Makrolon® 2805, 2865, 2807, 2867 and 2858

- **Polycarbonate (PC)**
- **General purpose grades**
- **Medium viscosity**
- **Injection molding**

Characterization

The Makrolon® 28.. injection molding grades are linear, medium viscosity polycarbonates on the basis of bisphenol-A.

- Makrolon® 2805: Easy release
- Makrolon® 2865: Easy release, improved flammability

  Makrolon® 2807: UV stabilized, easy release
- Makrolon® 2867: UV stabilized, easy release, improved flammability
- Makrolon® 2858: Easy release, EU/FDA quality, good hydrolysis resistance

Makrolon® 2865 and 2867 are largely comparable with Makrolon® 2805 and 2807. The key difference between Makrolon® 2865 and 2805 and Makrolon® 2867 and 2807 is the material's flammability performance.

Makrolon® 2865 and 2867 thus have a UL fire performance of UL 94V-2/3.0 mm and UL 94V-0/6.0 mm. (Makrolon® 2805 and 2807 UL 94HB/≥ 2.5 mm)

Makrolon® 2858 is an "FDA grade" which fulfills the requirements of the EU countries (including the BfR recommendations) and the FDA regulations for materials in contact with foodstuffs. Makrolon® 2858 is only available in colors which, in terms of the coloring agents used, fulfill the FDA regulations for food contact at service temperatures of up to 100 °C.

Abbreviation to DIN EN ISO 1043-1: PC

- Global grade

Designation to DIN EN ISO 7391-1:

Makrolon® 2805:
Thermoplastics ISO 7391-PC,MR,61-09-9

Makrolon® 2865:
Thermoplastics ISO 7391-PC,MR,61-09-9

Makrolon® 2807:
Thermoplastics ISO 7391-PC,MLR,61-09-9

Makrolon® 2867:
Thermoplastics ISO 7391-PC,MLR,61-09-9

Makrolon® 2858:
Thermoplastics ISO 7391-PC,MR,61-09-9

These are amorphous thermoplastics which, when injection molded, provide a unique combination of strength, rigidity and hardness, together with toughness and breaking strength. The heat resistance of these Makrolon® grades extends up to 135 °C, depending on the type of stress placed on the component. This, together with the low-temperature impact strength that is sufficient for a large number of applications, means that these grades can be used over a broad temperature range (- 100 to +135 °C).

Delivery form

Granules, packed in 25-kg PE bags, FIBC (flexible intermediate bulk containers - big bags), large cartons with a PE inliner or in bulk.

All batches of Makrolon® are homogenized after production.

The Makrolon® 28.. grades are supplied in all color shades with transparent, translucent or opaque coloring and an excellent depth of color.

The production plants for Makrolon® have been certificated to DIN ISO by the appropriate quality organizations.

Details on this can be found in our Technical Information Sheet "Plastics Business Group QM Certificates worldwide ISO 9000ff. ISO/TS 16949".

Applications

Electronics/electrical engineering:
distribution box lids, lamp holders, switches, sockets, functional components for the electrical industry

Lighting engineering:
lamp covers, lamp housings, lamp reflectors

Household/commodity:
shaver housings, food processor components, ironing appliances

Transport:
warning lights, signaling lights, traffic signs

Safety:
protective spectacles, helmet visors, glazing

Medical devices**:
dialysers, artery cannulas, milk pumps

Packaging/storage:
returnable milk bottles, babies' bottles, chocolate molds, food containers

The Safety Data Sheet can be supplied on request.

Properties (see also Table)

The key characteristic features of molded parts in the Makrolon® 28.. series of grades are:

- outstanding light transmission (transparent grades)
- high strength and impact strength
- dimensional stability, very low dimensional changes
- high heat resistance
- excellent electrical and dielectric properties
- suitable for food contact and medical devices** (Makrolon® 2858)

** Medical products see disclaimer

Mechanical properties

Molded parts made of the Makrolon® 28.. series of grades rank among the rigid materials on account of their strength and hardness, yet also amongst the elastic materials on account of their toughness. The low level of correlation between mechanical properties and temperature is striking; up to 140 °C, stress-free parts remain hard and dimensionally stable.

Molded parts made of grades in the 28.. series possess a particularly favorable energy absorption capacity under impact-type loads. The material is not, however, suitable for sliding bearings or toothed wheels where considerable stressing prevails. If parts are to be produced that will be exposed to dynamic loading, we recommend that model tests be conducted beforehand.

Stressing in excess of 20 MPa at 20 °C and in excess of 10 MPa at 60 °C can lead to surface cracking after a period of more than 10^4 hours. If the parts are employed in media other than air, then the permissible values may differ. Over and above this, allowance must be made for reduction factors as a function of the different influencing parameters (e.g. the molded part geometry, gate design and processing conditions). These reduction factors must be specified for each individual case.

Influence of coloring on toughness

The majority of transparent colors do not cause any change in properties, or at least no major change. Opaque pigments affect toughness depending on the type and quantity of pigment employed.

Thermal properties

Components made from the Makrolon® 28.. series of grades are noted for their high heat resistance. At low loading levels (e.g. inherent weight) the parts do not undergo any essential deformation at up to 135 °C. At above 145 °C (glass transition temperature), Makrolon® starts to soften and as of approximately 220 °C it assumes the molten state. Even higher temperatures are required, however, before it attains a flowability that will permit it to be processed on injection molding machines and extruders. Lengthy periods of heating to temperatures in excess of 320 to 340 °C leads to thermal decomposi-

tion, with carbon dioxide being split off, and discoloration.

The coefficient of thermal expansion is lower than for many other thermoplastics. If the material is subject to temperatures in excess of some 80 °C for long periods of time, then a structural change will occur, as a function of the temperature and duration of the thermal treatment, which is characterized by a slight increase in the tensile and flexural strength and a reduction in the notched impact strength. The maximum permitted service temperature for parts made of Makrolon® 28.. grades depends on the shape of the molded part, the type of loading and the specifications. The temperature indices to IEC 60216-1 and UL 746 B can be regarded as practical reference values for the permitted maximum temperatures during long-term service.

Where a component is subject to a high temperature and mechanical loading simultaneously, the creep behavior must be taken into account. Further details on this can be found in the CAMPUS® database.

Electrical properties

The favorable electric properties of molded parts in Makrolon® 28.. grades are not influenced notably by temperature fluctuations or by ambient humidity. The change in the measured values at higher frequencies must be taken into account when Makrolon® is used in the high-frequency sector. A further advantage is that no electrolytic corrosion is caused.

Optical properties

Makrolon® parts made from grades in the 28.. series have a high refractive index of 1.586. The virtually colorless, transparent grades possess a light transmission of up to 89 % in the visible range. Ultraviolet light, by contrast, is absorbed and leads to yellowing and a reduction in the impact strength in the course of time. In all cases where UV radiation is emitted, and particularly when it is emitted in conjunction with high temperatures, a UV-stabilized grade should be used (Makrolon® 2807, 2867). Finished parts, and particularly lamp covers, can be given subsequent UV protective treatment if required.

Behavior towards moisture and water (hydrolysis resistance)

Molded parts in Makrolon® 28.. absorb only 0.10 to 0.17 % water at room temperature with 50 % relative humidity. The physical/technological properties remain virtually unaffected. The dimensional changes are similarly insignificant. With immersion in water and rising temperatures, values of only 0.5 % or so are achieved. Although the EU/FDA grades, in the form of tableware, for example, can be cleaned many thousands of times in hot water, continuous service in water at temperatures in excess of 60 °C or so is not to be recommended, since hot water causes gradual chemical degradation coupled with a reduction in impact strength. Makrolon® parts in grades 2805, 2865, 2807 and 2867 are less suited to applications with hot water contact at above 60 °C than are parts in Makrolon® 2858. The same also applies to steam sterilization. The impact strength, notched impact strength and tensile strain at break are reduced through lengthy contact with hot water. This effect can also occur with storage in very moist, hot air. The steam permeability, measured on 100 µm thick film, is 15 g/m² · d. A notable level of permeability also exists for other gases (hydrogen, carbon dioxide, sulfur dioxide, helium and ethylene oxide).

Chemical resistance

Makrolon® is resistant to mineral acids, including in high concentrations, to a large number of organic acids (e.g. carbonic acid, lactic acid, oleic acid and citric acid), to oxidation and reducing agents, neutral and acidic saline solutions, a range of greases and oils, saturated aliphatic and cycloaliphatic hydrocarbons, and also alcohols, with the exception of methyl alcohol. Makrolon® is destroyed by alkaline solutions, ammonia gas and its solution, and amines. Makrolon dissolves in a large number of industrial solvents. Other organic compounds, such as benzene, acetone and carbon tetrachloride, cause it to swell.

Weatherability

Weatherability is generally adequate for a large number of applications and particularly for indoor applications. For stringent requirements, use of the UV stabilized grade, Makrolon® 2807 or 2867, is recommended. Maximum resistance can be

attained in finished parts through the subsequent application of a UV protective coating.

Food legislation provisions

Parts in the Makrolon® 28.. grades are odorless and tasteless and do not become discolored through normal contact with natural and synthetic coloring agents. While they do not display any defensive action vis-à-vis micro-organisms, they do not promote growth on their surface. Makrolon® 2858 can be used for the production of consumer goods for food contact.

1. For EU countries

Monomers used for the manufacture of plastics as well as a growing number of additives are regulated by EC Directives and their transformations into national ordinances, e.g. in Germany the "Ordinance on Consumer Goods" (Bedarfsgegenständeverordnung).

Since there are no finalized EC Directives covering all further plastics constituents (further additives, polymerization aids, colorants, etc.), these components have to comply with existing national rules/positive lists, which differ from one another in certain respects. In Germany for instance, the "BfR" (Bundesinstitut für Risikobewertung, formerly BgVV / BGA) recommendations are still to be observed for additives, etc.

With respect to its monomer and/or additive constituents Makrolon® 2858 complies with:

- Commission Directives 2002/72/EC*) of 06.08.2002 relating to plastics materials and articles intended to come into contact with foodstuffs (Official Journal of the European Communities, no. L 220/18, dated 2002)

  *) Directive 2002/72/EC consolidates and summarizes all earlier amendments to Directive 90/128/EEC (92/39/EEC, 93/9/EEC, 95/3/EC, 96/11/EC, 2001/62/EC and 2002/17/EC)

- the amended German "Ordinance on Consumer Goods" of 04.07.2003 (Federal Law Gazette, Part I, No. 14, 2003, pp. 486ff.).

The main sections of the above EC Directive and German Ordinance contain:

- the limit on "global migration": < 10 mg/dm² in relation to the surface of the article, and < 60 mg/kg in relation to the foodstuff
- the list of authorized monomers
- the incomplete list of authorized additives
- specific restrictions on individual monomers and additives (specific migration limits, SML, or, maximum residual content in finished plastic articles).

Regarding the monomers and/or the additives used in Makrolon® 2858, the following limits must be observed according to the Directive 2002/72/EC and the German Ordinance:

Carbonic acid dichloride -> max. residual content in the article:
< 1 mg/kg of plastic

Bisphenol A -> specific migration limit:
< 3 mg/kg of foodstuff

With respect to its further additives and/or further constituents, Makrolon® 2858 also complies with

- Recommendation XI, "Polycarbonate and mixtures of polycarbonates with polymers and copolymers", of the former German Federal Health Office (BgVV / BGA), now renamed the "Bundesinstitut für Risikobewertung" (BfR), status: 01.03.01 (202nd Communication: Bundesgesundh. Bl. 44, 546 (2001))
- Decreto Ministeriale dated 21.3.73 and its current supplements (Italy)
- Arrêté Royal of 25.08.1976 and its current supplements (Belgium)
- Verpakkingen- en Gebruiksartikelen-Besluit (Warenwet) dated 1.10.79 and its current supplements (Netherlands)
- Répression des Fraudes and its current supplements (France)
- Resolución de 04.11.1982 de la Subsecretaria para la Sanidad (Anexo) and its current supplements (Spain)

Evaluation:

At the moment, there are no recognized methods of analysis with sufficient precision for verifying these threshold values. This position seems unlikely to change in the near future. Methods of analysis are only adopted as European standards at CEN once lengthy standardization procedures have been carried out following completion of the necessary round-robin trials.

For this reason, we are only able to make provisional and non-binding statements about our products based on our own investigations and product knowledge.

We are working on the assumption that the global migration and monomer-specific limit can be met when Makrolon® 2858 is used for food contact applications at room temperature or for short periods at temperatures of up to 100 °C.

2. For the USA

Makrolon® 2858 complies with FDA Regulation 21 CFR §177.1580 "Polycarbonate resins" for food contact applications up to 100 °C.

Not all color shades comply with the provisions of the FDA, the BfR (formerly BgVV / BGA) or the French positive list.

Processing

The following processing methods can be employed:

Molding: Injection molding, extrusion, blow molding, rotational molding

Pre-treatment / drying[1)]

Makrolon® must be dried prior to processing. For injection molding no more than 0.02 % residual moisture may be present in the granules and, for extrusion, no more than 0.01 %. Moisture in the melt leads to surface defects as well as to an increased reduction in molecular weight. Makrolon® should be dried in suitable driers at 120 °C. The drying time for moist granules is largely a function of the nature and type of the drying unit and can total 2 to 12 hours depending on the drying capacity. Drying times of 2 to 4 hours are sufficient in modern high-speed driers. One means of dispensing with pre-drying is for the moisture to be removed during melting with the aid of a degassing unit, as has been standard practice in extrusion for a long time.

Injection molding[1)]

Makrolon® can be processed on all modern injection molding machines. Shut-off nozzles are suitable given sufficient, uniform heating. At high melt temperatures, melt can flow out of open nozzles. Molding shrinkage is more or less identical in all directions and amounts to between 0.6 and 0.8 %.

The melt temperatures generally employed during processing are between 280 and 320 °C.

It should be possible for the molds to be heated intensively and uniformly, and the mold temperature should be at least 80 °C to ensure parts with a low inherent stress and a good surface. No demolding difficulties are encountered at up to 120 °C. It will not generally be necessary to employ mold release agents when Makrolon® grades with easy mold release are used.

When Makrolon® is processed under the recommended processing conditions it is possible for small quantities of breakdown products to be emitted. In accordance with the Safety Data Sheet, compliance with the specified exposure limits at the workplace must be guaranteed through adequate

extraction and ventilation at the workplace, so as not to impair the health and well-being of the machine operators.

The specified processing temperatures must not be exceeded by any significant extent in order to prevent greater partial decomposition of the polymer and the splitting off of volatile breakdown products. Since excessive temperatures are generally attributable to operating errors or to malfunctions in the heating system, particular care and monitoring is called for here.

[1] Details on this can be found in our Technical Information Sheets

"Determining the dryness of Makrolon® by the TVI test"

"The Injection Molding of High-Quality Molded Parts"
- Preparing the Material: Drying
- Introduction and Product Range
- Production Equipment / Machinery
- Processing Data and Advice
- Increasing Productivity through Process Optimization
- Process Engineering Alternatives and Process Selection
- Wear Protection for the Plasticating Unit

Extrusion

Makrolon® 28.. grades can be processed on extruders in exceptional cases. As a general rule, the higher viscosity grades of the Makrolon® 3... series are more suitable for extrusion (higher melt rigidity).

Secondary finishing / post-treatment (molded parts)

The following processing methods can be employed:

- Forming:
  thermoforming, e.g. bending, embossing, cold forming, e.g. high-pressure forming, folding
- Machining:
  sawing, drilling, milling, turning, planing, filing, thread cutting, punching, cutting
- Joining:
  screwing, adhesive bonding, welding
- Post-treatment:
  painting, printing, high vacuum metallization, laser inscription

Injection moldings made of Makrolon® 28.. grades can be machined without any difficulty. There is only a low tendency towards "smearing" on account of the high softening temperature. Only air or clean water can be employed as cooling agents. Makrolon® components can be readily polished to a high gloss. Only alkali-free polishing pastes may be used, however, in order to prevent any chemical damage to the surface.

The industry supplies products for painting, printing and embossing which are specially tailored to polycarbonate. Makrolon® components can be vacuum metallized.

If parts in Makrolon® are to be glued together[2], solvents such as methylene chloride (dichloromethane), 1,2-dichloroethane and 1,3-dioxolane (1,3 dioxetane) are particularly suitable. These can be used to partially dissolve the contact surfaces prior to gluing (see Safety Advice).

Two-pack adhesives, such as those based on epoxy resin, silicone (with an amine-free hardening agent) or polyurethane are suitable both for gluing together parts made of Makrolon® and for gluing parts in Makrolon® to other materials. A condition for the use of adhesives based on epoxy resin, silicone and polyurethane is that these must not contain any components that are incompatible with Makrolon® .

Makrolon® parts can be welded by means of vibration, friction, heated tool or hot gas welding. Ultrasonic welding and riveting are the preferred processes.

[2] Details on this can be found in our Technical Information Sheet "The Adhesive Bonding of Makrolon® ".

Safety Advice[2)]

When handling the recommended adhesives and solvents, it is essential for the advice contained in the Safety Data Sheets for these products to be observed. The Safety Data Sheets will be made available by the individual suppliers.

Dichloromethane (methylene chloride)
Methylene chloride is a colorless liquid that is harmful to health. Vapors increase the CO-hemoglobin level in the blood, have a narcotic effect at high concentrations and irritate the eyes, skin (skin resorption) and the respiratory tract (Kühn-Birett Information Sheets: "Gefährliche Arbeitsstoffe M 25" (Hazardous Working Substances M25)). Dichloromethane damages the liver and kidneys and is also suspected of being carcinogenic (Section III, 3A of the German maximum workplace concentration (MAK) list). Methylene chloride should therefore only ever be handled under an extractor hood, with special attention being paid to the protection of the eyes and skin. In the event of a fire, phosgene and hydrogen chloride are hazardous decomposition products; do not allow to enter surface waters or sewerage systems; water hazard class WGK 2: hazardous to water.

1,2-dichloroethane (ethylene dichloride-1,2)
This colorless liquid is highly flammable but does not continue burning independently. It is harmful to health if swallowed or inhaled. Vapors irritate the eyes, respiratory tract and the skin and have a narcotic effect; liver and kidney damage is possible, inter alia (Kühn-Birett: Merkblätter Gefährliche Arbeitsstoffe M 19 (Hazardous Working Substances M 19)); danger of skin resorption. 1,2-dichloroethane is carcinogenic in animal tests (Section III 2 of the German maximum workplace concentration (MAK) list) and should therefore only ever be handled under an extractor hood with special attention paid to the protection of the eyes and skin. In the event of a fire, phosgene, chlorine and hydrogen chloride are hazardous decomposition products; do not allow to enter surface waters or sewerage systems; water hazard class WGK 3: severely hazardous to water.

1,3-dioxolane (glycol formal)
The acute toxicity of this highly flammable liquid is in the same range as for standard organic liquids. The substance irritates the eyes and skin. If inhaled or swallowed it will cause headaches, dizziness and vomiting. Peroxides form from unstabilized 1,3-dioxolane when it is in contact with air (stabilizers to prevent peroxide formation and polymerization include 2,6-di-tert.-butyl-4-methylphenol). Good ventilation is required when 1,3 dioxolane is handled. In the event of a fire, aldehydes, ketones and peroxides result as decomposition products; 1,3-dioxolane is completely miscible with water; do not allow to enter surface waters or be released into sewerage systems in an uncontrolled fashion; water hazard class WGK 1: slightly hazardous to water.

When handling the solvents referred to above, it is essential for the relevant safety instructions to be observed. Protective eyewear and gloves should be worn. The recommended wearing time of the gloves must not be exceeded due to the danger of the solvent diffusing through the glove material. Vapors should not be inhaled, and adequate ventilation of the workplace should be ensured. Work is thus best carried out under an exhaust hood. Any residual solvent or waste solvent should be disposed of by a technically suitable incineration plant authorized for this purpose.

Recycling/material disposal

Rejects and production waste can be reground, observing the drying and processing advice for virgin material, and made into new moldings. It is essential to check the property level and the color of molding compounds that contain regrind in respect of the envisaged application. The permissible regrind content must be established on a case-by-case basis.

When using regrind, it should be borne in mind that the grain geometry, which differs from that of extrusion granules, will influence the feed and plastification behavior. For this same reason, physical mixtures of regrind and granules tend to segregate on account of the movement they experience during transport, conveying and metering operations.

When Makrolon® is reprocessed, care should be taken to ensure that no foreign materials and no dirt is incorporated. Waste that contains pollutants and mixed waste can be chemically recycled or incinerated with energy recovery.

Non-recyclable Makrolon® waste can be disposed of in an environmentally compatible manner through the correct form of incineration and subsequent dumping of the slag.

Parts should be identified in accordance with DIN EN ISO 11469; the marking to be applied to parts in Makrolon® 2805, 2865, 2807, 2867 and 2858 is as follows:

>PC<

Details on this can be found in our Technical Information Sheet "Part Identification of Thermoplastics for Recycling".

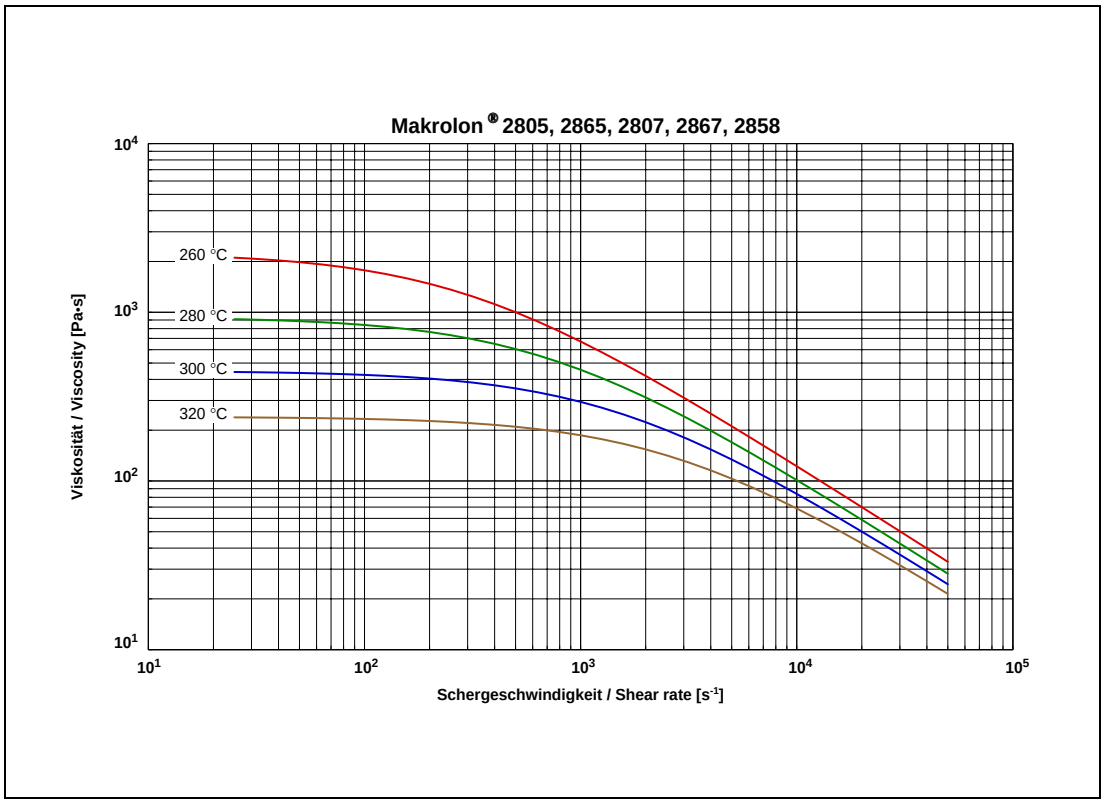

Fig. 1: Melt viscosity as a function of shear rate (Makrolon® 2805, 2865, 2807, 2867, 2858)

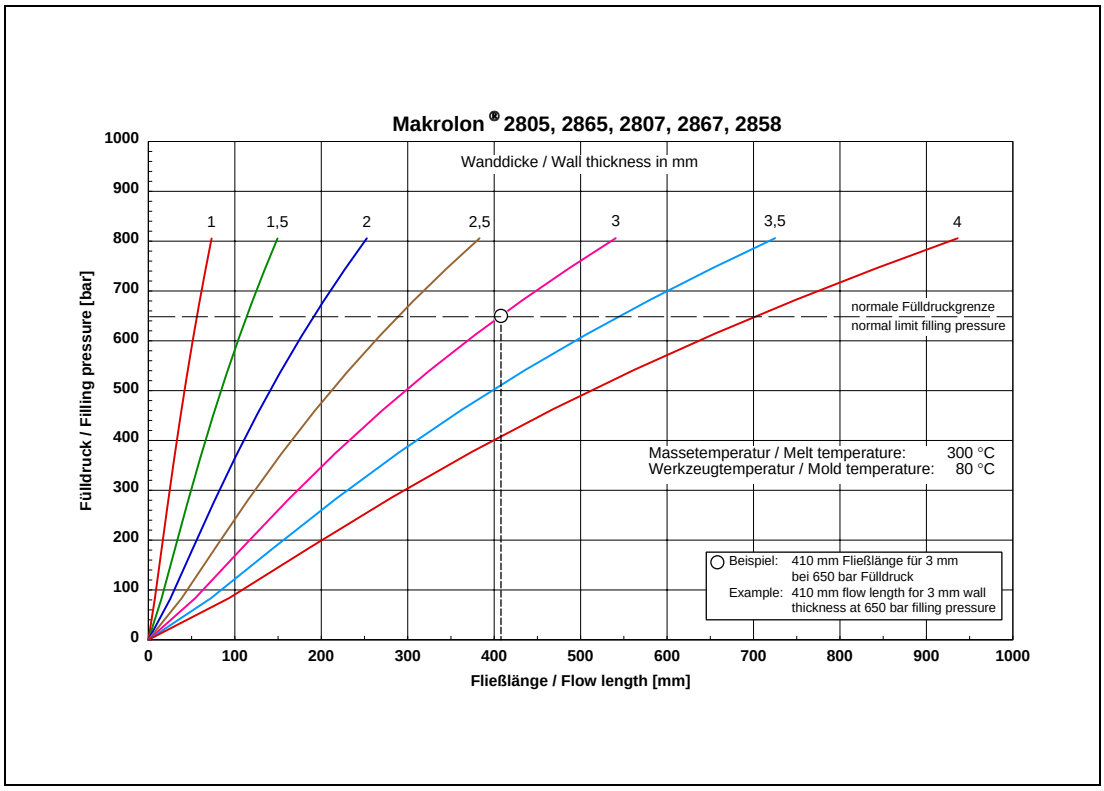

Fig. 2: Flow behavior - calculated values (Makrolon® 2805, 2865, 2807, 2867, 2858)

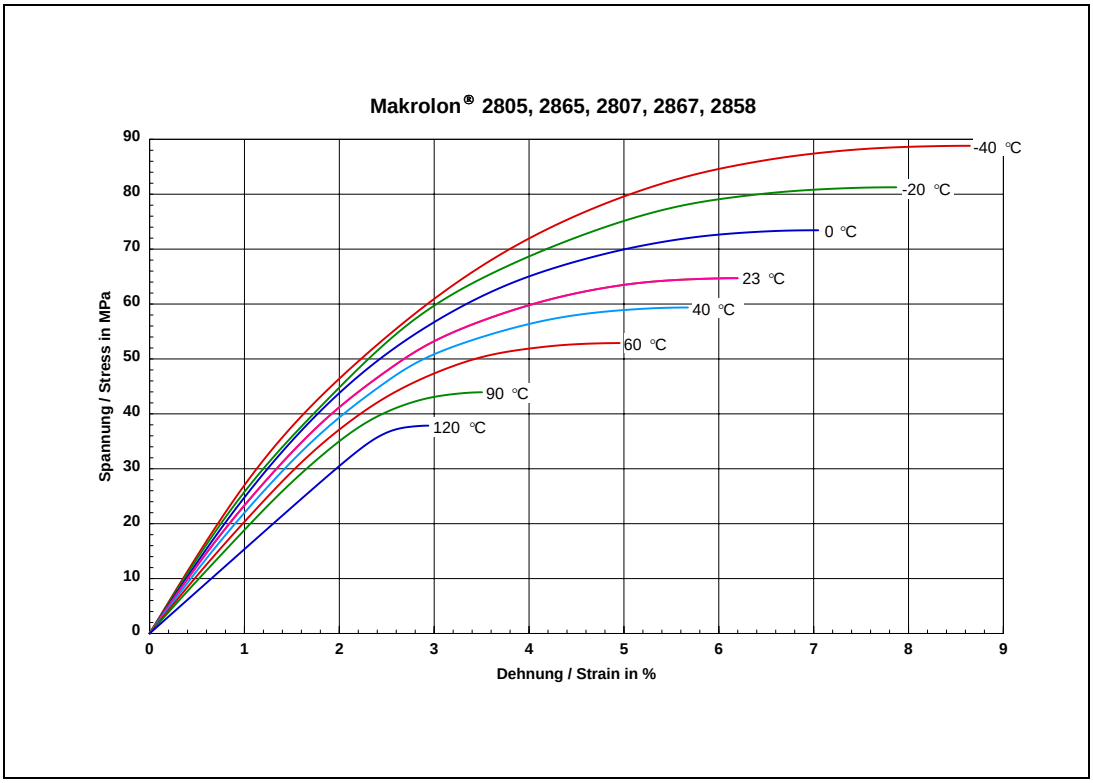

Fig. 3: Isothermal stress-strain curves from the short-time tensile test to ISO 527-1, -2 (Makrolon® 2805, 2865, 2807, 2867, 2858)

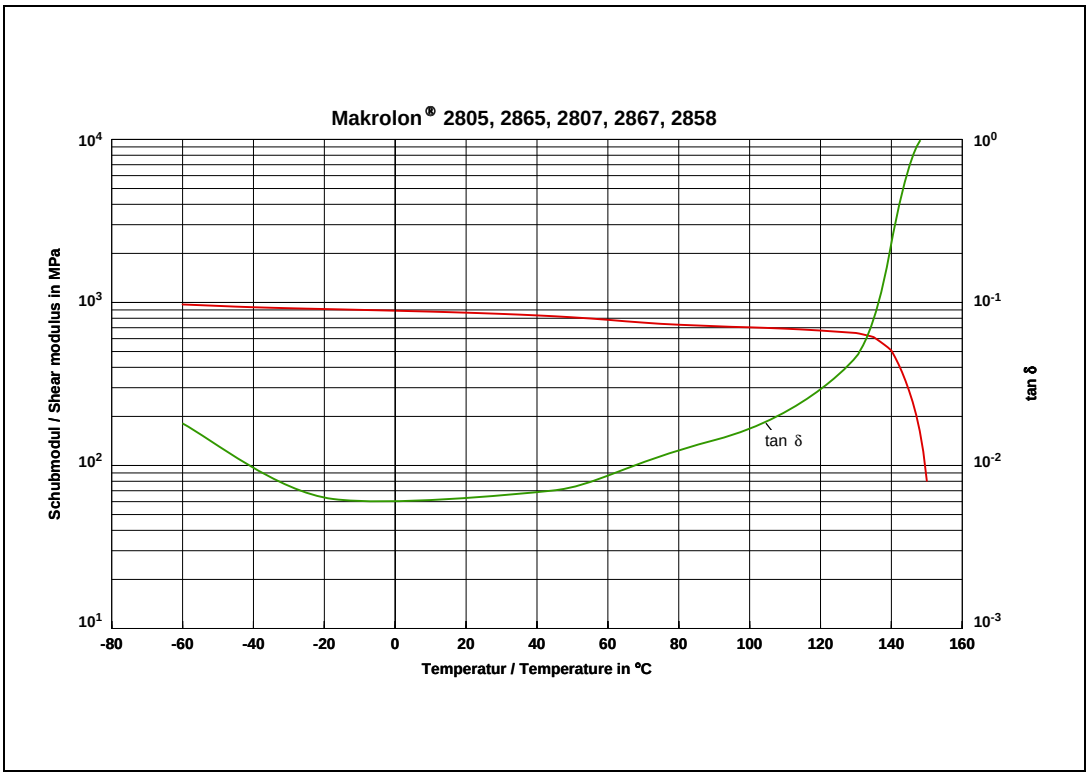

Fig. 4: Shear modulus as a function of temperature to ISO 6721-1, -2 (Makrolon® 2805, 2865, 2807, 2867, 2858)

Typical Values

	Properties	Test Conditions	Units	Standards	Makrolon® 2805	2865	2807	2867	2858
	Rheological properties								
C	Melt volume-flow rate	300 °C; 1.2 kg	cm³/(10 min)	ISO 1133	9.5	9.5	9.5	9.5	9.5
	Molding shrinkage, parallel/normal	Value range based on general practical experience	%	based ISO 2577	0.6 - 0.8	0.6 - 0.8	0.6 - 0.8	0.6 - 0.8	0.6 - 0.8
	Melt mass-flow rate	300 °C; 1.2 kg	g/(10 min)	ISO 1133	10	10	10	10	10
	Mechanical properties (23 °C/50 % r. h.)								
C	Tensile modulus	1 mm/min	MPa	ISO 527-1,-2	2400	2400	2400	2400	2400
C	Yield stress	50 mm/min	MPa	ISO 527-1,-2	66	66	67	67	66
C	Yield strain	50 mm/min	%	ISO 527-1,-2	6.1	6.1	6.1	6.1	6.1
C	Nominal strain at break	50 mm/min	%	ISO 527-1,-2	> 50	> 50	> 50	> 50	> 50
	Stress at break	50 mm/min	MPa	ISO 527-1,-2	65	65	65	65	65
	Strain at break	50 mm/min	%	based ISO 527-1,-2	115	115	115	115	115
C	Tensile creep modulus	1 h	MPa	ISO 899-1	2200	2200	2200	2200	2200
C	Tensile creep modulus	1000 h	MPa	ISO 899-1	1900	1900	1900	1900	1900
	Flexural modulus	2 mm/min	MPa	ISO 178	2350	2350	2350	2350	2350
	Flexural strength	2 mm/min	MPa	ISO 178	98	98	98	98	98
	Flexural strain at flexural strength	2 mm/min	%	ISO 178	7.0	7.0	7.0	7.0	7.0
	Flexural stress at 3.5 % strain	2 mm/min	MPa	ISO 178	74	74	74	74	74
C	Charpy impact strength	23 °C	kJ/m²	ISO 179-1eU	N	N	N	N	N
C	Charpy impact strength	-30 °C	kJ/m²	ISO 179-1eU	N	N	N	N	N
	Charpy notched impact strength	23 °C; 3 mm	kJ/m²	based ISO 179-1eA	70P	70P	70P(C)	70P(C)	70P
	Charpy notched impact strength	-30 °C; 3 mm	kJ/m²	based ISO 179-1eA	12C	12C	12C	12C	12C
	Izod notched impact strength	23 °C; 3.2 mm	kJ/m²	based ISO 180-A	85P	85P	85P(C)	85P(C)	85P
	Izod notched impact strength	-30 °C; 3.2 mm	kJ/m²	based ISO 180-A	12C	12C	12C	12C	12C
C	Puncture maximum force	23 °C	N	ISO 6603-2	5400	5400	5400	5400	5400
C	Puncture maximum force	-30 °C	N	ISO 6603-2	6300	6300	6300	6300	6300
C	Puncture energy	23 °C	J	ISO 6603-2	60	60	60	60	60
C	Puncture energy	-30 °C	J	ISO 6603-2	65	65	65	65	65
	Ball indentation hardness		N/mm²	ISO 2039-1	115	115	115	115	115
	Thermal properties								
C	Glass transition temperature	10 °C/min	°C	ISO 11357-1,-2	145	145	145	145	145
C	Temperature of deflection under load	1.80 MPa	°C	ISO 75-1,-2	125	125	124	124	125
C	Temperature of deflection under load	0.45 MPa	°C	ISO 75-1,-2	138	138	137	137	138
C	Vicat softening temperature	50 N; 50 °C/h	°C	ISO 306	145	145	144	144	145
	Vicat softening temperature	50 N; 120 °C/h	°C	ISO 306	146	146	145	145	146
C	Coefficient of linear thermal expansion, parallel	23 to 55 °C	10-4/K	ISO 11359-1,-2	0.65	0.65	0.65	0.65	0.65
C	Coefficient of linear thermal expansion, transverse	23 to 55 °C	10-4/K	ISO 11359-1,-2	0.65	0.65	0.65	0.65	0.65
	Burning behavior UL 94	0.75 mm	Class	UL 94	V-2		V-2		V-2
	UL recognition	0.75 mm			UL		UL		UL
C	Burning behavior UL 94 (1.6 mm)	1.5 mm	Class	UL 94	V-2	V-2	V-2	V-2	V-2
	UL recognition	1.5 mm			UL	UL	UL	UL	UL
C	Burning behavior UL 94	2.5 mm	Class	UL 94	HB		HB		HB
	UL recognition	2.5 mm			UL		UL		UL
C	Burning behavior UL 94	3.0 mm	Class	UL 94	HB	V-2	HB	V-2	HB
	UL recognition	3.0 mm			UL	UL	UL	UL	UL
	Burning behavior UL 94	6.0 mm	Class	UL 94	HB	V-0	HB	V-0	HB
	UL recognition	6.0 mm			UL	UL	UL	UL	UL
C	Oxygen index	Method A	%	ISO 4589-2	27	30	27	30	27
	Thermal conductivity	23 °C	W/(m·K)	ISO 8302	0.20	0.20	0.20	0.20	0.20
	Resistance to heat (ball pressure test)	-	°C	IEC 60335-1	135	135	135	135	135
	Temperature index (Tensile strength)	20000 h; 1.5 mm	°C	IEC 60216-1	130		130		130
	Halving interval (Tensile strength)	1.5 mm	°C	IEC 60216-1	8.7		8.7		8.7
	Temperature index (Tensile impact strength)	20000 h; 1.5 mm	°C	IEC 60216-1	120		120		120
	Halving interval (Tensile impact strength)	1.5 mm	°C	IEC 60216-1	7.4		7.4		7.4
	Temperature index (Electric strength)	20000 h; 1.5 mm	°C	IEC 60216-1	135		135		135
	Halving interval (Electric strength)	1.5 mm	°C	IEC 60216-1	7.4		7.4		7.4
	Relative temperature index (Tensile strength)	1.5 mm	°C	UL 746 B	125	125	125	125	125
	Relative temperature index (Tensile impact strength)	1.5 mm	°C	UL 746 B	115	115	115	115	115
	Relative temperature index (Electric strength)	1.5 mm	°C	UL 746 B	125	125	125	125	125

C These property characteristics are taken from the CAMPUS plastics data bank and are based on the international catalogue of basic data for plastics according to ISO 10350.

Impact properties: N = non-break, P = partial break, C = complete break

Typical Values (continuation)

	Properties	Test Conditions	Units	Standards	Makrolon® 2805	2865	2807	2867	2858
	Thermal properties								
	Glow wire test (GWFI)	1.0 mm	°C	IEC 60695-2-12	850	850	850	850	850
	Glow wire test (GWFI)	1.5 mm	°C	IEC 60695-2-12	850	850	850	850	850
	Glow wire test (GWFI)	2.0 mm	°C	IEC 60695-2-12	850	960	850	960	850
	Glow wire test (GWFI)	3.0 mm	°C	IEC 60695-2-12	900	960	900	960	900
	Glow wire test	1.5 mm	°C	based EDF HN60 E.02	750		750		750
	Glow wire test	3.0 mm	°C	based EDF HN60 E.02	750		750		750
	Application of flame from small burner	Method K; 2.0 mm	Class	DIN 53438-1,-3	K1	K1	K1	K1	K1
	Application of flame from small burner	Method F; 2.0 mm	Class	DIN 53438-1,-3	F1	F1	F1	F1	F1
	Needle flame test	Method K; 1.5 mm	s	IEC 60695-2-2	5	5	5	5	5
	Needle flame test	Method K; 2.0 mm	s	IEC 60695-2-2	5	5	5	5	5
	Needle flame test	Method K; 3.0 mm	s	IEC 60695-2-2	10	10	10	10	10
	Needle flame test	Method F; 1.5 mm	s	IEC 60695-2-2	60	60	60	60	60
	Needle flame test	Method F; 2.0 mm	s	IEC 60695-2-2	60	60	60	60	60
	Needle flame test	Method F; 3.0 mm	s	IEC 60695-2-2	120	120	120	120	120
	Incandescent bar test	-	Rating	IEC 60707-BH	BH2/< 30 mm	BH2/< 30 mm	BH2/< 30 mm	BH2/< 30 mm	BH2/< 30 mm
	Burning rate, US-FMVSS	>=1.0 mm	mm/min	ISO 3795	passed	passed	passed	passed	passed
	Flash ignition temperature	Procedure B	°C	ASTM D1929	470	470	470	470	470
	Self ignition temperature	Procedure B	°C	ASTM D1929	540	540	540	540	540
	Electrical properties (23 °C/50 % r. h.)								
C	Relative permittivity	100 Hz	-	IEC 60250	3.1	3.1	3.1	3.1	3.1
C	Relative permittivity	1 MHz	-	IEC 60250	3.0	3.0	3.0	3.0	3.0
C	Dissipation factor	100 Hz	10^{-4}	IEC 60250	5	5	5	5	5
C	Dissipation factor	1 MHz	10^{-4}	IEC 60250	90	90	85	85	90
C	Volume resistivity		Ohm·m	IEC 60093	1E14	1E14	1E14	1E14	1E14
C	Surface resistivity		Ohm	IEC 60093	1E16	1E16	1E16	1E16	1E16
C	Electric strength	1 mm	kV/mm	IEC 60243-1	33	33	33	33	33
C	Comparative tracking index CTI	Solution A	Rating	IEC 60112	275	275	275	275	275
	Comparative tracking index CTI M	Solution B	Rating	IEC 60112	125	125	125	125	125
	Electrolytic corrosion		Rating	IEC 60426	A1	A1	A1	A1	A1
	Other properties (23 °C)								
C	Water absorption, Saturation value	water at 23 °C	%	ISO 62	0.30	0.30	0.30	0.30	0.30
C	Water absorption, Equilibrium value	23 °C; 50 % RH	%	ISO 62	0.12	0.12	0.12	0.12	0.12
C	Density	-	kg/m³	ISO 1183	1200	1200	1200	1200	1200
	Water permeation	23 °C; 85 % RH; 100 µm film	g/(m²·24 h)	ISO 15106-1	15	15	15	15	15
	Gas permeation, Oxygen	100 µm film	cm³/(m²·24 h·bar)	based ISO 2556	700	700	700	700	700
	Gas permeation, Oxygen	25.4 µm (1 mil) film	cm³/(m²·24 h·bar)	based ISO 2556	2760	2760	2760	2760	2760
	Gas permeation, Nitrogen	100 µm film	cm³/(m²·24 h·bar)	based ISO 2556	130	130	130	130	130
	Gas permeation, Nitrogen	25.4 µm (1 mil) film	cm³/(m²·24 h·bar)	based ISO 2556	510	510	510	510	510
	Gas permeation, Carbon dioxide	100 µm film	cm³/(m²·24 h·bar)	based ISO 2556	4300	4300	4300	4300	4300
	Gas permeation, Carbon dioxide	25.4 µm (1 mil) film	cm³/(m²·24 h·bar)	based ISO 2556	16900	16900	16900	16900	16900
	Bulk density	Pellets	kg/m³	ISO 60	660	660	660	660	660
	Material specific properties								
C	Viscosity number	-	cm³/g	ISO 1628-4	59	59	59	59	59
	Refractive index	Procedure A	-	ISO 489	1.586	1.586	1.586	1.586	1.586
	Haze for transparent materials	3 mm	%	ISO 14782	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
	Luminous transmittance (clear transparent materials)	1 mm	%	ISO 13468-2	89	89	89	89	89
C	Luminous transmittance (clear transparent materials)	2 mm	%	ISO 13468-2	89	89	89	89	89
	Luminous transmittance (clear transparent materials)	3 mm	%	ISO 13468-2	88	88	88	88	88
	Luminous transmittance (clear transparent materials)	4 mm	%	ISO 13468-2	87	87	87	87	87
	Processing conditions for test specimens								
C	Injection molding-Melt temperature	-	°C	ISO 294	300	300	300	300	300
C	Injection molding-Mold temperature	-	°C	ISO 294	80	80	80	80	80
C	Injection molding-Injection velocity	-	mm/s	ISO 294	200	200	200	200	200

C These property characteristics are taken from the CAMPUS plastics data bank and are based on the international catalogue of basic data for plastics according to ISO 10350.

**Only Bayer plastics which fulfil the test requirements of ISO 10 993-1 may be used for medical articles which come within the scope of this standard.

Applications involving long-term contact for which Bayer plastics are not intended are exceptions.

However, the biocompatibility tests which we perform according to this standard do not cover the following ranges of application for medical articles manufactured from our material:

- Long-term use over 30 days, particularly use as (cosmetic or reconstructive) implant
- Long-term contact over 30 days with endogenous substances (blood, tissue, dentin, other body fluids)
- Multiple use for medical applications

Therefore Bayer plastics should not be used for long-term applications or with long-term contact.

Use of recycled material and incompatible additives
Our test results for biocompatibility do not apply to the use of recycled materials or the use of other additional material components in the finished product.

Responsibility of the manufacturer of the medical article
The use of our material outside the above-mentioned test scope of ISO 10 993-1 occurs exclusively on the responsibility of the processor of our material and the manufacturer of the finished product.

As regards the production conditions of the processor of our material which are not known to us, it is the responsibility of the processor to ascertain the suitability of our materials in the finished product in terms of directives and statutes to be observed.

The suitability of our materials also depends on the ambient conditions (see below) for the finished product.

Chemical compatibility, temperature, design of the medical article, method of sterilization, internal stress within the finished article, and external stress all influence suitability, and are therefore the responsibility of the processor and the manufacturer of the finished product.

Multiple-use of medical articles

Medical articles which are intended for single use and which were manufactured from Bayer plastic are not suitable for multiple use.

If the medical article was manufactured for multiple use, it is the responsibility of the manufacturer of the finished product to determine an appropriate number of times it may be used, by determining and evaluating the conditions of sterilization and final use.

Appropriate warnings and instructions must be given to the final user.

Sterilization

The use of various methods of sterilization and the permitted number of sterilization cycles for a medical article which is made from our materials depend on the design of the parts, the processing parameters, the sterilization temperature and the chemical environment. Therefore the manufacturer must determine and evaluate the most suitable method of sterilization (and if applicable the permitted number of sterilization cycles) for each medical article. Appropriate instructions and warnings must be given to the final user.

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