



PLEXIGLAS[®] and PLEXALLOY[®] Molding Compounds

NTAA – Design and Processing Recommendations

PLEXIGLAS® and PLEXALLOY® for injection molding of automotive exterior trim parts

Content

- 2 Mold Configuration and Design
- 4 Injection Molding Machine
- 6 Pretreatment and Processing
- 10 Products
- 11 Polishing Moldings

PLEXIGLAS® and PLEXALLOY® molding compounds are highly suitable for manufacturing add-on automotive parts due to their specific characteristics. Their excellent weather resistance, strength, outstanding gloss and ease of processing make them the best choice for these applications. Class-A surfaces can be produced in high-gloss polished molds without additional coating. Compared with coated systems, solutions using PLEXIGLAS® and PLEXALLOY® molding compounds can offer an enormous reduction in component costs – for example, by up to 40 percent for B-pillar covers compared to coated systems.

For many years, our PMMA molding compounds have stood the test in a multitude of series applications in numerous vehicles for all renowned OEMs. Until now, the main applications have been: A-, B-, and C-pillar covers, rear panels and panels in the roof area. Development is turning increasingly toward applications in the vehicle interior as well as large-surface parts – in the passenger vehicle roof area or as decorative panels for commercial vehicles.

In this brochure, you will find basic technical information on mold design, injection molding machines, pretreatment and processing of molding compounds, among other topics.

Mold Configuration and Design

Steel grades

The current steel grades used in tool making can be used to manufacture injection molds. Good polishing behavior is essential. For this reason, very pure, vacuum-melted steels containing chromium are normally used.

Here are a few examples:

Material-no.	Designation
1.2379	X155CrVMo121 Good strength, highest wear resistance
1.2343	X38CrMoV5-1 Good polishability
1.2344	X40CrMoV5-1 Good polishability
1.2738	40CrMnNiMo8-6-4 Good polishability
1.2767	X45NiCrMo4 For highly stressed plastic molds
1.2316	X38CrMo16 Stainless, good polishability

Surface quality

A completely smooth surface of the mold cavity is a prerequisite for producing parts with high surface quality (Class-A surface). Surface: mirror finish, free from minor scratches and grooves, RZ and RA = < 0,001

Minimum wall thickness

Wall thicknesses below 1 mm are not recommended. Extremely thin-walled parts always have a high degree of molecular orientation due to excessively fast injection and cooling. This can lead to deformation, even below the indicated heat deflection temperature.

Draft angle

Undercuts should be avoided when processing thermoplastics with a high modulus of elasticity. The demolding conicity should be 15-20 percent. Drafts of 1-2° are generally recommended for PLEXIGLAS® molding compounds.



Mold venting

Sufficient venting in the parting line should be provided to enable quick displacement of the air from the cavity during filling. Trapped air can prevent complete cavity filling and can lead to burning of the melt (diesel effect) due to strong compression combined with a temperature increase.

Recommended dimensions for venting channels:

- Width: 15-20 mm
- Diameter: 0.03 mm to max. 0.05 mm

The surface of the venting channels should be polished. To prevent the formation of deposits in the mold, we recommend regular cleaning of the venting channels.

Feed systems

Cold runner systems: The runners are incorporated in the mold plates and are therefore practically components of the molded part. The molding compound in the runner solidifies after the injection process and is removed with the molded part.

Hot runner technology: An essential advantage of this technology is the low-waste production. To prevent thermal damage to the melt, special attention needs to be paid to design and dimensioning.

Additional advantages are:

- low pressure loss, which enables the realization of longer flow paths
- trouble-free production of multiple-cavity molds
- gate systems without subsequent sprue removal are standard
- high automation of the production process
- high degree of freedom for the gate location

Material shrinkage

Dimensional differences between the molded part and the mold cavity due to shrinkage must be considered during design.

The total shrinkage consists of

- the demolding shrinkage, which can be measured directly after ejection of the part,
- the processing shrinkage, measured after storage for 16 hours in a standard conditioning atmosphere,
- and the post-shrinkage.

Shrinkage of 0.3 to 0.7 percent along the flow direction can be assumed as standard for PLEXIGLAS® and PLEXALLOY® molding compounds. The values are lower for dimensions perpendicular to the flow direction. The longitudinal shrinkage depends on the specific holding pressure level over the flow length.

It is difficult to predict the processing shrinkage with any degree of accuracy since it is determined by a number of factors, such as material, processing conditions, component design and mold technology.



Injection Molding Machine

Clamping unit

The clamping unit is exposed to the greatest stress during the manufacture of large-surface moldings. The required closing forces can be taken to be 250 to 500 bar per cm^2 of projected area as a rough estimate.

For simple parts with good flow cross-sections, the value is closer to 250 bar, and for thin-walled parts with long flow paths, closer to 500 bar. For thin-walled molded parts, which require the reproduction of detailed optical structures, an even higher pressure may be necessary.

Nozzle and nozzle point

PLEXIGLAS® and PLEXALLOY® molding compounds are usually processed with open nozzles. Since the melt viscosity can be adjusted by a suitable nozzle temperature at the nozzle aperture, processing with open nozzles does not present any problems.

The diameter of the aperture should, however, be ample. It is also important that the nozzle aperture is slightly conical so that the cold slug is pulled out with the sprue.

Cylinders and screws

PLEXIGLAS® and PLEXALLOY® molding compounds can be processed on all commercially available injection molding machines. Standard screws and cylinders suitable for other thermoplastics (e.g. PC, ABS, etc.) can also be used.

	Material-no.	Designation
Common steel types for cylinders		
	1.8519	31CrMoV9
	1.8550	34CrAlNi7
Common steel types for screws		
	1.4122	X35CrMo17
	1.4057	X22CrNi17

Suggested screw geometry for processing PMMA

Our proposed zone divisions accord with standard screw recommendations. For processing PMMA, a reduction of the compression zone to $3 \times D$ can additionally decrease the danger of air intake. In general we recommend consulting the machine manufacturer regarding screws that are specially developed for PMMA.

Screw geometry without venting	Screw length = 20D
Feed zone	$L = 12 \times D$ (60%)
Flight depth in the feed zone	$h = 0.15 \times D$
Compression zone	$L = 4 \times D$ (20%) (better 3D) (core progressive)
Metering zone	$L = 4 \times D$ (20%)
Flight depth in the metering zone	$h = 0.07 \times D$
Compression	2.1
Pitch	1D



PLEXIGLAS® and PLEXALLOY®:
High depth of color and classy look-and-feel

Conveying

Owing to their high surface hardness, PLEXIGLAS® and PLEXALLOY® molding compounds can cause abrasion in feed pipes. For this reason, feed pipes should be made of stainless steel. Polyurethane is suitable for short, flexible connections. Pipes made of PVC are not recommended due to their low wear resistance.



Pretreatment and Processing

Predrying

PMMA is hygroscopic, i.e. it absorbs ambient moisture. If the moisture content is too high when processing the molding compounds, it can lead to streaks on the molded parts. For optimal processing, we generally recommend predrying of our molding compounds in a desiccant-type dryer. As a general rule: dry at the hottest temperature possible so that the highest moisture removal is achieved in the shortest time.

Owing to the different softening temperatures, the drying temperatures are also different for the individual molding compound grades.

Standard values for the optimum drying temperature: 15K below the Vicat softening temperature of the respective compound.

This formula provides the following results for our standard grades:

Molding compound grade	Maximum drying temperature
PLEXIGLAS® 8N	90°C
PLEXIGLAS® FT15	100°C
PLEXALLOY® NTA-1	95°C
PLEXALLOY® NTA-3	100°C

If the drying temperature falls substantially below the temperatures indicated, the drying times are lengthened, and in unfavorable cases (environmental conditions, relative humidity) a high residual level of moisture remains even after drying for several hours. The duration of drying depends on the degree of moisture and lies between 2 and 6 hours. The more difficult the production of the molded parts (long flow paths, high melt temperatures), the more care should be taken with predrying.

The permissible water content for flawless processing lies at < 0.05 percent depending on the processing conditions and the complexity of the molded part.



Metering

Likewise, maintaining the standard values for the metering stroke is important for avoiding air intake during plasticizing. Here, the maximum metering stroke $3 \times D$ should not be exceeded. Metering strokes of $< 1 \times D$ should likewise be avoided. Metering strokes that are too short can also cause undesired air intake.

Screw speed

Dependent on the screw diameter: the larger the diameter, the lower the rotational speed (circumferential speed $< 0.3 \text{ m/s}$).

Recommendations:

Screw diameter	Max. screw speed
30 mm	120 rpm
45 mm	90 rpm
60 mm	70 rpm
90 mm	50 rpm
120 mm	30 rpm

At increasing rotational speeds, the shear increases in the melt and the compound temperature rises.

Note: At temperatures that are too high, there is a danger of thermal damage (visible in the form of streaks on the molding surface).

Back pressure

Up to 20 bar. This corresponds to a pressure in the molding compound of approximately 100 to 200 bar. At increasing back pressures, the compound temperature and mixing effect increase and the plasticizing capacity drops.

Injection speed

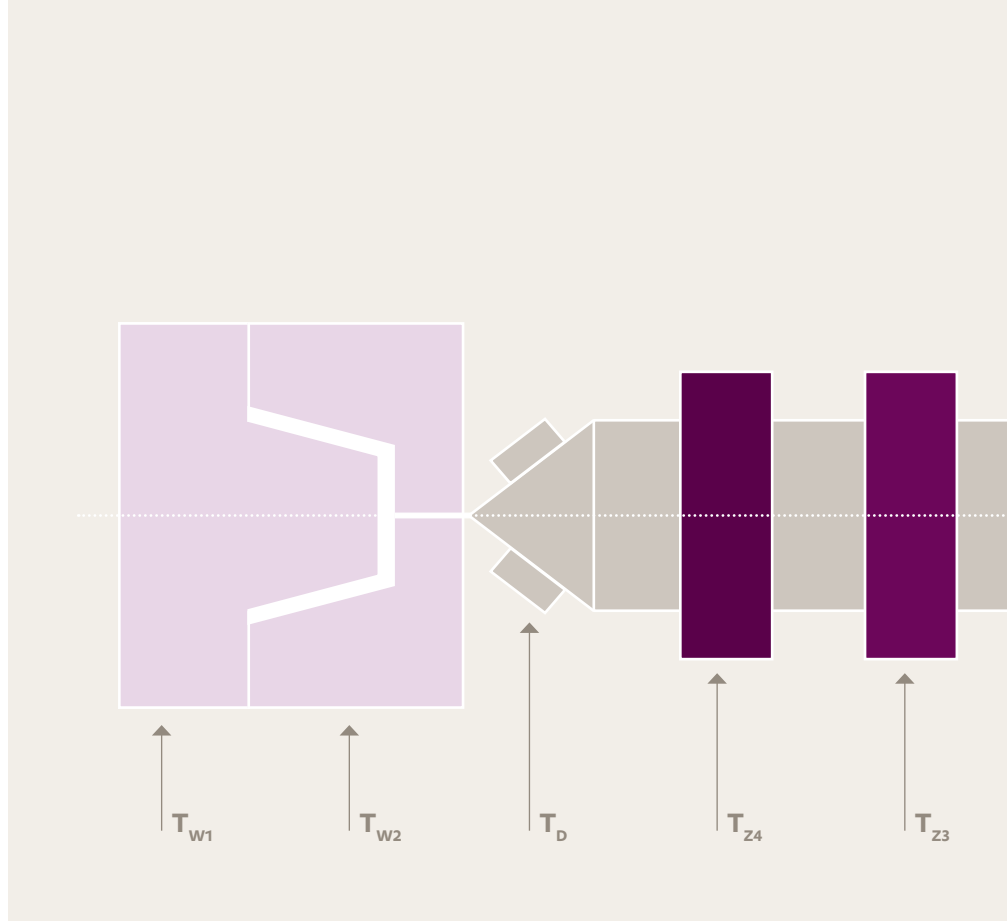
Thick-walled molded parts: slow (otherwise creases and sink marks).
Thin-walled molded parts: fast (otherwise irregular surface and so-called orange peel effect).

Injection pressure (specific)

Keep injection pressure low at the beginning of production and increase until the mold cavity is completely filled. This will allow you to avoid unnecessarily high injection pressure!

Holding pressure

The constant pressure head (approx. 60 percent of the injection pressure) and the duration should be selected in such a way that the mold is well filled and no sink marks are visible.



Pretreatment and Processing

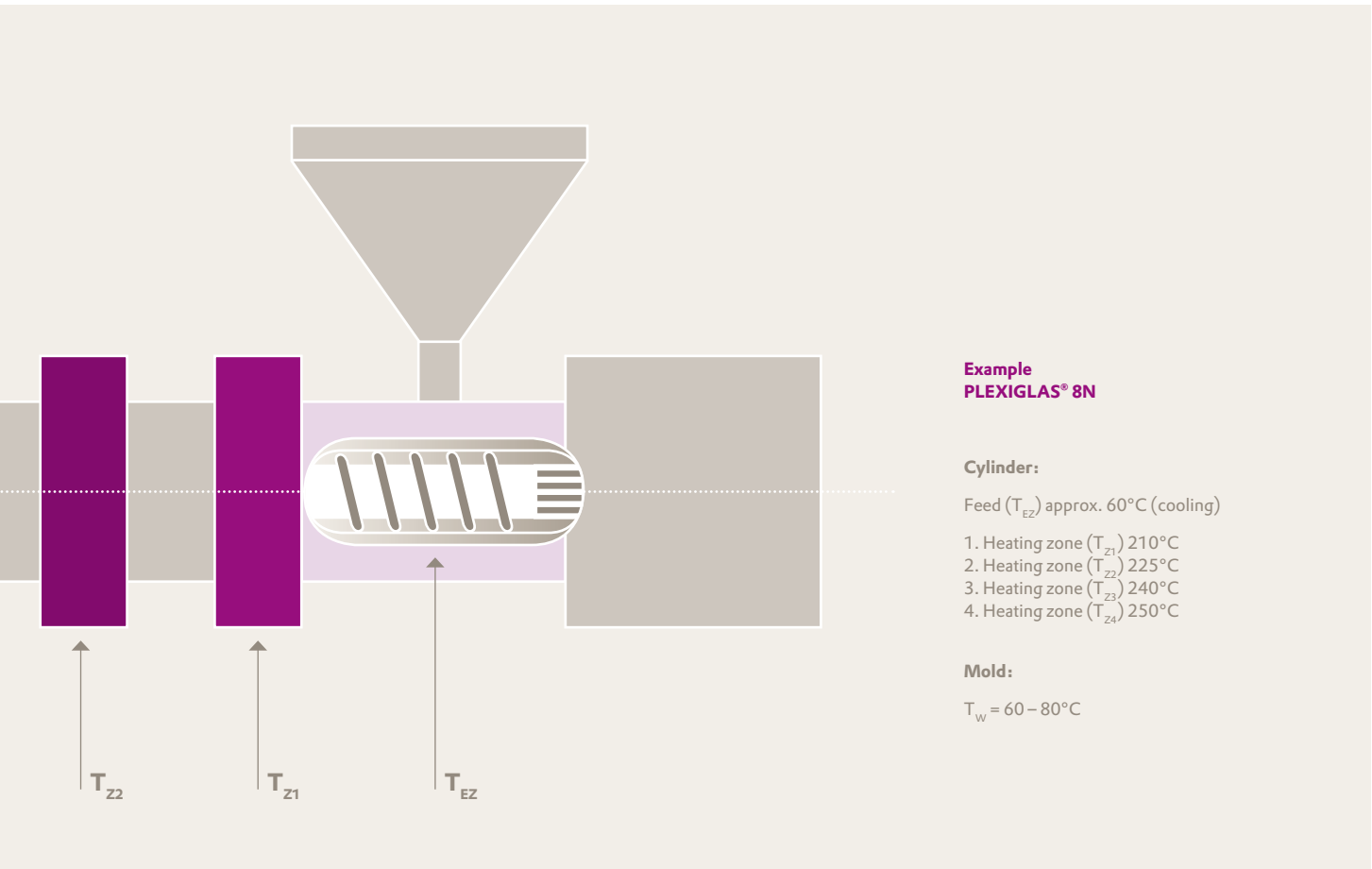
Temperature control of the mold and cylinder

The influence of the mold temperature on the processing and the characteristics of the finished part is often underestimated. Injecting PLEXIGLAS® or PLEXALLOY® melt into a cold mold makes filling more difficult and often leads to high cooling stress, warpage, strong orientation, sub-optimal surfaces, and sink marks in the molded part. Therefore it is necessary to guarantee a constant mold temperature by using a connected temperature control unit.

Water thermostats are almost always sufficient, because a mold temperature higher than 90°C is seldom required. We advise against cooling purely with water during throughput (without thermostat) as a means of removing heat.

The heating-cooling channels in the mold should be distributed in such a way that all zones of the molded part are cooled more or less simultaneously; that means that more heat can be dissipated in thick areas than in thin ones.

The closer the channels are to the mold surface, the more effective the temperature control. For molded parts with large wall differences or for molded parts with unequal surfaces (one surface smooth, another surface textured), warpage can be compensated by separate temperature control of the two mold halves.



Cylinder temperatures

To guarantee stable feed, the first zone should be adjusted to a somewhat lower temperature. Cylinder temperatures according to molding compound grade approx. 210 to 260°C.

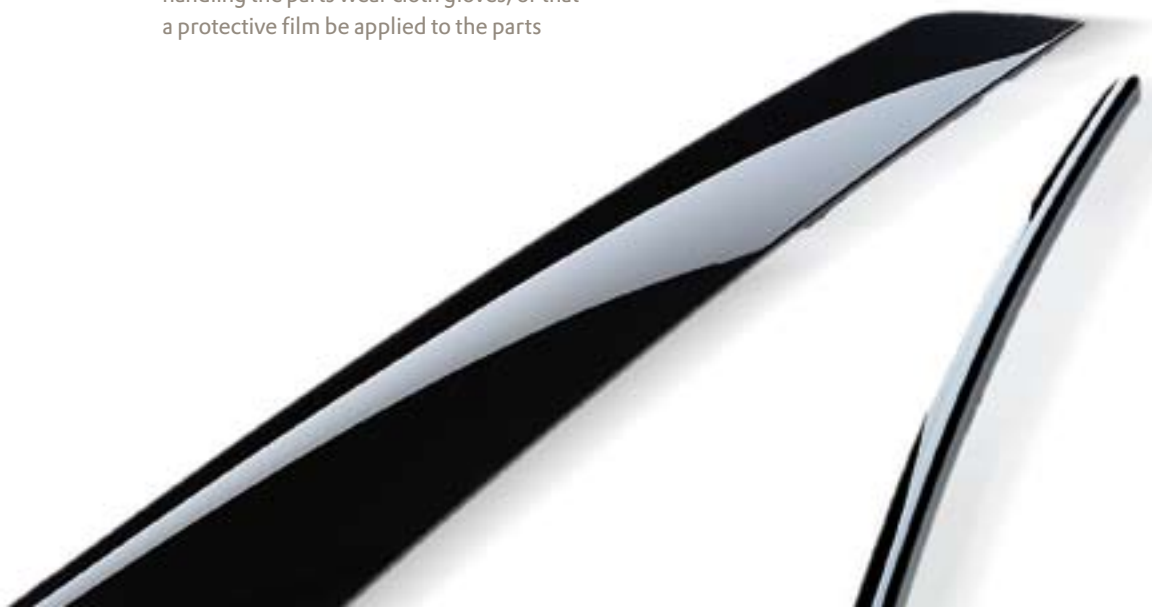
Treatment after injection molding

Released molded parts are statically loaded and there is a risk that they may attract ambient dirt and dust. Therefore the greatest possible cleanliness should be maintained when producing moldings with Class-A surfaces.

After injection molding, the surface of the molded part is especially vulnerable to scratches. We recommend that anyone handling the parts wear cloth gloves, or that a protective film be applied to the parts

immediately after removing them from the mold. The scratch resistance of the parts increases with longer storage times due to the absorption of moisture.

Any possible testing of the scratch resistance should therefore only be performed at the earliest 48 hours after the protective film is removed or the production of the molded part is completed.



Typical values

	Einheit	Norm	PLEXIGLAS®		PLEXALLOY®	
			8N	FT15	NTA 1	NTA 3
Mechanical values						
Tensile modulus (1 mm/min)	MPa	ISO 527	3300	3500	2700	2900
Yield stress (50 mm/min)	MPa	ISO 527	77 (1)	50 (1)	68	60
Elongation at yield (50 mm/min)	%	ISO 527			5	0
Nominal elongation at break	%	ISO 527	5.5 (2)	3.1 (2)	10	2.6
Charpy impact strength (23°C)	kJ/m ²	ISO 179	20	18	50	16
Thermal values						
Vicat softening temperature (B/50)	°C	ISO 306	108	115	110	116
Glass transition temperature	°C	IEC 10006	117	121	120	126
Heat deflection temperature under load (1.8 MPa)	°C	ISO 75	98	105	103	106
Fire behavior		DIN 4102	B2	B2	B2	B2
Flammability UL 94 at nom. 1.6 mm	Class	IEC 707	HB	HB	HB	HB
Rheological values						
Melt volume-flow rate MVR (230/3.8)	cm ³ /10 min	ISO 1133	3	4.5	4	2
Other values						
Density	g/cm ³	ISO 1183	1.19	1.19	1.18	1.18
Water absorption in water	%	ISO 62			> 3 %	> 3 %

(1) Fracture stress (5 mm/min) (2) Elongation at break (5 mm/min)

Products



The various PLEXIGLAS® and PLEXALLOY® grades have specific property profiles designed to meet the full range of requirements for various add-on automotive body parts.



Polishing

Polishing Moldings Made of Black PLEXIGLAS® and PLEXALLOY® Molding Compounds

PLEXIGLAS® and PLEXALLOY® molding compounds have the highest surface hardness of all thermoplastics. Therefore, scratches seldom occur. Any scratches that do occur and are particularly noticeable on high-gloss black surfaces can be removed by polishing.

Detailed information on this subject is available on request.

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Initial state

Surface treated with sandpaper up to the upper right edge

Subsequent high gloss polishing of the surface



® = reg. trademark

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