Makrolon® 3106, 3156 and 3206

- **Polycarbonate (PC)**
- **Food contact grades**
- **High viscosity**
- **Injection molding**

Short description

Makrolon® 3106:
Global grade; MVR (300 °C/1.2 kg) 6.0 cm³/10 min; food contact quality; high viscosity; good hydrolysis resistance; injection molding - melt temperature 280 - 320 °C; extrusion; available in transparent, translucent and opaque colors

Makrolon® 3156:
Global grade; MVR (300 °C/1.2 kg) 6.0 cm³/10 min; food contact quality; high viscosity; easy release; good hydrolysis resistance; injection molding - melt temperature 280 - 320 °C; extrusion; available in transparent, translucent and opaque colors

Makrolon® 3206:
MVR (300 °C/1.2 kg) 5.0 cm³/10 min; food contact quality; high viscosity; good hydrolysis resistance; injection molding - melt temperature 280 - 320 °C; extrusion; available in transparent, translucent and opaque colors

Characterization

Makrolon® 3106, 3156 and 3206 are transparent, high viscosity, linear polycarbonates based on bisphenol A, with good hydrolysis resistance.
Makrolon® 3156 is an easy-release grade.

The Makrolon® 31.. grades have more favorable flowability than the Makrolon® 32.. grades.

Makrolon® 3206 possesses the highest melt viscosity of the linear polycarbonates and has a higher level of mechanical properties than the other Makrolon® grades.

Abbreviation to DIN EN ISO 1043-1: PC

Designation to DIN EN ISO 7391-1:

Makrolon® 3106:
Thermoplastics ISO 7391-PC,M,(,,)-09-9

Makrolon® 3156:
Thermoplastics ISO 7391-PC,MR,(,,)-09-9

Makrolon® 3206:
Thermoplastics ISO 7391-PC,M,(,,)-05-9

These Makrolon® grades are "food contact" grades that comply with the regulations of the EU and its member states with regard to plastics in contact with foodstuffs and also comply with the relevant FDA regulations, while similarly fulfilling the recommendations of Germany's Bundesinstitut für Risikobewertung (BfR = Federal Institute for Risk Assessment)

Makrolon® 3106, 3156 and 3206 are only available in colors for which the colorants conform to the regional regulations concerning materials for food contact applications, such as the relevant recommendations of Germany's Bundesinstitut für Risikobewertung (BfR = Federal Institute for Risk Assessment) and/or the FDA regulations on colorants in food contact applications and certain application conditions.
In its current version, EC Directive 2002/72 for plastics does not regulate the use of colorants.
A confirmation that specific type/color combinations comply with the statutory requirements for plastics in food contact applications can be sent on request.

Parts in Makrolon® 3106, 3156 and 3206 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. These Makrolon® grades can be used for the production of consumer goods for food contact.

Delivery form

Granules, packed in 25-kg polyethylene sacks, big bags, octatainer with a polyethylene inliner or in bulk.

All Makrolon® batches are homogenized after production.

Makrolon® 3106, 3156 und 3206 are supplied in transparent, translucent and opaque colors with an outstanding color depth.

The production plants for Makrolon® have been certificated to DIN ISO by the appropriate quality organizations.
The certificates can be found in the INTERNET at
http://www.bayermaterialscience.com
(Customer Services/Certificates).

Registered customers can access Safety Data Sheet on the Internet (bayerone.bayer.com). It can also be sent on request.
The Safety Data Sheet includes data on labeling, transport and storage, as well as information on handling, product safety and toxicological and ecological profiles.

Applications

Makrolon® 3106, 3156 and 3256 can be used for the production of consumer goods for food contact.

e.g. babies ' bottles, food containers

Properties (see also table)

In terms of their flow behavior, processability and mechanical, thermal and electric properties, Makrolon® 3106 and 3156 are comparable to the corresponding general-purpose grades[1)] in the Makrolon® 31.. series of grades. The basic difference compared with the standard grades is their hydrolysis resistance.

If attaining the highest possible toughness represents the chief requirement on a PC molded part, then it is recommended that use be made of Makrolon® 3206 and that the design and mold be adapted to the short flow paths at the same time.

1) Details on this can be found in our Technical Information Sheet.

"Makrolon® 3105 and 3107"

Behaviour towards moisture and water (hydrolysis resistance)

Molded parts in Makrolon® 3106, 3156 and 3206 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 food contact 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. 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 hot, very moist air.

Food legislation provisions

Information on food contact legislation and the corresponding declarations relating to Makrolon® grades 3106, 3156 and 3206 can be accessed by registered customers on the Internet or sent to them by mail on request.

http://plastics.bayer.com/plastics/emea/en/index.html
(Library/Certificates)

Processing

Pre-treatment / drying[2)]

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 dryers 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 dryers. 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[2)]

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 to 0.8 %.

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

Material damage has to be expected with excessively high processing temperatures or excessively long residence times in the cylinder and hot runner. This can lead to a reduction in toughness and/or to surface defects in the form of streaks.

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.

Under the recommended processing conditions small quantities of decomposition product may be given off during processing. To preclude any risk to the health and well-being of the machine operatives, tolerance limits for the work environment must be ensured by the provision of efficient exhaust ventilation and fresh air at the workplace in accordance with the Safety Data Sheet.

In order to prevent the partial decomposition of the polymer and the generation of volatile decomposition products, the prescribed processing temperatures should not be substantially exceeded.

2) Details on this can be found in our Technical Information Sheet.

"Determining the dryness of Makrolon® by the TVI test"
"Processing data for the injection molder"
"The Injection Molding of High-Quality Molded Parts"

Recycling

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 granule geometry, which differs from that of extrusion granules, will influence the feed and plastication 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 are 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® 3106, 3156 and 3206 is as follows:

>PC<

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

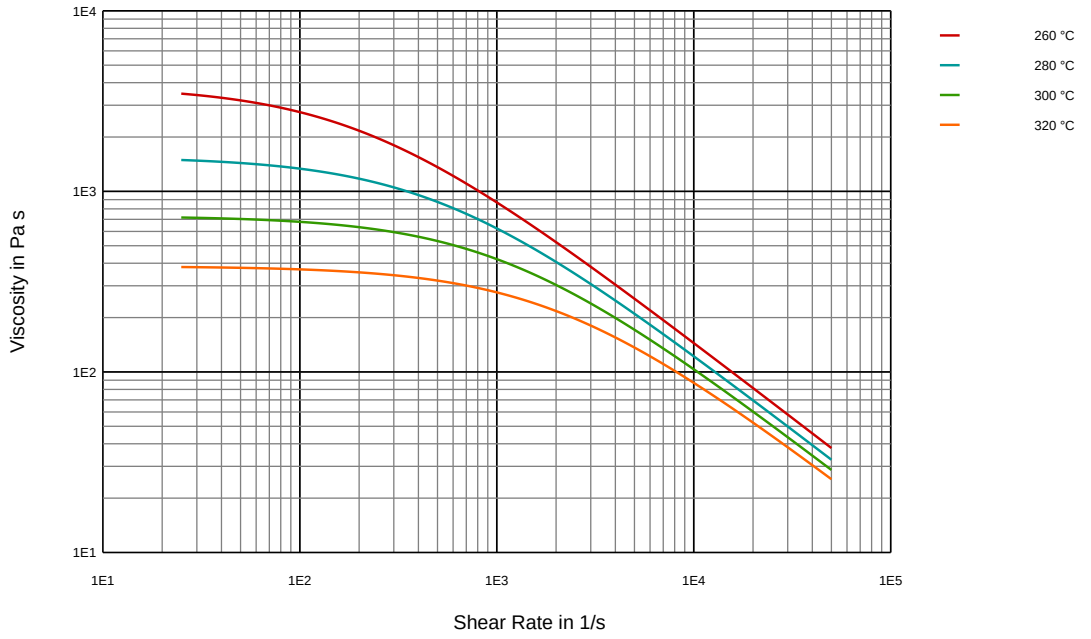

Fig. 1: Melt viscosity as a function of shear rate (Makrolon® 3106, 3156)

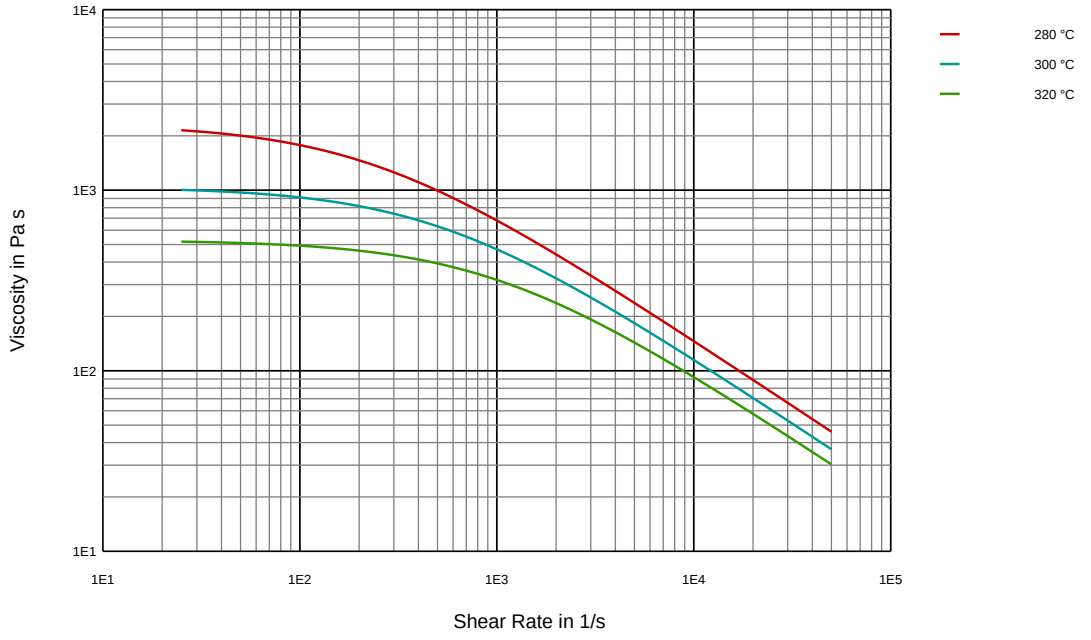

Fig. 2: Melt viscosity as a function of shear rate (Makrolon® 3206)

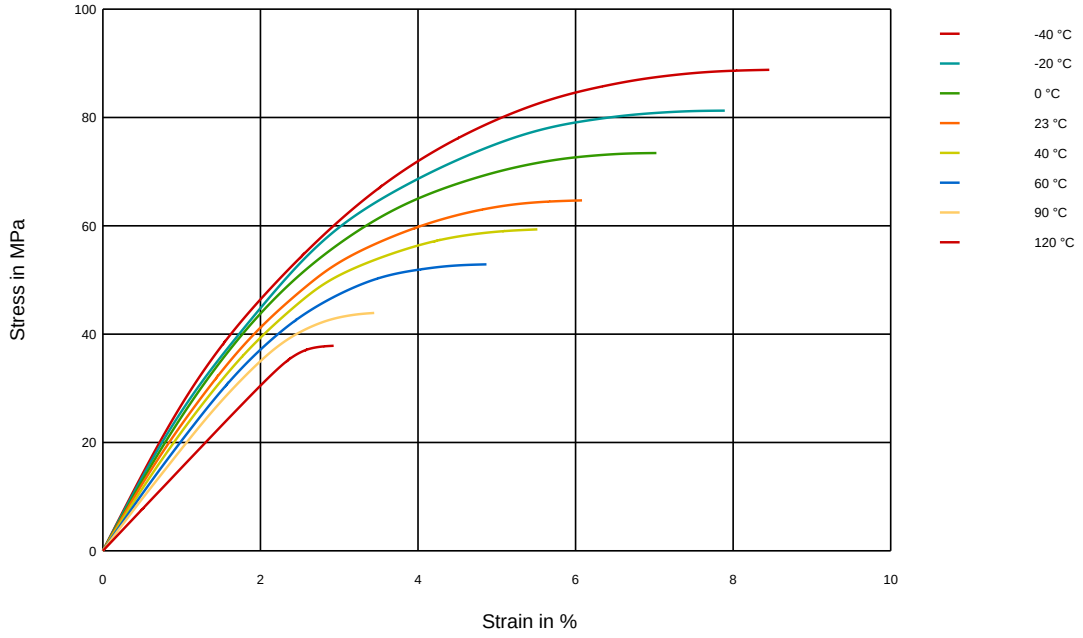

Fig. 3: Isothermal stress-strain curves from the short-time tensile test to ISO 527-1, -2 (Makrolon® 3106, 3156)

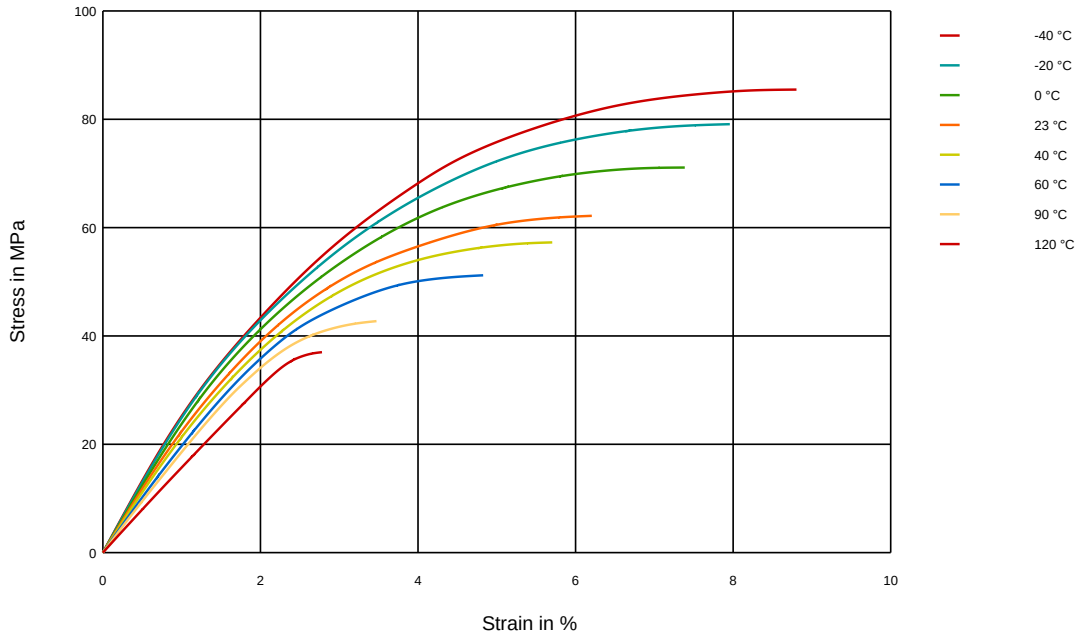

Fig. 4: Isothermal stress-strain curves from the short-time tensile test to ISO 527-1, -2 (Makrolon® 3206)

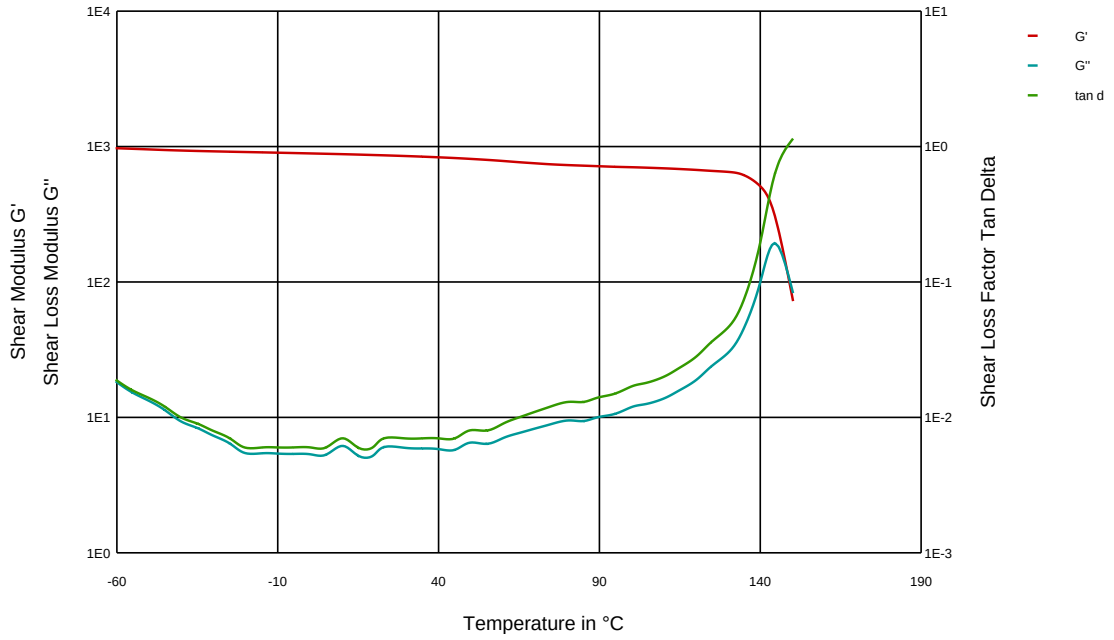

Fig. 5: Shear modulus as a function of temperature to ISO 6721-1, -2 (Makrolon® 3106, 3156, 3206)

Typical Values

	Property	Test Condition	Unit	Standard	Makrolon® 3106	Makrolon® 3156	Makrolon® 3206
Rheological properties							
C	Melt volume-flow rate	300 °C; 1.2 kg	cm³/10 min	ISO 1133	6.0	6.0	5.0
C	Molding shrinkage, parallel	60x60x2; 500 bar	%	ISO 294-4	0.7	0.7	0.7
C	Molding shrinkage, normal	60x60x2; 500 bar	%	ISO 294-4	0.75	0.75	0.75
	Molding shrinkage, parallel/normal	Value range based on general practical experience	%	b.o. ISO 2577	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	6.5	6.5	5.5
Mechanical properties (23 °C/50 % r. h.)							
C	Tensile modulus	1 mm/min	MPa	ISO 527-1,-2	2350	2400	2350
C	Yield stress	50 mm/min	MPa	ISO 527-1,-2	65	66	65
C	Yield strain	50 mm/min	%	ISO 527-1,-2	6.3	6.2	6.3
C	Nominal strain at break	50 mm/min	%	ISO 527-1,-2	> 50	> 50	> 50
	Stress at break	50 mm/min	MPa	ISO 527-1,-2	75	70	75
	Strain at break	50 mm/min	%	b.o. ISO 527-1,-2	125	120	125
C	Tensile creep modulus	1 h	MPa	ISO 899-1	2200	2200	2200
C	Tensile creep modulus	1000 h	MPa	ISO 899-1	1900	1900	1900
	Flexural modulus	2 mm/min	MPa	ISO 178	2350	2400	2350
	Flexural strength	2 mm/min	MPa	ISO 178	96	97	95
	Flexural strain at flexural strength	2 mm/min	%	ISO 178	7.2	7.1	7.2
	Flexural stress at 3.5 % strain	2 mm/min	MPa	ISO 178	72	73	72
C	Charpy impact strength	23 °C	kJ/m²	ISO 179-1eU	N	N	N
C	Charpy impact strength	-30 °C	kJ/m²	ISO 179-1eU	N	N	N
	Charpy impact strength	-60 °C	kJ/m²	ISO 179-1eU	N	N	N
	Charpy notched impact strength	23 °C; 3 mm	kJ/m²	ISO 7391/b.o. ISO 179-1eA	80P	80P	80P
	Charpy notched impact strength	-30 °C; 3 mm	kJ/m²	ISO 7391/b.o. ISO 179-1eA	18C(P)	16C	18C(P)
	Izod notched impact strength	23 °C; 3.2 mm	kJ/m²	b.o. ISO 180-A	90P	90P	90P
	Izod notched impact strength	-30 °C; 3.2 mm	kJ/m²	b.o. ISO 180-A	16C(P)	14C	16C(P)
C	Puncture maximum force	23 °C	N	ISO 6603-2	5600	5600	5800
C	Puncture maximum force	-30 °C	N	ISO 6603-2	6500	6500	6700
C	Puncture energy	23 °C	J	ISO 6603-2	60	60	65
C	Puncture energy	-30 °C	J	ISO 6603-2	70	70	75
	Ball indentation hardness		N/mm²	ISO 2039-1	111	113	111

Typical Values

	Property	Test Condition	Unit	Standard	Makrolon® 3106	Makrolon® 3156	Makrolon® 3206
Thermal properties							
C	Glass transition temperature	10 °C/min	°C	ISO 11357-1,-2	149	146	150
C	Temperature of deflection under load	1.80 MPa	°C	ISO 75-1,-2	129	126	130
C	Temperature of deflection under load	0.45 MPa	°C	ISO 75-1,-2	141	138	142
C	Vicat softening temperature	50 N; 50 °C/h	°C	ISO 306	149	147	150
	Vicat softening temperature	50 N; 120 °C/h	°C	ISO 306	150	148	151
C	Coefficient of linear thermal expansion, parallel	23 to 55 °C	10^{-4}/K	ISO 11359-1,-2	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
C	Burning behavior UL 94 (1.5 mm)	1.5 mm	Class	UL 94	HB	HB	HB
C	Burning behavior UL 94	3.0 mm	Class	UL 94	HB	HB	HB
	Burning behavior UL 94	0.75 mm	Class	UL 94	V-2	V-2	
	Burning behavior UL 94	1.4 mm	Class	UL 94	V-2	V-2	
	Burning behavior UL 94	6.0 mm	Class	UL 94	HB	HB	HB
C	Oxygen index	Method A	%	ISO 4589-2	27	27	27
	Thermal conductivity	23 °C	W/(m·K)	ISO 8302	0.20	0.20	0.20
	Resistance to heat (ball pressure test)		°C	IEC 60695-10-2	140	138	141
	Relative temperature index (Tensile strength)	1.5 mm	°C	UL 746B			125
	Relative temperature index (Tensile impact strength)	1.5 mm	°C	UL 746B			115
	Relative temperature index (Electric strength)	1.5 mm	°C	UL 746B			125
	Glow wire test (GWFI)	1.0 mm	°C	IEC 60695-2-12	850	850	850
	Glow wire test (GWFI)	1.5 mm	°C	IEC 60695-2-12	850	850	850
	Glow wire test (GWFI)	2.0 mm	°C	IEC 60695-2-12	850	850	850
	Glow wire test (GWFI)	3.0 mm	°C	IEC 60695-2-12	930	930	930
	Glow wire test (GWFI)	4.0 mm	°C	IEC 60695-2-12	960	960	960
	Glow wire test (GWIT)	1.0 mm	°C	IEC 60695-2-13	875	875	875
	Glow wire test (GWIT)	1.5 mm	°C	IEC 60695-2-13	875	875	875
	Glow wire test (GWIT)	2.0 mm	°C	IEC 60695-2-13	875	875	875
	Glow wire test (GWIT)	3.0 mm	°C	IEC 60695-2-13	900	900	900
	Glow wire test (GWIT)	4.0 mm	°C	IEC 60695-2-13	900	900	900
	Glow wire test	1.5 mm	°C	b.o. EDF HN60 E.02	850	850	850
	Glow wire test	3.0 mm	°C	b.o. EDF HN60 E.02	850	850	850
	Application of flame from small burner	Method K and F; 2.0 mm	Class	DIN 53438-1,-3	K1, F1	K1, F1	K1, F1
	Needle flame test	Method K; 2.0 mm	s	IEC 60695-11-5	5	5	5
	Needle flame test	Method K; 3.0 mm	s	IEC 60695-11-5	10	10	10
	Needle flame test	Method F; 1.5 mm	s	IEC 60695-11-5	60	60	60
	Needle flame test	Method F; 2.0 mm	s	IEC 60695-11-5	120	120	120
	Needle flame test	Method F; 3.0 mm	s	IEC 60695-11-5	120	120	120
	Burning rate (US-FMVSS)	>=1.0 mm	mm/min	ISO 3795	passed	passed	passed
	Flash ignition temperature		°C	ASTM D1929	480	480	480
	Self ignition temperature		°C	ASTM D1929	550	550	550
Electrical properties (23 °C/50 % r. h.)							
C	Relative permittivity	100 Hz	-	IEC 60250	3.1	3.1	3.1
C	Relative permittivity	1 MHz	-	IEC 60250	3.0	3.0	3.0
C	Dissipation factor	100 Hz	10^{-4}	IEC 60250	5	5	5
C	Dissipation factor	1 MHz	10^{-4}	IEC 60250	95	95	95
C	Volume resistivity		Ohm·m	IEC 60093	1E14	1E14	1E14
C	Surface resistivity		Ohm	IEC 60093	1E16	1E16	1E16
C	Electrical strength	1 mm	kV/mm	IEC 60243-1	34	34	34
C	Comparative tracking index CTI	Solution A	Rating	IEC 60112	250	250	250
	Comparative tracking index CTI M	Solution B	Rating	IEC 60112	125M	125M	125M
	Electrolytic corrosion		Rating	IEC 60426	A1	A1	A1

Typical Values

	Property	Test Condition	Unit	Standard	Makrolon® 3106	Makrolon® 3156	Makrolon® 3206
Other properties (23 °C)							
C	Water absorption (saturation value)	Water at 23 °C	%	ISO 62	0.30	0.30	0.30
C	Water absorption (equilibrium value)	23 °C; 50 % r. h.	%	ISO 62	0.12	0.12	0.12
C	Density		kg/m³	ISO 1183-1	1200	1200	1200
	Water vapor permeability	23 °C; 85 % RH; 100 µm film	g/(m²·24 h)	ISO 15106-1	15	15	15
	Gas permeation	Oxygen; 100 µm film	cm³/(m²·24 h*bar)	b.o. ISO 2556	700	700	700
	Gas permeation	Oxygen; 25.4 µm (1 mil) film	cm³/(m²·24 h*bar)	b.o. ISO 2556	2760	2760	2760
	Gas permeation	Nitrogen; 100 µm film	cm³/(m²·24 h*bar)	b.o. ISO 2556	130	130	130
	Gas permeation	Nitrogen; 25.4 µm (1 mil) film	cm³/(m²·24 h*bar)	b.o. ISO 2556	510	510	510
	Gas permeation	Carbon dioxide; 100 µm film	cm³/(m²·24 h*bar)	b.o. ISO 2556	4300	4300	4300
	Gas permeation	Carbon dioxide; 25.4 µm (1 mil) film	cm³/(m²·24 h*bar)	b.o. ISO 2556	16900	16900	16900
	Bulk density	Pellets	kg/m³	ISO 60	660	660	660
Material specific properties							
	Refractive index	Procedure A	-	ISO 489	1.587	1.587	1.587
	Haze for transparent materials	3 mm	%	ISO 14782	< 0.8	< 0.8	< 0.8
	Luminous transmittance (clear transparent materials)	1 mm	%	ISO 13468-2	89	89	89
C	Luminous transmittance (clear transparent materials)	2 mm	%	ISO 13468-2	89	89	89
	Luminous transmittance (clear transparent materials)	3 mm	%	ISO 13468-2	88	88	88
	Luminous transmittance (clear transparent materials)	4 mm	%	ISO 13468-2	87	87	87
Processing conditions for test specimens							
C	Injection molding-Melt temperature		°C	ISO 294	300	300	310
C	Injection molding-Mold temperature		°C	ISO 294	80	80	90
C	Injection molding-Injection velocity		mm/s	ISO 294	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.

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

colored fields = UL recognition

Under the recommended processing conditions small quantities of decomposition product may be given off during processing.To preclude any risk to the health and well-being of the machine operatives, tolerance limits for the work environment must be ensured by the provision of efficient exhaust ventilation and fresh air at the workplace in accordance with the Safety Data Sheet. In order to prevent the partial decomposition of the polymer and the generation of volatile decomposition products, the prescribed processing temperatures should not be substantially exceeded.

Unless specified to the contrary, the values given have been established on standardized test specimens at room temperature. The figures should be regarded as guide values only and not as binding minimum values. Please note that, under certain conditions, the properties can be affected to a considerable extent by the design of the mold/die, the processing conditions and coloring.

Editor: Global Innovations - Polycarbonates
Bayer MaterialScience AG
D-51368 Leverkusen, Germany
www.bayermaterialscience.de
pcs-info@bayermaterialscience.com