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THE MECHANICAL PROPERTIES, DOMAINS OF USAGE AND RECYCLING OF THE ULTRAFORM POM

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Summary:
Ultraform is the trade name for polyoxymethylene copolymer product range of BASF. The Ultraform product range comprises versatile engineering plastics having the most varied properties designed for use in exacting components capable of withstanding high stresses. The Ultraform grades fulfill the demands imposed on an engineering material in especially high measure. They combine high rigidity with mechanical strength and afford good elastic properties, high toughness, dimensional stability and excellent sliding friction properties.

1. INTRODUCTION

Ultraform POM is manufactured by copolymerization of trioxane and a further monomer to from linear chains in which the statistically distributed and firmly attached comonomer is responsible for significantly higher stability (heat, chemicals) by comparison with a homopolymer. The plastic possesses a partially crystalline structure with a high degree of crystallinity. The Ultraform product range comprises grades for processing by means of extrusion and injection molding.

The product range may be subdivided into the following product groups (Fig.1):

a) Grades having high melt strength and high molecular weight for the extrusion of both thin-walled and thick-walled tubes and sheet as well as thick-walled semifinished products and hollow sections. Gear wheels, bearings and other mechanical elements are made from these by means of cutting tools.
b) Standard injection molding grades subdivided into viscosity classes; capable of rapid processing, readily demolded and free of films.
c) Impact-modified injection molding grades for applications with especially high demands on impact strength.
d) Glass-fiber reinforced injection molding grade having very high strength, rigidity, hardness and relatively high dimensional stability on exposure to heat.
e) Mineral-filled injection molding grade for low-warpage and dimensionally stable moldings having increased rigidity, thermostability and hardness.
f) Grades containing special additives for the improvement of resistance to light, UV radiation and weather, the sliding and abrasion behavior, the electric conductivity, the resistance to hot diesel fuel and the markability with Nd:YAG lasers.

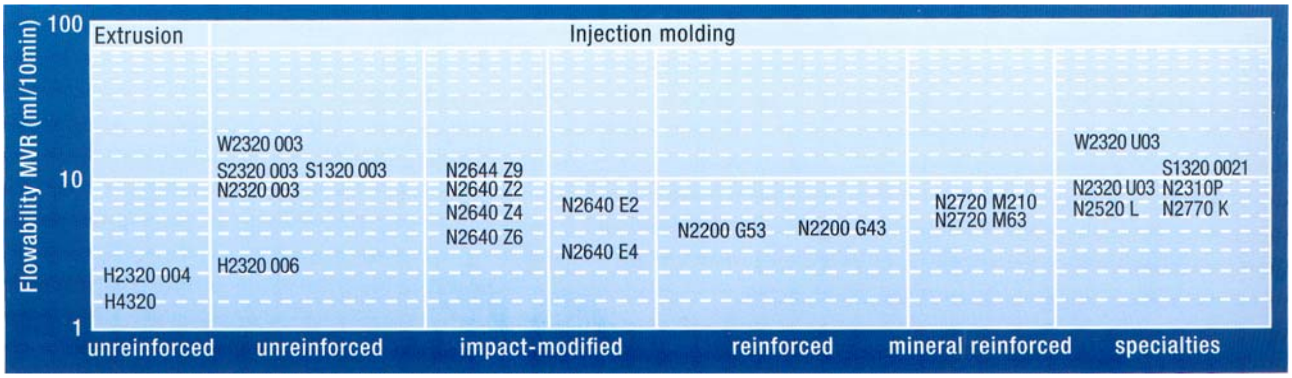

Fig.1. Selection of grades from the Ultraform range

2. MECHANICAL PROPERTIES

The special feature about Ultraform is its ideal combination of strength, rigidity and impact resistance, which is attributable to the structure of the product. Due to its high crystallinity, Ultraform is more rigid and stronger than other thermoplastics, particularly in the temperature range of 50 - 120˚C (see Fig.2). At room temperature, Ultraform has a pronunced yield point at about 8 – 10% strain. Below this limit, POM exhibits good resilience, even under repeated loading, and is therefore especially suitable for elastic elements. In addition, it has high creep strength and low tendency to creep (see Fig.3).

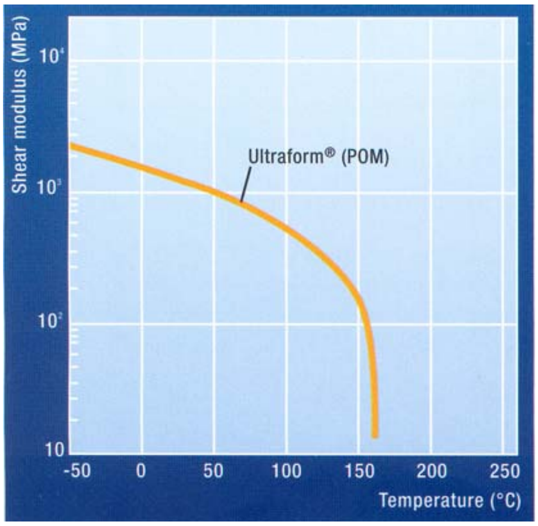

Fig.2. Shear modulus as a function of the temperature (measured according to ISO 6721)

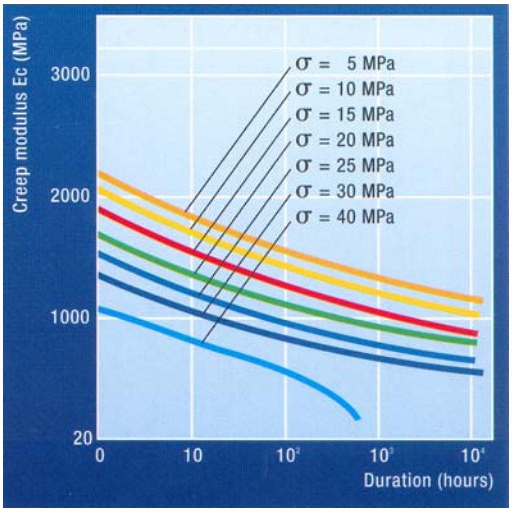

Fig.3. Creep modulus E_C of Ultraform N2320 003 as a function of loading duration (measured in accordance with ISO 899-1 under standard climatic conditions, 23˚C/50% r.h.)

This combination of characteristics in association with good tribological properties makes it very suitable for engineering applications. Ultraform POM absorbs very little water: approx. 0,2% under normal conditions 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 varied over a wide range by means of glass fibers, mineral fillers and incorporation of elastomers.

Thus glass-fiber reinforced Ultraform is distinguished by high mechanical strength, rigidity and hardness. Mineral-filled Ultraform affords high rigidity and hardness in association with a low tendency to warpage.

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. Fig.8 shows a plot of impact strength versus rigidity for this and other selected grades.

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.3) and creep curves (Fig.4).

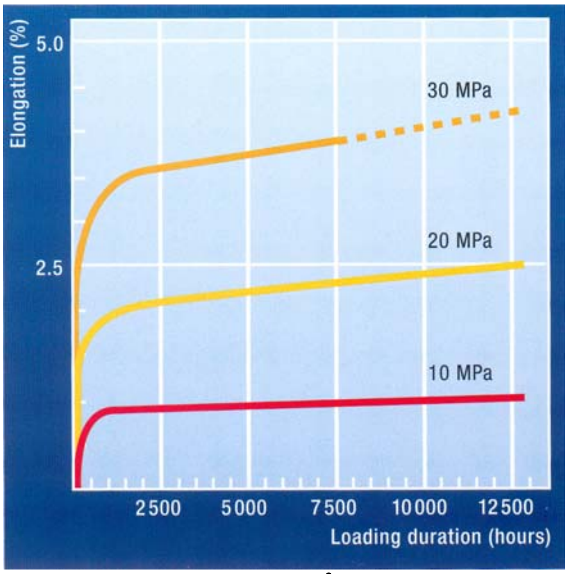

Fig.4. Creep curves for Ultraform N2320 003 at 23˚C, measured in accordance with ISO 899-1

Figs.5 and 6 show the isochronous stress-strain curves for standard and glass-fiber reinforced Ultraform.

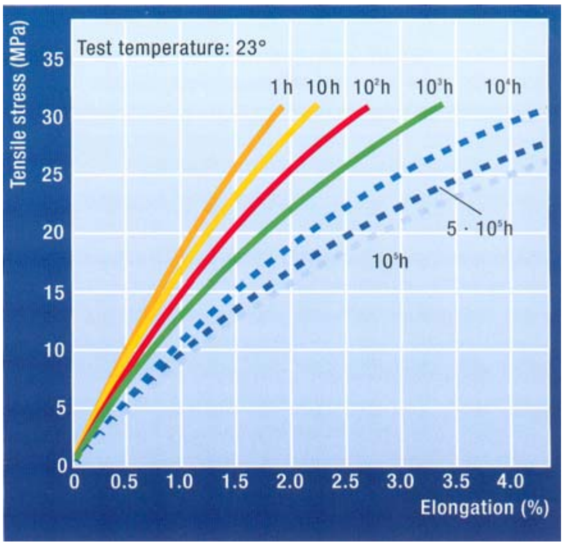

Fig.5. Isochronous stress-strain curves for Ultraform N2320 003, measured in accordance with ISO 899-1

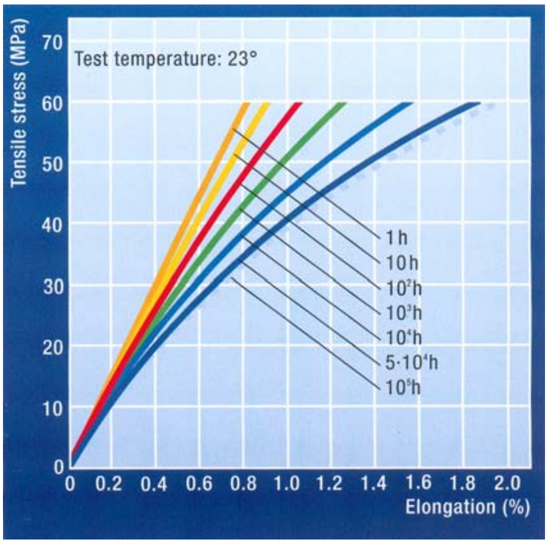

Fig.6. Isochronous stress-strain curves for Ultraform N2200 G53, measured in accordance with ISO 899-1

The creep strength values determined for pipes made from Ultraform reflect a multiaxial stress condition and the allround action of water (see Fig.7).

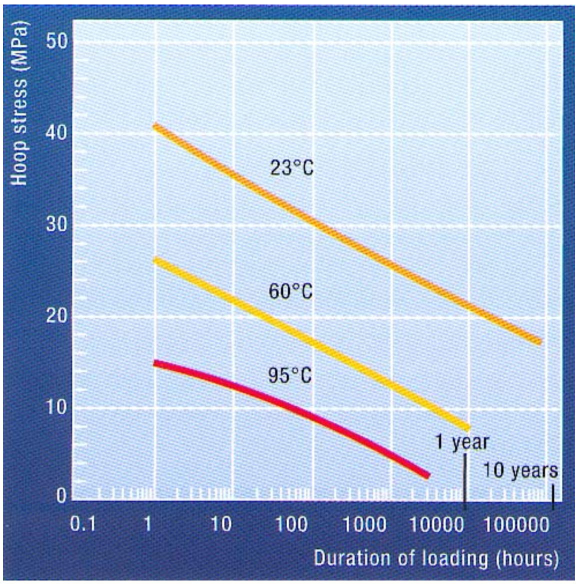

Fig.7. Creep strength of pipes made from Ultraform H4320 at various temperatures, with water inside and outside

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 applictions with demands on toughness. Fig.8 shows a plot of impact strength versus rigidity for these and other grades. Asubstantial gain in impact strength is obtained at the expense of a moderate loss in rigidity.

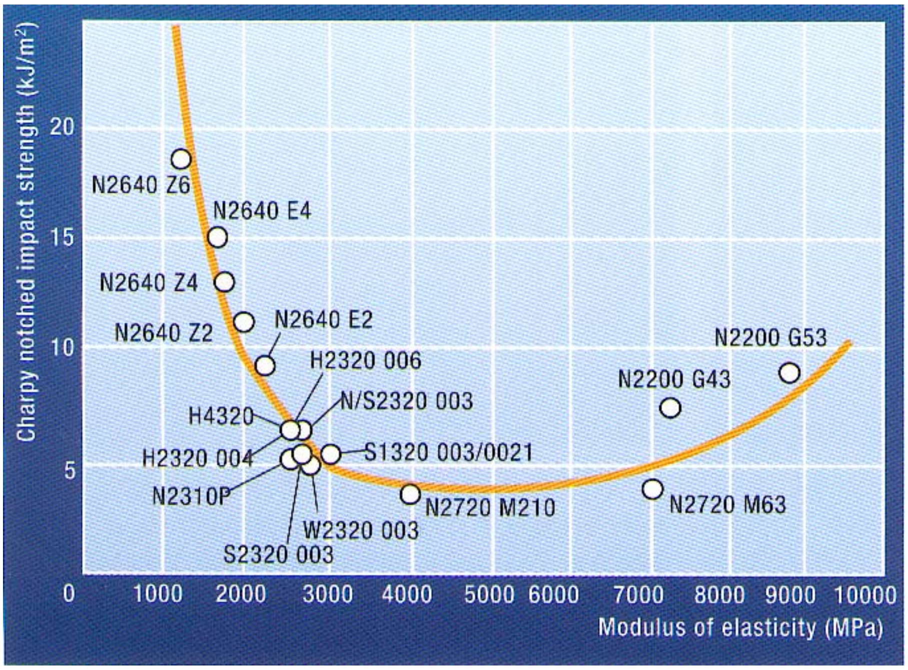

Fig.8. Impact strength vs. stiffness for selected Ultraform grades

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 50100) up to very high load-cycle rates. The results are presented in what are known as Wohler diagrams obtained by plotting the applied stress against the load-cycle rate achieved in each case (see Fig.9). The flexural fatigue strength is defined as the stress level a sample can withstand for at least 10^7 cycles.

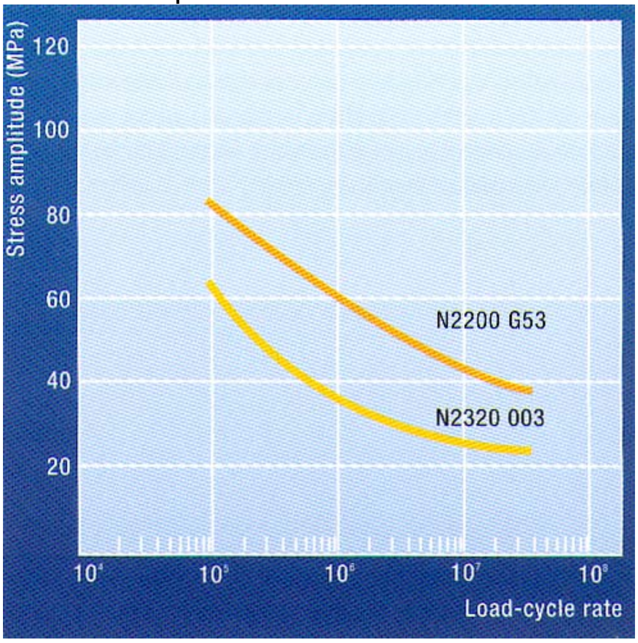

Fig.9. Wohler diagram for unreinforced and reinforced Ultraform determined in the flexural fatigue tests in accordance with DIN 50100. Normal climatic conditions, load cycle frequency 10 Hz

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.

3. APPLICATIONS AND RECYCLING

The most important applications of Ultraform POM are in vehicle construction, in the home and at leisure in office and industrial applications.

Examples of uses of Ultraform in the automotive industry include gas filler caps, tank level sensors, gasoline pump housings and parts, valves, seat-belt release buttons, windshield wiper clips, loudspeaker grilles, suspension stabilizer links, levers and rods, sun roof frames, ball sockets, roll-over valves and wash nozzles.

In the domestic and leisure area Ultraform is used for parts in sanitary fittings, curtain hooks, buckles, clips, parts for toys, guide rollers for audio and video tape cassettes, cutlery baskets for dishwashers, kettles, tea and coffee makers, espresso machines, window and door mountings, inserts for dishwashers, parts for vacuum cleaners, pastille dispensers, parts for garden sprinkler systems and plumbing fittings.

In industrial applications Ultraform is used for valves, small motor parts, chain links (for chain conveyors), ventilator rotors, guide rollers, thread guidance systems in spinning machines, ball and roller bearings, gear wheels and fastening elements.

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.

4. CONCLUSIONS

The Ultraform combine high rigidity with mechanical strength and afford good elastic properties, high toughness, dimensional stability and excellent sliding friction properties. The most important applications of Ultraform POM are in vehicle construction, in the home and at leisure in office and industrial applications.

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