all commercial molding machines provided that the plasticizing unit has been correctly designed.

Injection unit

Three-section screw

The usual single-flighted, three-section screws are suitable for the injection molding of Ultraform®. In modern machines the effective screw length is 20 - 23 D and the pitch is 0.8 -1.0 D. The tried and tested geometry for three-section screws is shown in Fig. 16. Feed and fusion of the granules is substantially determined by the temperature control on the barrel and the depth of the screw flight. Recommended flight depths for different screw diameters are set out in Fig. 21. When using shallow-flighted screws the plasticizing power is somewhat lower than in standard screws. They pick up less material than deep-flighted screws. However, gentler fusion, shorter residence times in the barrel and better homogeneity of the melt are achieved. This yields advantages for the quality of molded parts made from Ultraform®.

Processing in degassing screws is inadvisable.

Injection nozzle, non-return valve

An open injection nozzle is generally adequate for the injection molding of Ultraform®. Apart from its simple design ensuring smooth flow, this type of nozzle has the advantage that any gaseous decomposition products formed as a result of thermal damage can escape without pressure build-up. This can arise when residence times are unintentionally long, at high melt temperatures, during stoppages or other interruptions.

A shut-off nozzle prevents outflow of the melt during plastication and when the nozzle is retracted from the mold. Spring-loaded needle shut-off nozzles are particularly suitable for this purpose. For optimum production the screw should also be fitted with a non-return valve to prevent the melt flowing back over the screw flights during the injection and holding pressure phases.

A non-return valve is the only way to achieve a melt cushion and a holding pressure acting on the melt.

Protection against wear
When glass-fiber reinforced Ultraform® is processed, hard-wearing plasticizing units, e.g. bimetallic barrels and hardened screws, screw tips and non-return valves, should be used.

Injection mold

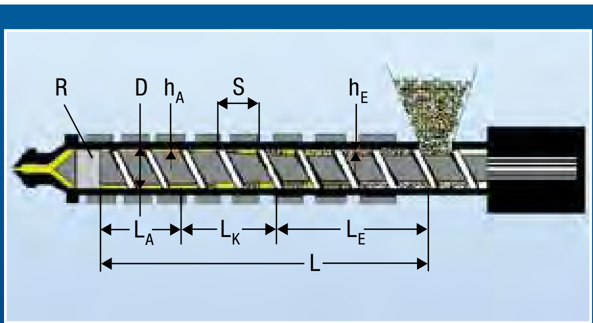
Gate and mold design
All know types of gate, including ante-chamber and hot runner systems, can be used for the injection molding of Ultraform®. The relevant construction guidelines for the design of gates and molds for injection-molded parts made from thermoplastics also apply to Ultraform®. Runners and gates must not be too small.

Due to the low melt viscosity, surface contours are reproduced extremely accurately. Accordingly, the inner surfaces of the mold must be impeccably machined. The same applies to the mold parting surfaces. The parting line must not cause flash formation but must ensure adequate venting of the mold.

It is important that there is a good seal between the cooling water circuit and the mold cavity, otherwise entry of water may result in solutions which corrode the mold.

Use of metal inserts
Metal inserts can be encapsulated without any trouble. They should, however, be preheated to 80 - 120 °C before insertion in the mold so that no internal stresses arise. The metal parts must be free of grease and be knurled, grooved or similar to ensure good anchorage. Care has to be taken that the metal edges are well rounded.

Mold temperature control
A well thought-out and effective temperature control system is of special importance since the temperature of the mold has a major impact on the surface finish, shrinkage, warpage and tolerances of the moldings. The temperature control should be designed in such a way that the same temperature prevails in all shaping parts of the mold.



D	outer diameter of the screw		
L	effective screw length	20 - 23	D
L_E	length of the feed section	0.5-0.55	L
L_K	length of the compression section	0.25-0.3	L
L_A	length of the metering section	0.2	L
h_A	flight depth in the metering section		
h_E	flight depth in the feed section		
S	pitch	0.8-1.0	D
R	non-return valve		

Fig. 20: Screw geometry – terms and dimensions for three-section screws for injection-molding machines

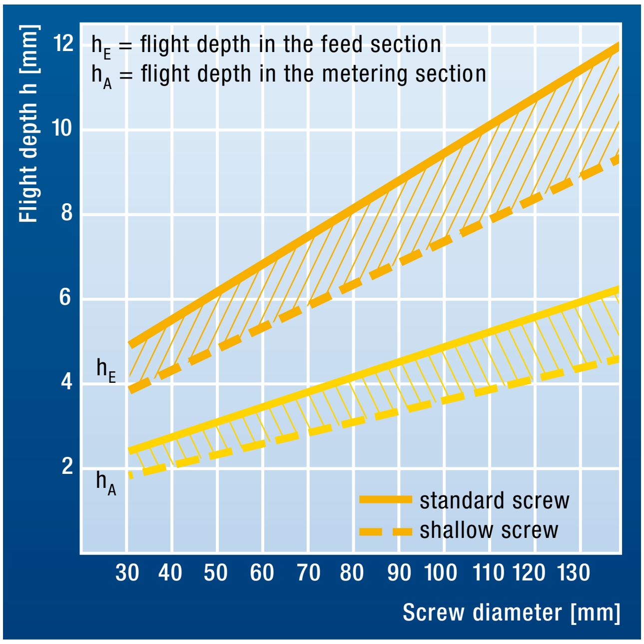


Fig. 21: Screw flight depths for three-section screws in injection-molding machines

The processing of Ultraform®

The temperature regulation should be selected in such a way that the same temperature is present in all of the shaping areas. In special cases, it can sometimes be necessary to systematically select divergent temperatures. Thus, for instance, the warpage of the molded parts can be influenced to a certain extent by systematically selecting different temperatures in the mold halves. This is only possible with separate circulation systems.

As with all partially crystalline thermoplastics, it is also the case with Ultraform® that the mechanical properties of an injection-molded article are determined in part by the degree of crystallinity. The crystallinity increases as the mold temperature rises. The hardness, stiffness and strength increase as the mold temperature rises (Fig. 22). The toughness values (Fig. 23) behave in precisely the opposite way.

Generally speaking, it is sufficient to regulate the temperature within the range from 60 °C to 90 °C. Precision parts require mold temperatures between 90 °C and 120 °C. If there is a need for especially high dimensional stability, the mold temperature should be set at least as high as the temperature at which the molded part will be used later on.

In order to avoid heat losses, it is recommended that insulation be fitted between the mold and platen.

Processing by injection molding

Processing temperature

As a rule melt temperatures of 180 °C to 220 °C are sufficient. Complex molds with long flow paths and thin walls may in exceptional cases require temperatures up to 230 °C. Higher processing temperatures involve the risk of thermal degradation. This is prevented if the production conditions allow a high shot rate and hence a correspondingly short residence time of the melt in the injection molding cylinder.

Continuous measurement of the melt temperature is recommended. Use of a needle shut-off nozzle affords a good opportunity of doing this because a thermocouple can be readily accommodated in this nozzle.

The individual heater bands in the injection molding machine can frequently be set to the same temperature. If cycle times are long, the first heater band (near the hopper) should be set to a slightly lower temperature to prevent premature melting of the pellets in the feed zone.

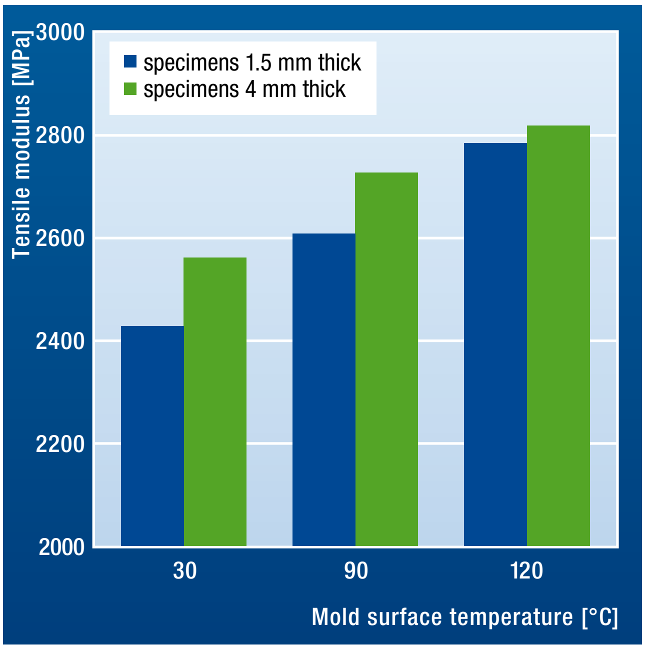


Fig. 22: Ultraform® N2320 003 – influence of the mold surface temperature on the stiffness of tensile bars with different thickness

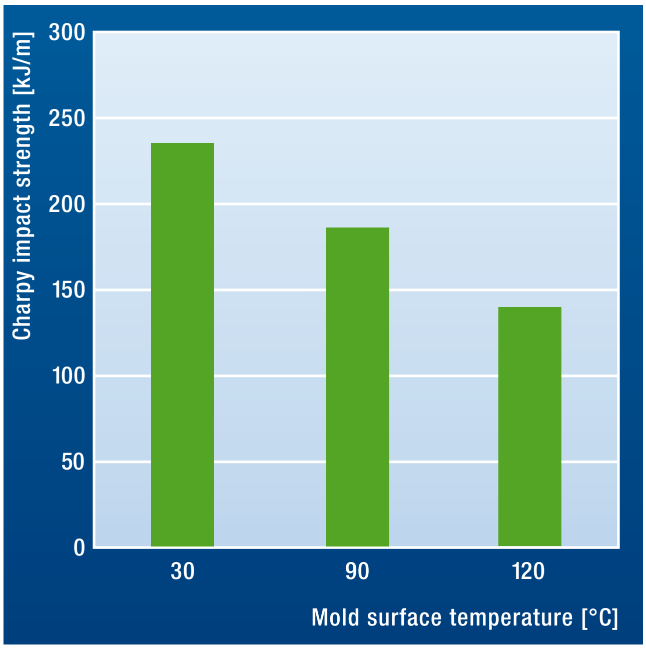


Fig. 23: Ultraform® N2320 003 – influence of the mold surface temperature on the charpy impact strength (ISO 179/1eU)

Feed characteristics
Ultraform® is drawn in without problem by standard screws (see Figs. 20, 21). The screw geometry, screw speed, back pressure and temperature control at the barrel determine the feed behavior of the granules and their plastication.

The cooling possible in most injection molding machines in the region of the hopper allows adjustment of the feed behavior if required. In special cases, a dropping temperature profile (e. g. 220 °C to 205 °C) has to be set from the hopper to the die for Ultraform® N2310 P.

The peripheral speed of the screw should not exceed 0.3 m/s.

Mold filling
The quality of the finished parts also depends on the speed at which the mold is filled. A filling rate which is too high promotes alignment of the molecules and results in anisotropic mechanical properties. On the other hand a filling rate which is too low yields parts with poor surface finish.

Particular care has to be taken that air in the mold cavity can escape easily at suitable points when injecting the melt, so that burn marks due to compressed air (Diesel effect) are not produced. An insufficient ventilation of the mold increases mold deposits. Fig. 24 shows a well-tried system for ventilation.

When material accumulates, the formation of voids is counteracted by making the holding pressure sufficiently high and the holding pressure time sufficiently long so that the contraction in volume occurring on cooling of the melt is compensated. The precondition for this is a sufficiently large and well sited gate so that the melt in this region does not solidify too early before the end of the holding pressure time and as a result seals the still plastic molding in the interior against the holding pressure of the melt.

Flow characteristics
Ultraform® H4320, the high-molecular-weight resin with the highest viscosity, is a preferred material for extrusion. It is also suitable, however, for the production of particularly tough injection-molded parts having relatively thick walls (> 3 mm).

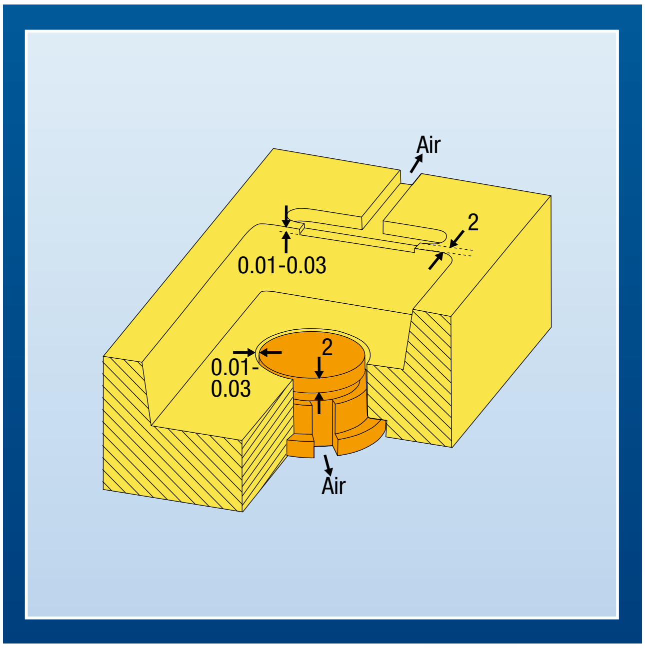


Fig. 24: Mold venting system

Conveyor belt

The processing of Ultraform®

Ultraform® N2320 003 is the standard grade for moldings of normal wall thickness (> 1.5 mm) and flow paths which are not too long. The free-flowing Ultraform® S2320 003 is recommended when the walls are thinner and the flow paths longer.

Ultraform® W2320 003 and the especially easy-flowing Ultraform® Z2320 003 are available when due to the upper processing temperature limit complete filling of the mold with Ultraform® S2320 003 is no longer possible.

The flow characteristics of these grades as a function of the wall thickness as revealed by the spiral flow test are shown in Fig. 25. Although this test is not standardized, it nevertheless allows a practice-based assessment. The flowability or the flow path of a product depends not only on the processing parameters, such as injection pressure, injection speed, melt and mold temperature, but also on the design of the mold and of the machine. Fig. 26 provides an overview of how flow depends on the melt temperature. Despite having good flow properties, Ultraform® injection molding grades do not tend to form flash.

Processing speed

Factors governing the processing speed in injection molding are on the one hand the time it takes for the melt to cool from the processing temperature to the setting temperature, and on the other hand the rate of solidification, which in the case of semicrystalline thermoplastics is closely related to the rate of crystallization.

In the case of thin-walled parts the processing speed is mainly determined by the rate of crystallization, while for thick walls it is principally determined by the rate of the plastic's heat conduction.

The Ultraform® grades are characterized by high solidification rates and are therefore exceptionally suitable for the economic production of thin-walled parts.

Demolding

Ultraform® can be readily demolded. Even with high mold surface temperatures it has no tendency to stick to the mold walls.

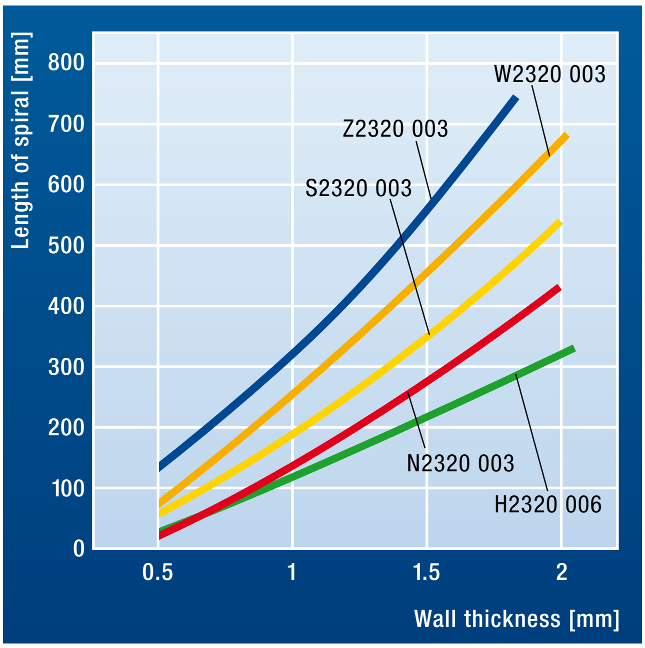


Fig. 25: Flowability as a function of wall thickness (spiral flow test). Machine: 1300 kN, screw diameter: 30 mm, mold: test spirals, injection pressure: 1200 bar, melt temperature: 210 °C, mold surface temperature: 80 °C

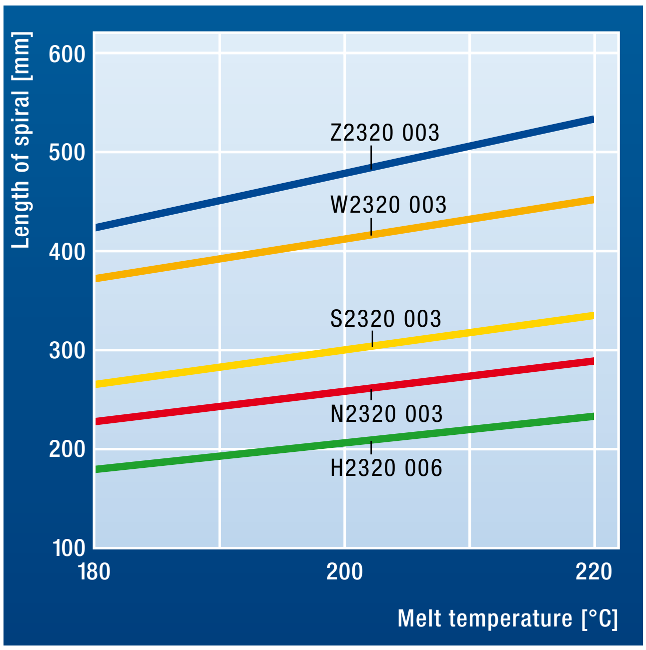


Fig. 26: Flowability as a function of melt temperature. Machine: 1300 kN, screw diameter: 30 mm, mold: 1.5 mm test spirals, cycle time: 20 s, injection pressure: 1000 bar, mold surface temperature: 80 °C

The drafts in injection molds are normally 1 to 2 degrees. Smaller drafts are possible for Ultraform® as a result of the high contraction in volume. However, the ejector or stripper plates must have a large contact area.

The general rule is that the ejector pins should not be too thin relative to the part, otherwise the moldings are damaged by indentation of the ejector pins when cycle times are short or the mold temperature is high.

The mold cooling channels should be designed in such a way that the molding is cooled as uniformly as possible and as a result can solidify largely free of warpage.

Shrinkage and aftershrinkage

Shrinkage is defined as the difference between the dimensions of the mold and those of the molding at room temperature. It is normally determined 24 hours after production and expressed in percent (ISO 294-3/4). As accurate a prediction as possible of the anticipated shrinkage is important, especially for the mold maker.

The dimensions of the mold must be designed in such a way that moldings with the desired final dimensions can be produced. Although shrinkage is primarily a property of the material, it is additionally determined by the shape and wall thickness of the injection-molded part and by the processing conditions (mold surface temperature, melt temperature, holding pressure, injection speed, position and size of the gate). The interaction of these different factors usually makes it very difficult to predict shrinkage exactly. The test box as depicted in Figure 27 has proven its suitability for ascertaining the practice-relevant shrinkage dimensions. Usually the length A is evaluated as the measure of the shrinkage of the bottom of the box.

The greatest influence on the shrinkage comes from the temperature of the mold surface and from the wall thickness of the molded part. Figure 28 shows this dependence with reference to test boxes having wall thicknesses of 1.5 mm, 5 mm and 8 mm. It can be seen that shrinkage increases rapidly as the mold temperature rises. Here the mold temperature is always to be taken as the measured surface temperature and not the temperature of the temperature control medium.

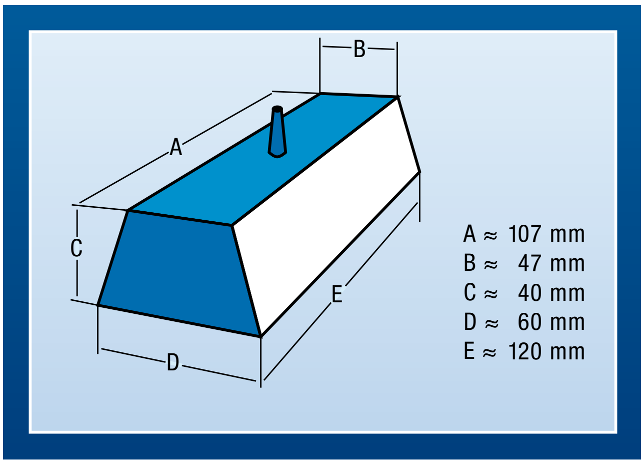


Fig. 27: Test box

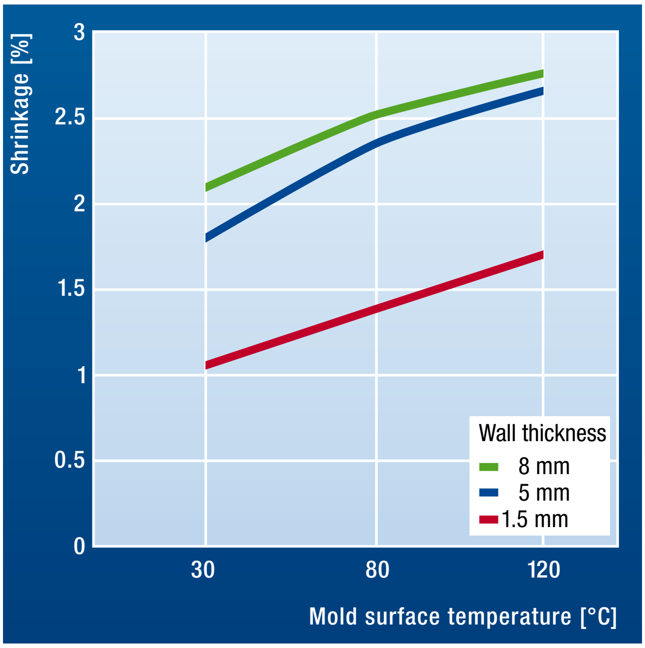


Fig. 28: Shrinkage of test boxes molded from Ultraform® N2320 003 one hour after molding (distance A)

The processing of Ultraform®

With reference once more to the test box having a wall thickness of 1.5 mm, Fig. 29 shows the dependence of shrinkage on holding pressure. Higher holding pressures partially compensate for shrinkage. This effect is reinforced by higher mold temperatures and greater wall thicknesses.

Other factors, such as the melt temperature or the injection speed for example, do not affect the shrinkage of Ultraform® to any great extent. It only increases slightly as the melt temperature rises and the injection speed falls.

Over time the dimensions of injection moldings may alter slightly owing to temperature-dependent and time-dependent post-crystallization and also in small measure to the relaxation of internal stresses and alignments.

Fig. 30 shows the shrinkage measured on the test box after an hour (Curve 1), 14 days and 60 days (Curves 2 and 3). The parts were stored at room temperature. Aftershrinkage, i.e. the increase in shrinkage due to postcrystallization, is visible from the curves. Curve 4 shows the shrinkage of the same parts after 24 hours at a temperature of 120 °C.

Tempering is worthwhile when injection-molded parts made from Ultraform® are to be exposed to relatively high temperatures in later use. The tempering anticipates the change in dimensions otherwise to be expected as a result of postcrystallization. As Fig. 30 shows, however, tempering can be dispensed with when injection molding is carried out at high mold temperatures.

Shrinkage of the glass-fiber reinforced Ultraform® N2200 G53 is substantially smaller than that of the unreinforced grades. However, due to the orientation of the glass fibers, the shrinkage is anisotropic. Depending on the shape, gate position and processing conditions, this can cause warpage of the moldings.

By contrast, the mineral-filled Ultraform® N2720 M63 is largely characterized by isotropic shrinkage. Fig. 31 shows shrinkage parallel and perpendicular to the direction of flow for free shrinkage of unreinforced, glass-fiber reinforced and mineral-filled Ultraform®.

Shower head insert

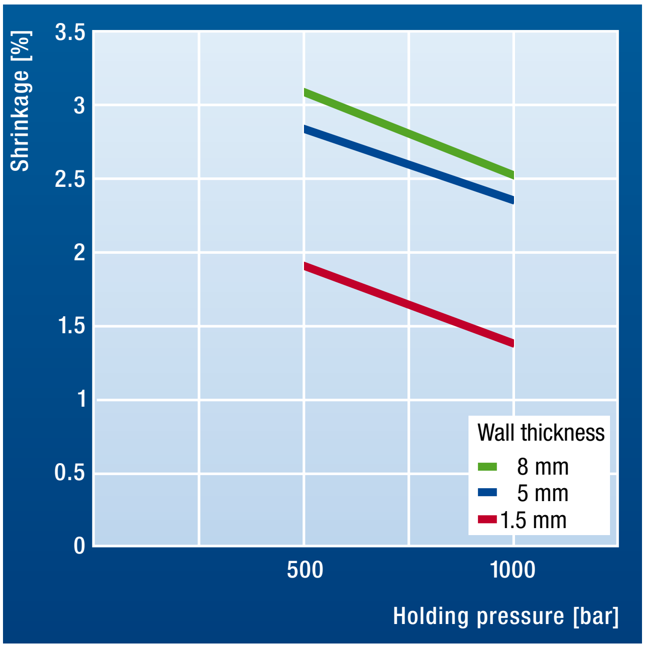


Fig. 29: Shrinkage of test boxes molded from Ultraform® N2320 003 one hour after molding (distance A)

Loudspeaker grills

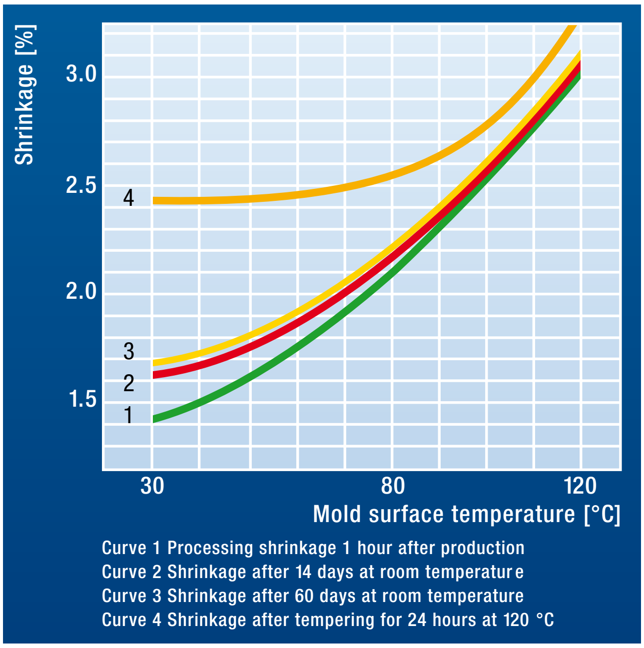


Fig. 30: Shrinkage and aftershrinkage of Ultraform® N2320 003 as a function of mold temperature, time and temperature determined on the basis of a box having a wall thickness of 1.5 mm. Machine: 1300 kN, mold: test box with walls 1.5 mm thick, melt temperature: 210 °C, holding pressure: 500 bar, dimension measured: A = 107 mm

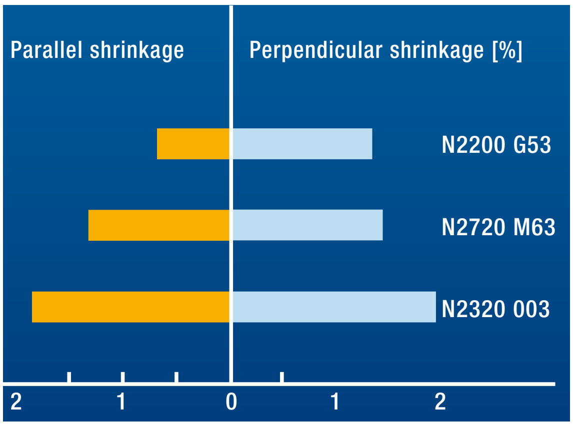


Fig. 31: Shrinkage of unreinforced, glass-fiber reinforced and mineral-filled Ultraform® parallel and perpendicular to the direction of flow for free shrinkage determined for sheet measuring 110 x 110 x 2 mm; melt temperature: 200 °C, mold surface temperature: 80 °C

The processing of Ultraform®

Extrusion

The main form of Ultraform® used for extrusion is the high-molecular weight grade H4320. Another grade Ultraform® H2320 004, is available for extruding small pipes and slab stock.

Up to a few years ago the most common type of screw for POM was the short-compression zone screw.

On the basis of BASF-experience, Ultraform® can be processed to particular advantage using three-section screws having a total length L of 20 to 25 D and a constant pitch of about 1 D. Table 1 contains suggested screw geometries for the most frequently used extruder sizes. Material stresses and degradation due to friction can be significantly reduced by means of a feed zone of appropriate length and an extended compression section having a maximum compression ratio of 3:1.

Table 1: Guide values for the screw geometry (extrusion)

Length of section					Flight depths	
Overall length	L	20 - 25	D	D mm	h_E mm	h_A mm
Feed section	L_E	8	D	45	7.7	2.8
Compression section	L_K	3 - 5	D	60	9.3	3.3
Metering section	L_A	9 - 12	D	90	10.8	3.8

D = screw diameter
h_E = flight depth in the feed section
h_A = flight depth in the metering section

Production of semi-finished parts

Thick-walled hollow and solid profiles are usually manufactured by the cooled-die extrusion method. The dimensions for the standard sizes of such POM profiles and the quality requirements for them are standardized as follows:

- DIN 16985 Technical delivery conditions
- DIN 16980 Round-section rod
- DIN 16986 Flat bar
- DIN 16978 Hollow rod
  (An integrated European standard is in preparation: EN 1549)

The requirements of DIN 16985 can be very reliably fulfilled by Ultraform® H4320, because this grade, when correctly processed, has very little tendency to discolor or to produce voids. Compared with products, this type allows processing speeds which are significant higher.

Table 2: Processing examples for the production of round-section rods

	Ultraform® H4320
Rod diameter	60 mm (4-aperture die)
Extruder	45 mm ∅, 22 D
Screw	
Section length	L_A = 9 D, L_E = 9 D, L_K = 4 D
Flight depth	h_E/h_A = 7.5/2.5 mm
Temperature control	
Extruder	200/180/170 °C
Adapter	175 °C
Die heated	175 °C
Die cooled	20 °C
Screw speed	42 min^{-1}
Take-off rate	20 mm/min (per rod)
Output	17 kg/h

The necessarily long residence time of the melt in the extrusion of semi-finished parts requires that the melt temperature be kept as low as possible. For thicker rod, for example, the melt temperature should not exceed 175 °C to 180 °C.

Volume shrinkage can be compensated by high pressure and an output rate adapted to the wall thickness.

Stresses can arise due to the different solidification and cooling of the melt, which varies according to time and place. These can be removed by subsequent heat treatment. Tempering is essential when high demands are placed on dimensional stability. It can be carried out in air, liquid wax or oil at temperatures of 130 °C to 150 °C, mostly 140 °C to 145 °C. Lower temperatures are not effective. The duration depends on the wall thickness (10 minutes per 1 mm wall thickness).

Gear wheels

Production of tubes and pipes

Smaller Ultraform® tubes are mainly used to protect and guide Bowden cables. They have an outer diameter of 3 to 10 mm and a wall thickness in the range 0.4 -1.0 mm.

The vacuum water bath method is recommended for the production of tubes and pipes. For calibration, draw plates (set) arranged one behind the other or radially slotted or drilled calibration sleeves are suitable. In both cases the internal diameter of the calibration unit is set approximately 2.5 % greater than the desired outer diameter of the tube to be produced. Based on experience, this difference corresponds to the shrinkage in processing. In order to be in a position to utilize the off-take speeds possible with this product, the ratio of the die diameter of the pipe extrusion head to the internal diameter of the calibration tube must lie approximately in the range 2:1 to 4:1, depending on the size of the tube. The die gap of the pipe extrusion head should be 3 to 4 times the size of the desired wall thickness of the tube.

The rapid solidification requires that the distance between the pipe extrusion head and the calibration unit be kept as small as possible. If the spacing is too great the outer skin of the molten tube will have solidified so much at the inlet that the tube can no longer be reliably calibrated.

Large, thick-walled pipes are preferably produced by the vacuum water bath method.

Table 3: Examples of the production of pipes from Ultraform® H2320 004

	Unit	
Pipe dimensions (external diameter x wall thickness)	mm	3.5 x 0.9
Extruder	mm	45 ∅, 20 D
Screw		
Section lengths: $L_E/L_K/L_A$		8 D/3 D/9 D
Flight depths: h_E/h_A	mm	7.7/2.7
Temperature control		
Extruder	°C	180…180
Adapter	°C	180
Die body/die aperture	°C	170/170
Pipe extrusion head		
Die ∅	mm	12
Mandrel ∅	mm	6
Gap	mm	3
Vacuum water bath		
Draw plate ∅	mm	3.6
Water temperature	°C	18
Distance between pipe extrusion head and calibration unit	cm	approx. 3
Screw speed	min^{-1}	26
Off-take speed	m/min	16
Output	kg/h	approx. 10

The processing of Ultraform®

With standard equipment and standard extrusion grades, such as Ultraform® H4320, it is possible to produce pipe with a maximum wall thickness of 8 mm. For thicknesses greater than this, the melt flows increase in the direction of gravity, causing a growing difference in thickness between the upper and lower sides of the pipe.

Production of sheet

Ultraform® H2320 004 is excellent for producing sheet with thicknesses between 1 and 6 mm. Standard sizes are defined in DIN 16 977 and the quality requirements in DIN 16985.

Sheet is produced on commercial installations aligned horizontally with slot dies, three-roll polishing stack followed by an off-take unit. The lips of the slot dies should extend as close as possible to the nip. The temperatures of the rolls depend on the sheet thickness and vary between 130 °C and 170 °C.

The throughput and off-take rate are matched to one another in such a way that a small, uniform bead is formed over the width of the roll ahead of the nip. In this way the tolerance and surface quality of the sheet can be adjusted in optimum manner. By using vented extruders, the surface quality can be improved still further. Otherwise pre-drying of the pellets is recommended (3 hours at 100 °C to 110 °C).

Manufacture of monofilaments

Ultraform® H2320 004 and H2320 006 are suitable for manufacturing stiff bristles and technical monofilaments with a diameter of up to about 0.5 mm. A quick cooling-phase and recking is important.

Blow molding

Ultraform® E3120 BM makes it possible to produce elaborate hollow bodies by extrusion blow molding.

When blow molding Ultraform®, it is generally necessary to ensure good and homogeneous processing of the melt. It is recommended that a screw with an effective screw length of no less than 20 D and a low channel depth be used so that the melt can be processed homogeneously. Maddock, rhombus-shaped mixing elements, barrier webs and other suitable screw elements can further enhance the processing.

Appropriate temperature control which differs from traditional blow molding is also required. Controlling the temperature of the feeding zone to a temperature between 100°C and 230°C helps to melt the granules. The zones next to the feeding zone should be heated up from 180°C to 230°C. Constant temperature control or a temperature profile which declines slightly toward the tip of the extruder with melt temperatures of around 200°C helps to produce a stable melt and components with good mechanical properties.

The blow molding tool should preferably have a temperature of over 90°C. Controlling the temperature of the tool helps to mold the tool cavity well. The blow pressure to be chosen depends on the component, but in most cases it will be between 4 bar and 10 bar.

Table 4: Example of the production of sheet from Ultraform® H2320 004

Sheet cross-section	770 mm x 1.6 mm
Extruder	90 mm Ø, 30 D
Screw	
Section lengths	L_E = 9 D, L_K = 1,5 D, L_A = 6 D
Venting	0,5 D
	L_{E1} = 4.5 D, L_{K1} = 1D, L_{A1} = 7.5 D
Flight depths	h_E/h_A = 10.8/4 mm
	h_{E1}/h_{A1} = 16.8/5.6 mm
Die	800 mm wide
Temperature control	
Barrel	150/160/160/170/170/155/155/155 °C (while extruder is running)
Adapter	180 °C
Die	185 °C throughout
Three-roll stack	300 mm roll diameter
	Temperature (set): top 170 °C, center 145 °C, bottom 140 °C
Screw speed	25 min^{-1}
Melt temperature	200 °C
Off-take rate	0.63 m/min
Output	68 kg/h

Fabrication and finishing processes

Machining
Semi-finished parts made from Ultraform® can be machined with all conventional machine tools. As a general rule of thumb cutting speeds should be high and feed rate low.

Joining methods
Parts made from Ultraform® can be joined at low cost by a variety of methods. The mechanical properties of Ultraform®, especially its toughness, allow the use of self-tapping screws. Ultraform® parts can be connected without difficulty to one another or to parts made from other materials by means of rivets and bolts. Snap-in and press-fit connections can also withstand high stresses. Ultraform®'s outstanding elasticity and strength, even at high temperatures, are particularly suitable for this form of construction.

Ultraform® parts can be welded by heating-element (thermal contact and radiation) methods, and by ultrasonic, vibration and spin welding methods. Only high-frequency welding is not feasible for Ultraform® on account of the low dielectric dissipation factor.

The laser irradiation welding method is suitable for combinations of parts molded from Ultraform® which is transparent to IR radiation (e.g. natural-colored) and parts molded from Ultraform® absorbing IR radiation (e.g. black). In this way very clean welded joints can be produced without flash.

Ultrasonic welding is preferred in cases where short welding times and ready integration into fully automated production flows are required. The strongest welded joints are achieved with the heating-element method.

Apart from the welding method and the welding parameters, the geometry of the mating surfaces is of great importance for the quality of the welded joints. It is therefore advantageous to choose the best method at the design stage and then to design the mating surfaces accordingly.

Adhesive bonding
In order to activate the non-polar material, it is necessary to pre-treat the surfaces, e.g. by etching, priming or corona discharge.

Adhesive bonding is possible only with pressure-sensitive adhesives. The joint obtained is impervious to gas, air and moisture, but has only low mechanical strength.

Since the pre-treatment, primer and adhesive form a single system, adhesives suppliers or the BASF Application Engineering experts should be contacted to provide help in solving bonding problems.

Printing, embossing, varnishing and metallization
Ultraform®'s hard, smooth surface and high resistance to chemicals have an adverse effect on the bonding strength of coatings. The usual methods of pre-treating plastics do not afford satisfactory results.

The use of certain printing inks in conjunction with a subsequent, brief flame treatment or with high-temperature ageing translates into high adhesive strength without the need for any special pre-treatment Please consult the BASF Applications Engineering experts for the clarification of any specific questions.

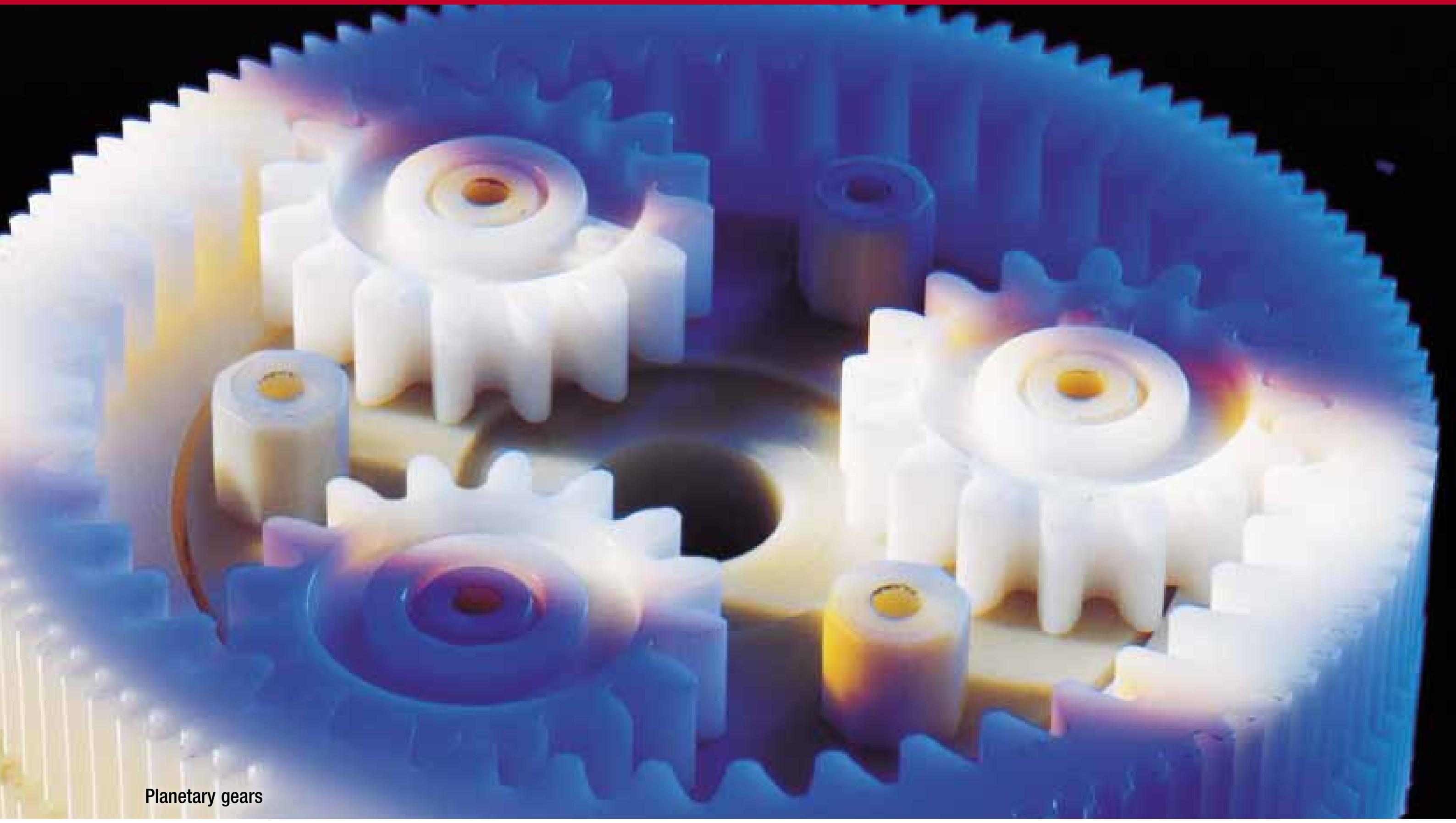
Embossing films are available for hot stamping which exhibit adequate adhesion even without pre-treatment of the surfaces.

Electroplating
Surface pre-treatment is necessary for the production of electroplated moldings. Parts made from Ultraform® can be electroplated by the method commonly used for ABS. The first stage in the process, however, etching with chromosulfuric acid, is replaced by acid treatment in dilute sulfuric or nitric acid.

It is imperative that the use of baths containing hydrochloric acid be avoided.

To remove any superficial acid residues the parts are then immersed in a weakly alkaline bath and rinsed thoroughly. The rest of the process is as for ABS.

The processing of Ultraform®



Planetary gears

Using this method relatively firm anchorage of the metal layer to the molding is achieved, as has been confirmed by cyclical temperature tests in the automotive and sanitary ware industry.

Laser marking

Table 5 provides an overview of the suitability of undyed and black Ultraform® to be marked by various lasers. Nd:YAG lasers having a wavelength of 1064 nm are often employed for printing.

In general, black Ultraform® grades – color code "Black 11020" in particular – enable high-contrast lettering and images with Nd:YAG lasers.

Table 5: Laser marking performance of Ultraform®

Laser	Wavelength	Uncolored Ultraform®	Ultraform® black 120
UV	308 nm	–	light marking
UV	355 nm	–	light marking
Nd:YAG „green"	512 nm	–	light marking
Nd:YAG	1064 nm	–	light marking
CO_2	10.6 µm	engraving	engraving

General information

Safety notes

Safety precautions during processing

Ultraform® decomposes when subjected to excessive heat. The decomposition products formed in this case consist essentially of formaldehyde, a gas which has a pungent smell even at very low concentrations and irritates the mucous membranes. Decomposition can rapidly result in the build-up of a high gas pressure in the barrel of the processing unit.

If the die is sealed there may be a sudden release of pressure via the filling hopper. If the dies and filling opening are blocked there is a risk that, as a result of the rising gas pressure in the barrel, the bolts between the barrel and the barrel head on the one hand or between the cylinder head and die on the other hand will shear and endanger human life. It is therefore essential to check the correct operation of the measurement and control devices before the processing machine is started up. Fully automatic systems must be capable of early detection and elimination of technical malfunctions in the processing machine.

When Ultraform® is properly processed, as a rule, only very little formaldehyde appears in the area of the processing equipment. In contrast, if the melt is severely or especially improperly stressed, for example, due to processing at an excessively high temperature and/or with a long residence time of the melt in the processing machine, a stronger formaldehyde odor can be the result. In case of such an operational malfunction, which is also noticeable in the form of brownish burn streaks on the molded parts, the cylinder of the processing machine should be flushed by spraying the melt outside. At the same time the barrel temperature must be reduced. Nuisances caused by odors can be prevented by cooling the damaged material in a water bath.

Measures should be taken to ensure ventilation and venting of the work area, preferably by means of an extraction hood over the barrel unit.

Gas sampling devices for monitoring the country-specific occupational exposure limits for formaldehyde are available on the market.

Contamination of Ultraform® by thermoplastics that cause decomposition of polyacetals, e.g. PVC or plastics containing halogenated fire protection agents, must be avoided under all circumstances. Even small quantities can cause uncontrolled and rapid decomposition of the Ultraform® during processing.

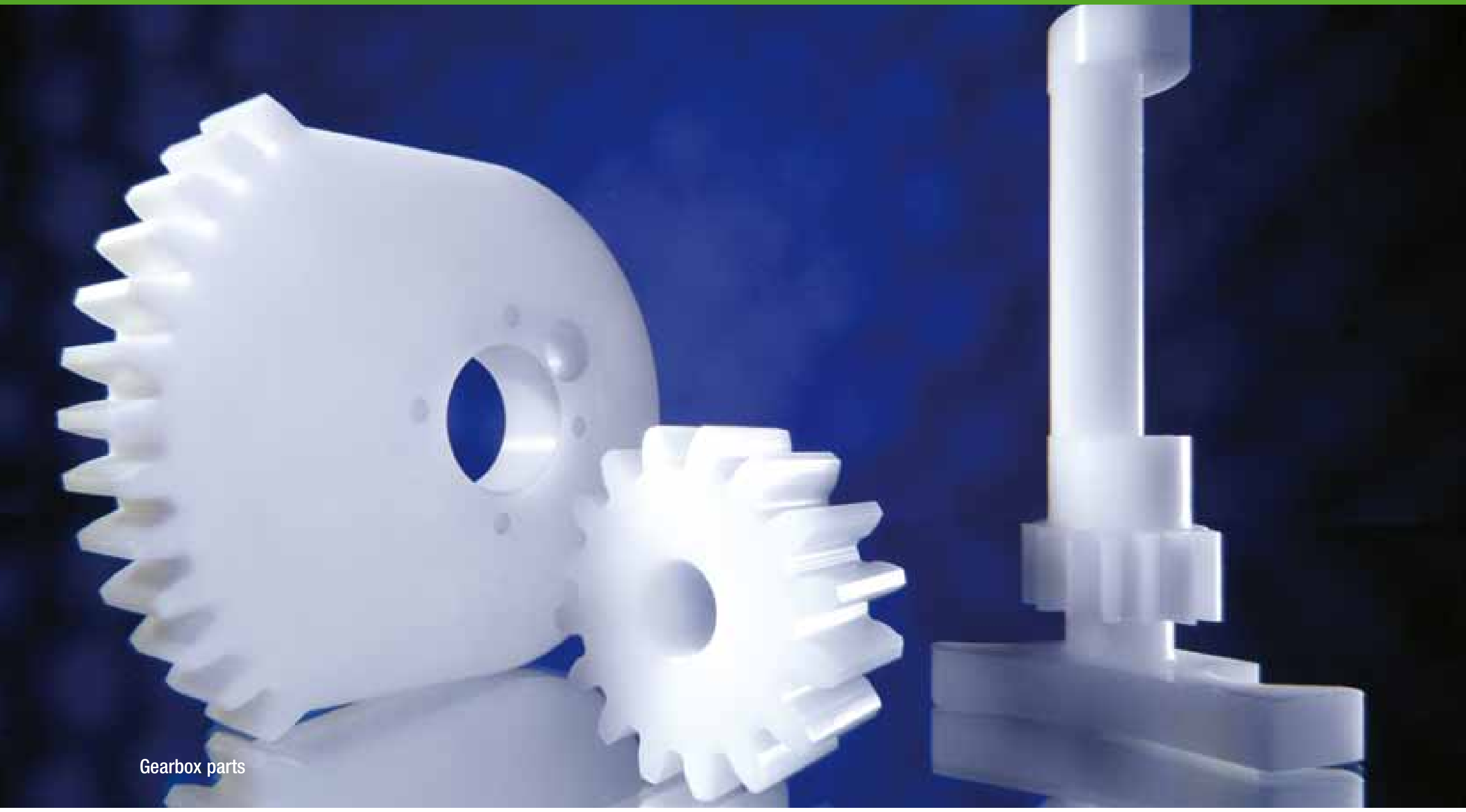
Pellets and finished parts must not be allowed to come into contact with strong acids (especially concentrated hydrochloric acid) since they cause Ultraform® to decompose.

Biological action

No detrimental effects to people engaged in the processing of Ultraform® have come to light when the material has been correctly processed and the work areas have been well ventilated.

The country-specific occupational exposure limits for formaldehyde must be observed.

General information


Gearbox parts

Food legislation

The uncolored standard-grades of our Ultraform® product line (N2320 003, S2320 003, W2320 003, H2320 006, H4320) are in conformity with the current regulations for food contact in Germany, Europe and the USA with respect to their composition. Registered users can download compliance letters for these and other products at BASF's internet site www.plasticsportal.com. In case of detailed information about the food contact status for a certain standard grade, a coloured Ultraform® or a special grade please contact BASF (plastics.safety@basf.com) directly. We are pleased to send you a food contact compliance letter with respect to the regulations in force at present.

Quality and environmental management

Quality and environmental management are central to BASF's policy. A key aim is customer satisfaction. Making continuous improvements to our products and services in terms of quality, the environment, safety and health is important.

BASF's business unit Engineering Plastics Europe uses a quality and environmental management system which has been certified by the German Association for the Certification of Management Systems (DQS):

- Quality management system in accordance with ISO 9001 and ISO/TS 16949
- Environmental management system in accordance with ISO 14001. The certification covers all the services that the business unit delivers for the development, manufacturing, marketing, and distribution of engineering plastics. Regular internal audits and training measures for staff ensure that the management systems work properly and are constantly developed further.

Delivery and storage

Ultraform® is supplied in the form of granules having a bulk density of approx. 850 g/l. Standard packs are the 25-kg PE bag and the 1000 kg Oktabin (octagonal container). Ultraform® is not subject to change when it is stored in dry, ventilated rooms. After relatively long storage (>1 year) or when handling material from previously opened containers, preliminary drying is recommended in order to remove any moisture which has been absorbed.

Ultraform® and the environment

Ultraform® is not a hazardous material as defined in the German Ordinance on Hazardous Materials, so there is no obligation to provide warning labels. Furthermore, Ultraform® does not come under the Hazardous Materials Ordinance, Appendix II "1.1 Carcinogenic substances". When kept away from sunlight, Ultraform® can be stored in contact with air at temperatures of up to 40 °C for several years without change. If Ultraform® is exposed to strong sunlight, signs of decomposition in the form of reduced molecular weight and brittleness cannot be excluded.

All Ultraform® grades can be landfilled or incinerated together with household garbage in accordance with local authority regulations.

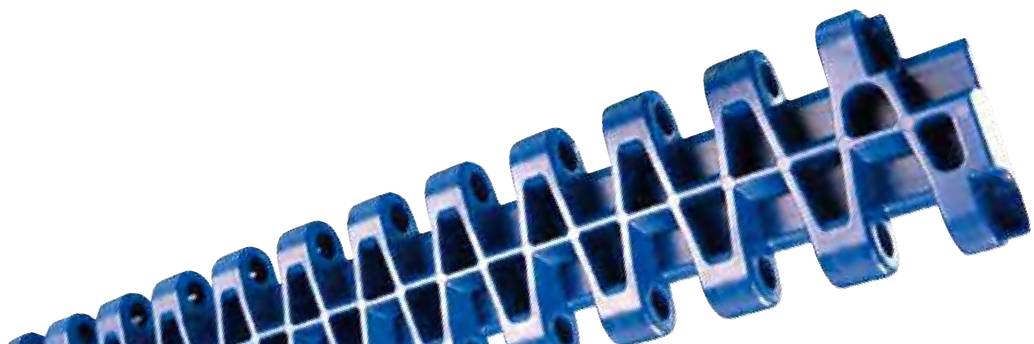
Ultraform® is assigned to the German water pollution class 0, i.e. Ultraform® poses no risk to groundwater.

Carbon dioxide and water are the products of the complete combustion of Ultraform®. When combustion is incomplete, traces of formaldehyde, carbon monoxide and other decomposition products, such as hydrocarbons and their oxidation products, may additionally be produced.

Saltshaker

Recycling

Waste materials, e.g. Ultraform® moldings and sprue, can be recycled provided the polymer is clean and has not been thermally degraded. After relatively long storage, the ground material should be dried before being returned it to reprocessing. The maximum permissible proportion of ground material depends on the dimensional and mechanical requirements imposed on the moldings and must be determined in trials. Further information in section "Reprocessing".



Conveyor belt part

General information

Nomenclature

Ultraform® grades are identified by letters and numbers.

1st character (letter):
Flowability
H = lowest flow rate = lowest melt index
Z = highest flow rate = highest melt index

2nd - 5th character (digits):
Number to characterize the composition of the polymer.

6th character:
An “X” here denotes a “development product”.

7th character:
Type of filler, impact modifier or additive
E = impact-modified with rubber
G = glass fibers
K = chalk
L = conductive carbon black
M = mineral
P = special lubricant
U = UV-stabilized
Z = impact-modified with thermoplastic polyurethane

8th character (digit):
Concentration of the fillers or impact modifiers defined by the 7th character;
the higher the digit (1-9), the higher the content.

9th to 14th characters (letters and digits):
Further product modification or additive.
LEV = low-odor

Examples

Example 1
Ultraform N2320 003:
N = flowability
2320 = rapidly solidifying standard product
003 = mold release agent

Example 2
Ultraform W2320 U035 LEV:
W = flowability
2320 = quickly-hardening standard product
U035 = UV-stabilization + demolding aid
LEV = low-odor

Example 3
Ultraform N2200 G53:
N = flowability
2200 = product composition
G = glass fibers
5 = approx. 25 % of glass fibers
3 = mold release agent

Example 4
Ultraform N2650 Z6:
N = flowability
2650 = product composition
Z = impact-modified with thermoplastic polyurethane
6 = approx. 30 % thermoplastic polyurethane

Colors

Colored grades are additionally identified by specifying the color and by means of a color number.

Subject index

Note

The data contained in this publication are based on our current knowledge and experience. In view of the many factors that may affect processing and application of our product, these data do not relieve processors from carrying out own investigations and tests; neither do these data imply any guarantee of certain properties, nor the suitability of the product for a specific purpose. Any descriptions, drawings, photographs, data, proportions, weights etc. given herein may change without prior information and do not constitute the agreed contractual quality of the product. It is the responsibility of the recipient of our products to ensure that any proprietary rights and existing laws and legislation are observed. (September 2010)

Please visit our websites:

BASF Plastics:
www.plasticsportal.com (World)
www.plasticsportal.eu (Europe)

Additional information on specific products:
www.plasticsportal.eu/name of product
e. g. www.plasticsportal.eu/ultraform

Tel.: +49 621 60-78780
Fax: +49 621 60-78730

Ultra Infopoint

E-Mail:
ultraplaste.infopoint@basf.com

Request of brochures:
KT/K, F 204
Fax: +49 621 60-49497

KTEF 1002 BE