Alcom® WP
Processing Guide
Injection Molding

Alcom® WP - Wear Protect - are compounds based on amorphous or semi-crystalline thermoplastics, tribologically modified by suitable additives and fillers.

The Alcom® WP compounds are mainly suitable for injection molding and can be processed on standard injection molding machines. The compounds vary in the base polymers used, technical polymers such as: POM, PA6, PA6.6, PPS, PC, ABS, etc. and the respective sliding friction modification consisting of the following fillers and additives with different properties for processing:

- **PTFE:** depending on the filler quantity, mold geometry and processing, deposit formation in the mold is possible.
- **Silicone:** Silicones act as a lubricant on the melt and at the same time as a plasticizer for the compound.
- **Molybdändisulfide:** Nucleating effect on semi-crystalline thermoplastics.
- **Graphite:** Nucleating effect on semi-crystalline thermoplastics.
- **Aramid:** reinforces the plastic matrix, distribution and orientation of the fibers are decisive for wear-reducing properties, but flowability decreases.
- **Carbon fiber:** reinforces the plastic matrix, distribution and orientation of the fiber decisive for wear-reducing properties, abrasive.
- **Special fillers:** Influences can be found in the data sheet.

Pre-drying

Depending on the polymer and filler system used, pre-drying may be mandatory. In general, however, pre-drying prior to injection molding is also recommended for non-hygroscopic Alcom® WP compounds in order to ensure high component quality and a stable injection molding process. Therefore, opened containers should not be stored open for a longer period of time.

Flow behavior and shrinkage

The flow behavior and shrinkage are influenced differently by both the polymer and the filler/additive package. A fiber filling, for example, not only leads to lower flowability, but also to anisotropic shrinkage, i.e. different shrinkage along and across the flow direction. Shrinkage also depends on the selected injection molding parameters and the part geometry. The shrinkage values given in the data sheets have been determined on sample plaques (60 x 40 x 2 mm) under special conditions and can therefore only be regarded as guide values. Depending on the process, processing conditions and component geometry, the shrinkage values may vary.

The flow behavior is significantly influenced by the filler system. Fibrous fillers, such as glass, carbon and aramid fibers, have a negative effect on flowability, resulting in shorter flow path lengths. Graphite also increase viscosity, depending on the filler content, but not as much as fibrous fillers. Furthermore, due to the powder form, graphite has no anisotropic effect on warpage.

Additives such as silicones and special lubricants act as an internal lubricant and promote the flow behavior of the melt.

A combination of different filler and additive systems can in turn cancel out the respective effect on the flow behavior. Thus, a compound filled with GF and PTFE may exhibit better overall flow behavior than a compound filled with GF only. However, the influence on the flow behavior always depends on the filler / additive content.

Special features of processing

The processing of Alcom® WP compounds is significantly influenced by the filler and additive systems. Both the filler and the filler content have a significant influence. However, the base polymers and blends used are also decisive for the injection molding process. When processing Alcom® WP compounds, the behavior of the base polymers as well as the fillers and additives must be considered. The following characteristics must be taken into account when processing Alcom® WP compounds:

Polymers

- **Polyamide (PA6 / PA66):** Polyamides are hygroscopic and absorb water when stored open. Therefore, polyamides should be sufficiently dried before processing. During processing, the maximum permissible residual moisture content is 0.15%. Airtight packed containers do not necessarily have to be pre-dried before processing. Openly stored containers, however, should be pre-dried. Moisture absorption may be influenced by hygroscopic fillers. Dry air dryers are suitable for drying. Polyamides are characterized by a very wide processing window, whereby the processing temperatures are mainly influenced by the fillers and additives. Especially for fiber-reinforced materials, it is recommended to use a wear-resistant plasticizing unit.
- **Polybutylenterephthalate (PBT):** PBT should be dried before processing, as it tends to absorb water. During processing, absorbed water leads to polymer degradation. The maximum permissible residual moisture content for processing is 0.02%. Airtight packed containers do not necessarily have to be pre-dried before processing, whereas openly stored containers should be pre-dried. Moisture absorption may be influenced by hygroscopic fillers. Circulating air and dry air dryers are suitable for drying. Especially for fiber-reinforced materials, it is recommended to use a wear-resistant plasticizing unit. Long residence times can damage the polymer and should therefore be avoided. These are caused, for example, by a machine that is too large depending on the shot weight or by cycle times that are too long. In case of production interruptions, the barrel temperature should be lowered and, if necessary, the screw should be flushed with new pellets when the process is resumed.
- **Polyoxymethylene (POM):** All Alcom® WP POM compounds are based on a POM copolymer. Depending on the filler used and the storage method and duration, POM can absorb moisture, which is why the material must be dried before processing after longer storage periods. This applies in particular to containers that have been opened. Before changing to POM, the screw must be completely cleaned of residues of the previous material; easy-flowing non-reinforced polyolefins are suitable as cleaning granules. Short production interruptions can be carried out by lowering the cylinder temperature without damaging the material. If the production is interrupted for a longer period, the machine must be emptied and the cylinder temperature lowered, since a too long dwell time or too high temperatures can lead to material degradation and the formation of toxic gases (formaldehyde). Furthermore, care should be taken not to raise the processing temperatures above the recommended temperatures, as this can also damage the material. Only in exceptional cases, e.g., with highly filled materials, or with long flow paths and thin wall thicknesses, can the temperature be raised to a maximum of 230°C. This, however, only under the condition of short residence times of the melt in the machine. Due to possible damage of the material, the shear must also be set as low as possible via the screw speed. The following applies: the larger the screw diameter, the lower the speed should be selected in order to avoid material damage due to excessive shear. Screws with venting are not recommended for processing POM.
- **Polycarbonate (PC):** PC is a hygroscopic polymer which requires pre-drying before processing to avoid material degradation during processing. The residual moisture should be below 0.02 %. Wear-resistant plasticizing units are recommended for processing filled PC compounds. Cleaning should be carried out with special cleaning granules. If production is interrupted, the barrel temperature should be reduced to approx. 170°C to avoid material damage.

- **Polyphenylensulfide (PPS):** PPS is a semi-crystalline engineering material and is characterized by good flowability. MOCOM's PPS compounds under the trade name Tedur® are based exclusively on linear PPS. Linear PPS is characterized by high purity and crystallization rate compared to branched PPS. PPS absorbs very little moisture (0.05% maximum). The value can be higher depending on the filler system. Moisture can lead to surface defects and molecular degradation during processing. Therefore, pre-drying is recommended, especially in case of longer storage and/or open containers. Corrosion-resistant steels with sufficient hardness should be used for high production quantities (see the following table):

Steel type	Name acc. DIN 17 006	Material no.	Surface hardness HRc	Comments
Corrosion resistant steels	X 90 CrMoV 18 X 105 CrMo 17	1.4112 1.4125	57 – 59 57 – 60	polishable
Corrosion resistant PM-steels	X 10 Cr 13 X 105 CrMo 17 X 200 CrVMo	1.4006 1.4125	> 56	Powder metallurgical steels (PM steels)
PM-special steel	Uddeholm „Elmax" Böhler „M 390" Zapp CPM T440V		57 – 60 57 – 60 58 – 59	very high wear and corrosion resistance
Hard material alloys	Ferro-Titanit S		66 – 70	Extremely highly wear and corrosion resistance

When using non-corrosion-resistant steels, the surface must be protected by common coating processes. Coating materials containing chromium are suitable. Furthermore, a surface hardness of > 56 HRc is recommended due to the high filler content of Tedur®. However, the steels should not be hardened by nitrating, as this in turn promotes corrosive attack. Wear and corrosion protection should be considered throughout the injection molding units, as the high filler contents cause increased wear.

Injection unit	Comments
Cylinder	Spinning out with suitable armor layer, mostly Fe-Cr-Ni-B base, insertion of spun-out bushings, carrier tube made of nitrated steels. (e.g.: 34 CrAlNi 7 (1.8550) or 31 CrMoV 9 (1.8519)
Screws	High Cr-alloyed through-hardeners, partially ionitrided (e.g. X 155 CrVMo 12 1 (1.2379), X 165 CrMoV 12 (1.2601), X 210 Cr 12 (1.2080), X 220 CrMo 12 2 (1.2378), X 210 CrW 12 (1.2436)); Stellite hardfacing with ionitrided CR steels with chromium-plated screw base and flanks
Cylinder head	High-alloy Cr steels, ionized, standard nitriding steels, hard-chrome plated
Backflow valve	Tip and thrust collar: high-alloy Cr steels, ionitrided if necessary, high Cr alloy through-hardeners
Locking ring	High Cr-alloyed steels with good toughness, through-hardened or quenched and tempered / ionitrided (e.g. X 155CrVMo 12 1 (1.2379), X 40 CrMoV 5 1 (1.2344), X 35 CrMo 17 (1.4122))

The screw must be completely cleaned of residues of the previous material before changing to PPS; PA and PMMA are suitable as cleaning granules. The screw is cleaned with the respectively valid processing temperatures of the materials. The barrel temperatures are then raised to the usual processing temperatures for PPS. The cleaning material is displaced with the PPS. Only after the screw has been completely cleaned of the cleaning material, the molding of PPS can be started.

Transition from PPS to another material: The barrel unit is also cleaned with PA or PMMA. As soon as the screw is flushed of PPS residues, the barrel temperature can be lowered to the processing temperature of PMMA or PA, the material continues to be injected into the open and the screw is flushed until there are no more PPS residues. If production is interrupted, the barrel temperature should be reduced to 270-300°C and the screw should be purged. Valve gate nozzles are suitable for processing due to the very good flowability of PPS. PPS requires a high mold temperature, which should be greater than 130°C and can be as high as 170°C. This can improve the surface quality and minimize post-shrinkage. Good venting must be ensured for the tools, as compressed air can cause burns and promote corrosive wear on the tool, which in turn reduces tool life. Effective venting is achieved, for example, with ducts in the parting line. The venting channel depth should not exceed 0.006 to 0.01 mm, as burr formation can occur due to the good flowability of PPS.

The width of the channels depends on the molded part and is usually 2 - 10mm. The vent channels should be polished.

Fillers and additives

- **PTFE**: Depending on various factors, such as filling quantity, processing conditions and geometry of the mold, the additive tends to form mold deposits. These deposits lead to shorter mold service times with increased cleaning efforts. Filler quantities of more than 10 % may lead to deposits, depending on the number of shots. Deposits are minimized by gentle processing, such as low injection speeds, avoidance of shear tips and gates with sufficiently large cross-sections. Rounded edges from the gate to the mold are also helpful in preventing rapid clogging.

- **Silicone**: The processing temperature of silicones is limited (depending on the molecular weight) and can lead to depolymerization of the silicone if the dwell time is too long. Therefore, high temperatures or a long residence time should be avoided.

- **Molybdenum disulfide:** The fine powder acts as a nucleating agent in semi-crystalline polymers. To obtain a good effect of the tribological additive, these compounds should be processed with the aim of maximum crystallization. Accordingly, in addition to a sufficiently high mold temperature (and melting temperature), the thermoplastic should be given sufficient time to crystallize (i.e. specification of a sufficiently long cooling time).

- **Graphite:** acts as a nucleating agent in semi-crystalline polymers and requires a sufficiently high mold temperature for optimum tribological properties, as well as long cooling phases to obtain maximum crystallization.

- **Reinforcement fibers:** increase the melt viscosity depending on the filler content. In addition, fibers are reduced in size by the high pressures and ambient conditions prevailing in the injection molding process. Excessive shortening of the fibers can be reduced by gentle process parameters (low shear, sufficiently large gates) and thus increases the reinforcing effect in the compound, which in turn improves the tribological properties.

Mold[1] Barrel temperature[1]

Mold	IV	III	II	I		
40 - 80	250 - 280	260 - 275	250 - 260	250	60 - 80	**PA6** unfilled
80 - 100	270 - 290	280 - 290	270 - 280	270	70 - 80	filled
40 - 80	270 - 290	280 - 290	270 - 280	270	60 - 80	**PA66** unfilled
80 - 120	280 - 300	290 - 300	280 - 290	280	70 - 80	filled
60 - 100	250 - 270	250 - 260	240 - 250	240	50 - 70	**PBT** unfilled
80 - 120	250 - 270	250 - 260	240 - 250	240	50 - 70	filled
60 - 90	190 - 210	190 - 200	180 - 190	180	60 - 70	**POM** unfilled
60 - 120	200 - 230	200 - 210	190 - 200	190	60 - 80	filled
130 - 170	320 - 340	320 - 330	300 - 310	300	70 - 90	**PPS** filled
80 - 110	270 - 300	290 - 310	290 – 300	270 - 290	70 - 90	**PC** unfilled
80 - 130	300 - 320	300 - 330	300 - 320	270 - 290	70 - 90	filled

Temperatures in degrees Celsius (°C)

[1]Guide values. For the start-up process, average values are recommended first, processing temperatures are to be taken from the data sheet, these can deviate!

Properties

Polymer	PA6 and PA66
Density (ISO 1183)	See technical data sheet

Injection machinery

Screw stroke	Metering stroke between 1 x D and 3 x D (D = screw diameter)
Screw type	Three zone screw with L/D ratio 18:1 to 22:1
Nozzle type	Open nozzle (to be preferred) or valve gate nozzle
Hopper type	Standard

Pre-processing

Storage	Dry, protected from heat and UV radiation
Dryer type	Dry air (desiccant)
Drying time	2 – 12 h
Drying temperature	80 °C[3]
Maximum moisture content	< 0,12 %

Processing conditions

	PA6 unfilled	PA66 unfilled	PA6 filled	PA66 filled
Mass temperature	250 – 280 °C[3]	270 – 290 °C[3]	270 – 290 °C[3]	280 – 300 °C[3]
Mold temperature	40 – 80 °C[3]		80 – 100 °C[3]	80 – 120 °C[3]
Coolant	Water			
Throughput coolant	Turbulent flow must be achieved.			
Peripheral screw speed	50 - 300 mm/s, e.g. screw speed of 40 rpm with a screw diameter of 50 mm			
Back pressure (specific)	50 – 150 bar			
Residence time	< 10 min			
Injection speed	Profile for constant flow front speed			

Shrinkage[2]

Strongly dependent on the filler and / or additive used, values can be taken from the data sheet

[2] Shrinkage is not a pure material property, but is influenced by fillers, the part/component geometry, ist wall thickness and the position and size of the gate. The processing parameters, such as mold wall and melt temperature, also play a decisive role.
[3] General guide values. Type-related values can be taken from the data sheet

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Properties

Polymer	PBT
Density (ISO 1183)	See technical data sheet

Injection machinery

Screw stroke	Metering stroke between 1 x D and 3 x D (D = screw diameter)
Screw type	Three zone screw with L/D ratio 18:1 to 22:1
Nozzle type	Open nozzle (to be preferred) or valve gate nozzle
Hopper type	Standard

Pre-processing

Storage	Dry, protected from heat and UV radiation	
Dryer type	Circulating air	Dry air (desiccant)
Drying time	4 – 8 h[3]	2 – 4 h[3]
Drying temperature	100 – 120 °C[3]	100 – 120 °C[3]
Permissible moisture content	< 0,02 %	

Processing conditions

	PBT unfilled	PBT filled
Mass temperature	250 – 270 °C[3]	250 – 270 °C[3]
Mold temperature	60 – 100 °C[3]	80 – 120 °C[3]
Coolant	Water	
Throughput coolant	Turbulent flow must be achieved	
Peripheral screw speed	50 - 300 mm/s, e.g. screw speed of 40 rpm with a screw diameter of 50 mm	
Back pressure (specific)	50 – 150 bar	
Residence time	4 - 8 min	
Injection speed	Profile for constant flow front speed	

Shrinkage[2]

Strongly dependent on the filler and / or additive used, values can be taken from the data sheet

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Properties

Polymer	POM
Density (ISO 1183)	See technical data sheet

Injection machinery

Screw stroke	Metering stroke between 1 x D and 3 x D (D = screw diameter)
Screw type	Three zone screw L/D ratio 20:1 to 23:1
Nozzle type	Open nozzle (to be preferred) with non-return valve
Hopper type	Standard

Pre-processing

Storage	Dry, protected from heat and UV radiation	
Dryer type	Circulating air	Dry air (desiccant)
Drying time	3 – 5 h[3]	2 – 3 h[3]
Drying temperature	100 – 110 °C[3]	100 – 110 °C[3]
Permissible moisture content	-	

Processing conditions

	POM unfilled	POM filled
Mass temperature	180 – 220 °C[3]	190 – 230 °C[3]
Mold temperature	60 – 90 °C[3]	60 – 120 °C[3]
Coolant	Water	
Throughput coolant	Turbulent flow must be achieved	
Peripheral screw speed	100 mm/s to 300 mm/s, e.g. screw speed of 35 rpm with a screw diameter of 50 mm	
Back pressure (specific)	50 – 150 bar	
Residence time	< 5 min	
Injection speed	Slow to medium, depending on the mold geometry	

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Properties

Polymer	PPS
Density (ISO 1183)	See technical data sheet

Injection machinery

Screw stroke	Meterin stroke between 1 x D and 3 x D (D = screw diameter)
Screw type	Three zone srew with L/D ratio 18:1 to 22:1
Nozzle type	Closed nozzle prefered
Hopper type	Standard

Pre-processing

Storage	Dry, protected from heat and UV radiation	
Dryer type	Circulating air	Dry air (desiccant)
Drying time	-	2 - 4h[3]
Drying temperature	-	130 – 140 °C[3]
Permissible moisture content	-	

Processing conditions

	PPS filled
Mass temperature	320 – 340 °C[3]
Mold temperature	> 130 °C[3]
Coolant	Oil recommended
Throughput coolant	Turbulent flow must be achieved
Peripheral screw speed	100 mm/s to 250 mm/s, low to medium screw speeds to be preferred
Back pressure (specific)	50 – 100 bar
Residence time	< 20 min
Injection speed	Slow to fast, depending on the mold geometry and filler

Shrinkage[2]

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Properties

Polymer	PC
Density (ISO 1183)	See technical data sheet

Injection machinery

Screw stroke	Metering stroke between 1 x D and 3 x D (D = screw diameter)
Screw type	Three zone screw with L/D ratio 18:1 to 22:1
Nozzle type	Open or needle shut-off nozzle
Hopper type	Standard

Pre-processing

Storage	Dry, protected from heat and UV radiation	
Dryer type	Circulating air	Dry air (desiccant)
Drying time	4 – 12 h[3]	3 – 4 h[3]
Drying temperature	120 °C	120 °C[3]
Permissible moisture content	< 0,02 %	

Processing conditions

Mass temperature	PC, unfilled	PC, filled
	280 – 310 °C[3]	310 – 330 °C[3]
Mold temperature	80 – 110 °C[3]	80 – 130 °C[3]
Coolant	Water	
Throughput coolant	Turbulent flow must be achieved	
Peripheral screw speed	50 mm/s to 300 mm/s, e.g. screw speed of 40 rpm with a screw diameter of 50 mm	
Back pressure (specific)	50 – 150 bar	
Residence time	4 – 8 min	
Injection speed	Profile for constant flow front speed	

Shrinkage[2]

Strongly dependent on the filler and / or additive used, values can be taken from the data sheet.

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