Battenfeld

Wittmann

PLASTICIZING SYSTEMS

The key to successful injection molding

world of innovation

WITTMANN BATTENFELD PLASTICIZING SYSTEMS
For top performance and efficiency

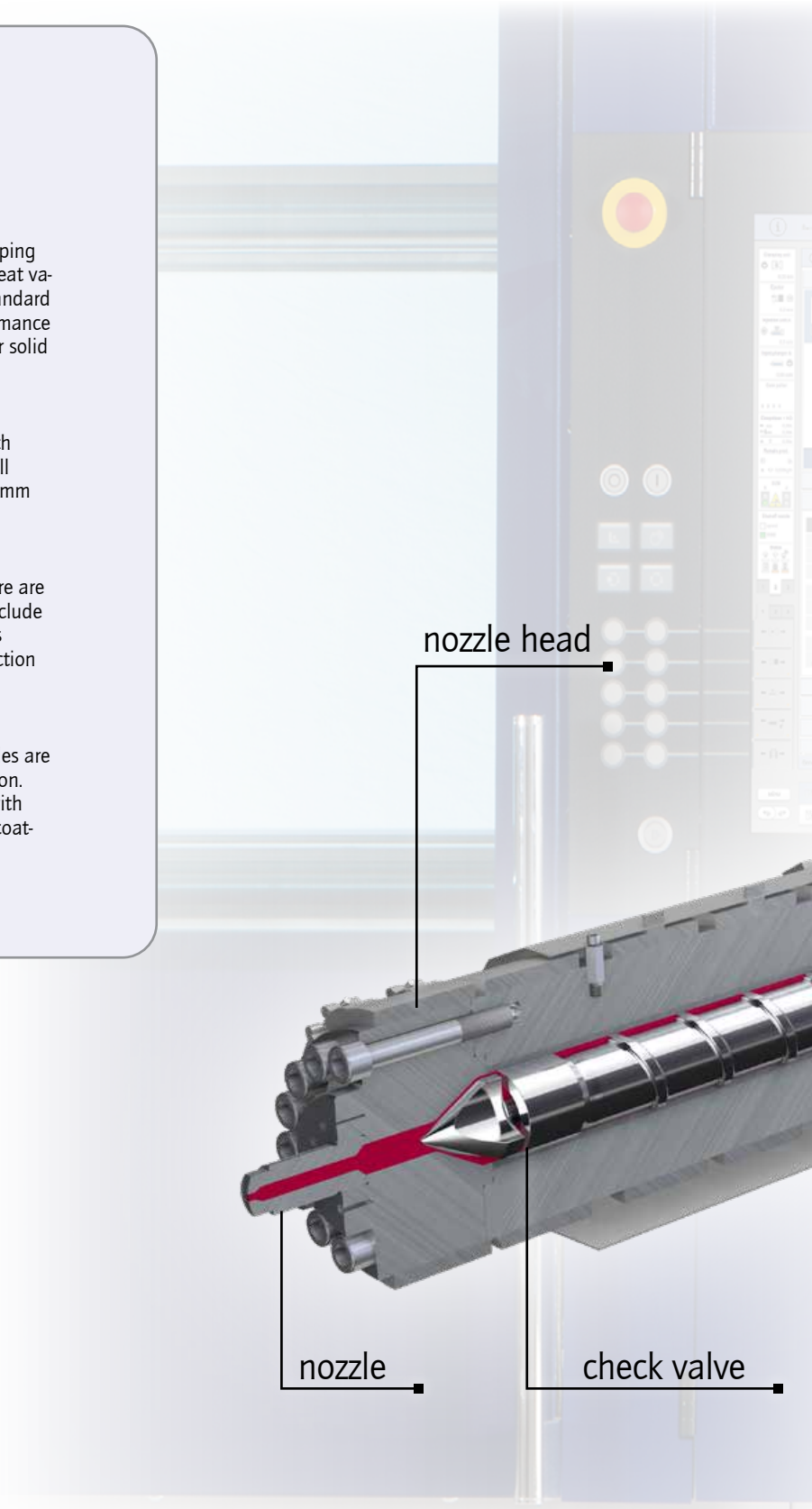
WITTMANN BATTENFELD
Plasticizing systems

» **In-house development**
Since 1948, WITTMANN BATTENFELD has been developing and manufacturing plasticizing systems to process a great variety of materials. These range from various types of standard materials to engineering plastics, including high-performance engineering polymers, which are transformed from their solid state into polymer melt to suit the specific application.

» **A wide range of different sizes**
The portfolio includes micro plasticizing aggregates with 14 mm screws and a stroke volume from 1.2 to 4 cm^3 all the way up to aggregates for large machines with 180 mm screws and 22266 cm^3 stroke volume.

» **An extensive choice of models**
In addition to the standard range of 3-zone screws, there are many variants tailored to special applications. These include solutions for PMMA, PVC and LIM processing as well as special designs for elastomer, thermoset and foam injection molding.

» **Perfect matches for every material**
Many variants of screws, barrels, check valves and nozzles are available to provide a perfect match for every application. These can be delivered nitrided or through-hardened, with hard chromium plating, or armored with a hard metal coating.



barrel
material feeding
cooling
heating
screw

PLASTICIZING KNOW-HOW
Experience combined with innovation

Our expertise for your success

Plasticizing systems for injection molding machines must meet many different requirements. These range from processing easy-flowing, semi-crystalline thermoplastics to molding highly reinforced, sluggishly flowing plastics with processing temperatures of up to 450 °C. Just as diversified is the interaction between the plastic materials processed and the plasticizing components coming into contact with them. In-depth expert knowledge is required to choose the right components in each case – and to manufacture them.

Experience

WITTMANN BATTENFELD can draw on many years of experience in manufacturing plastics processing machinery. Process technology performance and engineering expertise in screw-and-barrel systems have always been a major concern in its product development.

Knowledge

Knowledge accumulated over many years about the flow dynamics of plastics in plasticizing systems and its effect on various system components (abrasion, adhesion, corrosion) provides the basis for the high level of efficiency of WITTMANN BATTENFELD injection molding machines.

Innovation

Continuous verification of contact and wear effects produced by new plastics and compounds is a permanent driver of innovation in the design and choice of materials for plasticizing systems.

Expert advice

The choice of material combinations and geometries for screw-and-barrel systems depends on the processing attributes and wear intensity of the plastic materials to be processed.

Assistance

The WITTMANN BATTENFELD service portfolio does not end with assistance in making a selection for the basic project, but offers information and assistance with all questions concerning plastics processing as required.

WEAR MECHANISMS
Identification and understanding

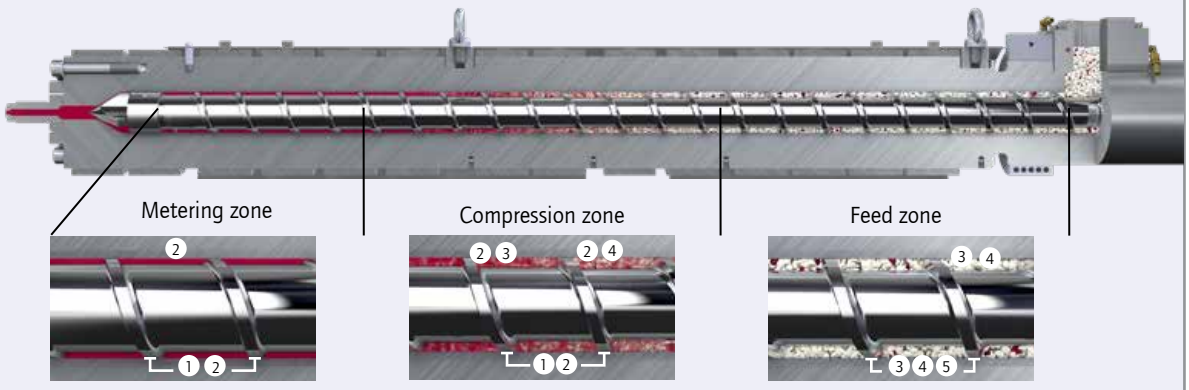
The plasticizing unit is the central aggregate of an injection molding machine whose components come into contact with the melting plastic material in all of its physical states.

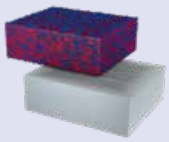
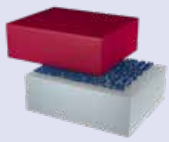
Depending on the momentary physical state of the plastic being processed, several processes of wear generally occur simultaneously (abrasion, corrosion and adhesion), according to the actual contact situation (tribological partners).

The extent and effect of the types and mechanisms of continuous wear are heavily influenced by the plastic material being processed (including all of its fillers and functional additives) as well as the process parameters (temperature, metering time, metering speed, pressure). To achieve a long service life, preventive measures to counteract the predominant types of wear are taken by choosing appropriate materials and a suitable protective surface coating.

For processing engineering thermoplastics in particular, a special focus is placed on protection against abrasion and corrosion, or a combination of both.

Types and mechanisms of wear in the plasticizing unit



Wear combination	1 metal (liquid) plastic metal	2 (liquid) plastic with mineral metal	3 (solid) plastic with mineral  metal	4 (solid) plastic with mineral  metal	5 metal metal
Type	wet abrasion	erosion (corrosion)	grain abrasion with restricted mobility	grain abrasion with additional rolling and circulation	sliding wear
Mechanisms	adhesion + abrasion	abrasion (corrosion)	abrasion	abrasion	adhesion + abrasion
Symptoms	seizure score marks	ripples depressions (perforations)	score marks embedding rolling marks	score marks chippings embedding smoothing	seizure score marks

PLASTICS AND ADDITIVES
How polymers challenge metals

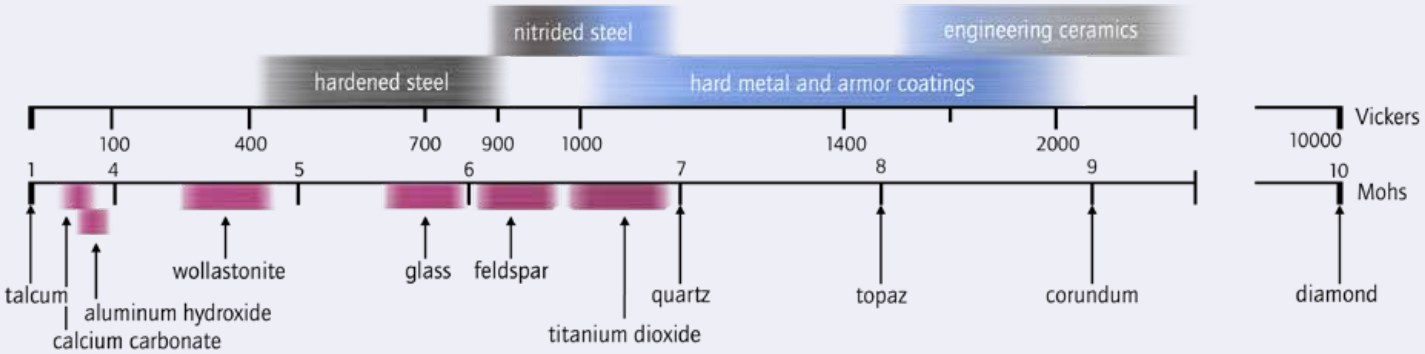
Thermoplastics are organic polymers with either amorphous or semi-crystalline structures in their solid state. Amorphous plastics (e.g. PS, PVC, PC) are long-chain molecules with a random structure, which, due to their structure, are transparent and have no fixed melting point. They melt gradually over a broad temperature range.

The microstructure of semi-crystalline materials consists of amorphous areas combined with crystalline structures (e.g. HDPE, POM, PA). The latter are characterized by dense, regular arrangement of the molecule chains. As a consequence, their attributes are greater hardness, narrower melting temperature ranges (definite melting points) and poor transparency. Here, the degree of crystallinity plays a vital part.

Accordingly, there are considerable variations in melting behavior, viscosity development and stress along the length of a plasticizing screw. Additional factors with an effect on the screw, barrel and check valve are additives (flame retardants, colorants, fibrous reinforcement materials, etc.), by which the original attributes of the virgin plastic material are modified. The most prevalent causes of system stress are friction effects, primarily in combination with a characteristic pressure development as plasticizing progresses, but also corrosion effects through chemical interaction. Such stress factors require appropriate counter-measures. These include various thermal treatment processes (surface hardening or through-hardening), hard coating and/or anti-corrosion coating, which are applied to various components of the plasticizing unit.

The chart below presents a comparison of hardness degrees between commonly available additives in plastics and the metal components used in plasticizing systems. Apart from the form of the fillers used (fibers, platelets, balls, etc.), their hardness is one of the most important indicators for sufficient protection against abrasive wear.

Hardness comparison between commonly available filler materials and wear protection systems



WEAR PROTECTION
The right surface is vital

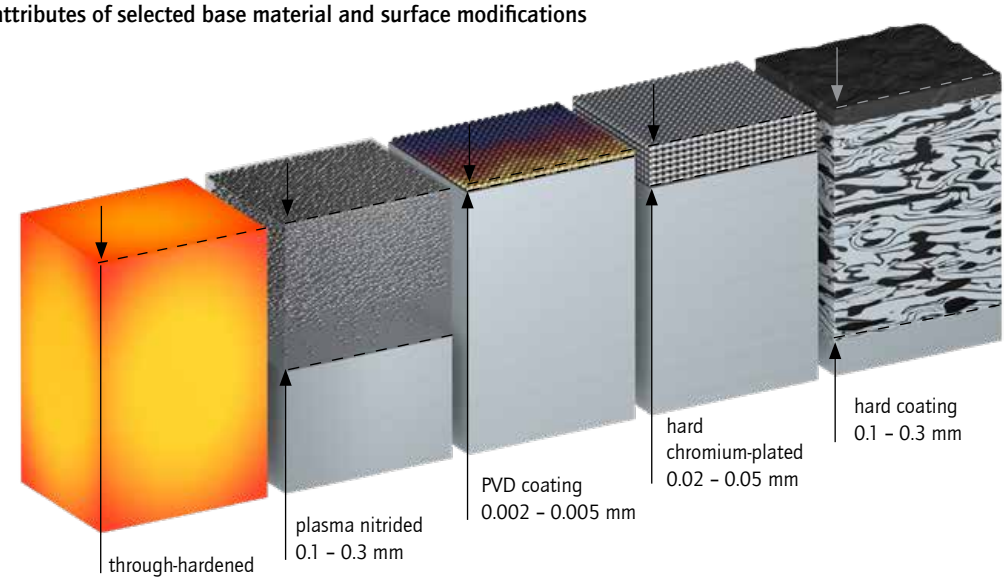
The components most strongly exposed to wear in a plasticizing unit are the screw and especially the check valve.

In addition to frequently high torque loads, the screw is required to withstand potential wear from the plastic material processed. Its surface must also be treated to prevent the adhesion of plastics residues to it effectively. This reduces the frequency of cleaning cycles and makes for high process stability.

The screw flights are among the most intensely worn areas, since they bear extra loads due to coming into contact with the barrel and to the high shearing speed of the reinforced plastic material in the narrow gaps between the barrel wall and the screw flights.

To meet these challenges in the best possible way, it is necessary to select the right base material for the screw and to combine it with the suitable surface treatment for each specific application.

Overview of attributes of selected base material and surface modifications



Designation of material / layer	PM steel	Plasma nitrided	PVD layer (CrN)	Hard chromium-plated	Hard coated
Layer thickness [mm]	through-hardened	0.1 – 0.3	0.002 – 0.005	0.02 – 0.05	0.1 – 0.3
Surface hardness [HV]	660 – 760	900 – 1200	2000 – 2500	1000 – 1200	1350 – 2100
Wear resistance	+++	++++	++	++++	+++++
Corrosion resistance	+++	+	++++	++	+++++
Used, for example, with	SM04	SM09*	SM08	SM10*	SM13*

* combined with flight armoring

FROM GRANULATE TO MELT
A complex mechanism

Plasticizing concept according to Maddock

The transition from plastic granulate to liquid plastic melt within the screw channel starts with the formation of a melt film on the heated barrel wall. The rotation of the screw generates a current flowing crosswise to the direction of the screw channel. In this way, the material which has already melted is transported to the active flank of the screw flight, where a melt vortex develops in the course of further infeed. This vortex increases in width as it approaches the tip of the screw, because the additional material melting on the barrel wall gathers in this place. Towards the end of the melting process, the remaining core of solid material breaks up into solid islands surrounded by plastic melt. Finally, these are melted too by the continuing heat input, until a homogeneous polymer melt has been produced.

Stroke volume, melt density (output factor) and shot weight

The heat input leads to a difference in density between the solid material and the melt. The melt density ς (g/cm³) (output factor) enables the calculation of a shot weight estimate, depending on the stroke volume. The shot weight (g) can be calculated by multiplying the stroke volume (cm³) with the specific output factor.

The metering stroke should not be allowed to exceed a maximum length of 3 to 4 screw diameters, because it shortens the effective length of the screw. With increasing length of the metering stroke and retraction of the screw, the length of the channel from the feed hole to the tip of the screw is increasingly shortened. If this is not taken into account, the consequences may be unstable metering processes, air intake or material inhomogeneity.

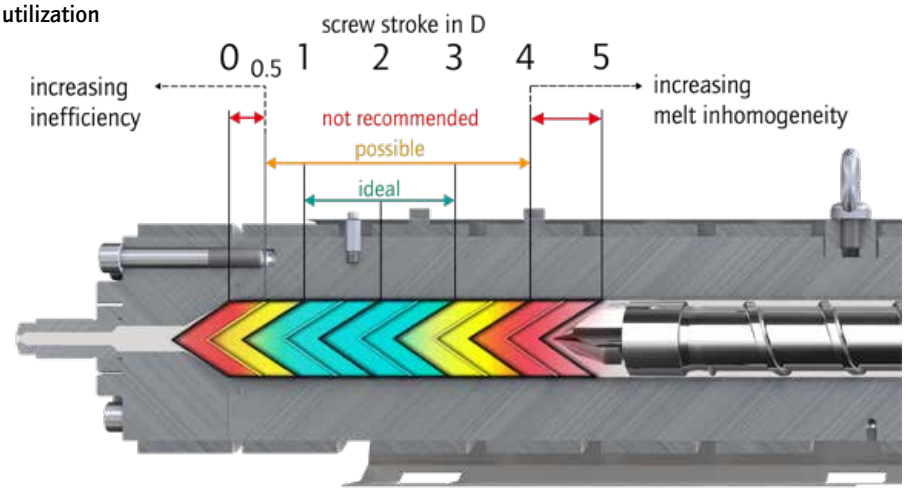
The metering stroke should not fall below one screw diameter either, since this would significantly increase the dwell time with the consequence of possible damage to the material. Moreover, production can be effected more economically on a smaller-sized machine than on a large one. An exception to this rule is with fast cycling machines, where the dwell time remains in its optimum range despite short metering strokes. Our experts are happy to help select the plasticizing system ideal for your application.

Melt density ς and output factor

Material	ς (g/cm³)
ABS	0.88
CA	1.02
CAB	0.97
PA	0.91
PC	0.97
PE	0.71
PMMA	0.94
POM	1.15
PP	0.73
PP + 20 % Talc	0.85
PP + 40 % Talc	0.98
PP + 20 % GF	0.85
PS	0.91
PVC rigid	1.12
PVC soft	1.02
SAN	0.88
SB	0.88
PF	1.3
UP	1.6

Dark gray fields = thermosets

Recommended stroke utilization



Standard 3-zone screw (UNIMELT)

The standard 3-zone geometry is the most commonly used screw geometry. It is characterized by a screw flight with a constant pitch divided into three zones with different flight depths (feed zone, compression zone, metering zone). In the compression zone, the flight depth is reduced by a steady increase in the core diameter. In the feed and metering zones, the flight depth remains constant.

The plasticizing process follows the Maddock concept. The effects of back pressure and the rotation of the screw generate complex, three-dimensional currents, which are responsible for the good mixing effect of a 3-zone screw.

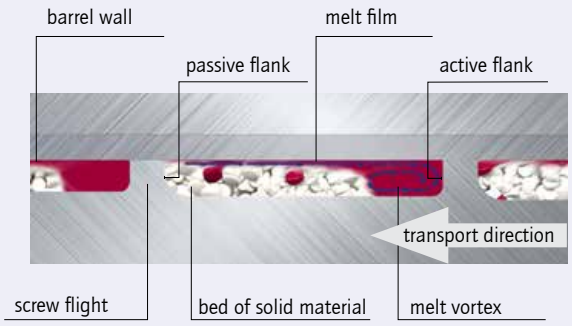
Barrier screw (MeltPro™)*

A barrier screw distinguishes itself from a standard 3-zone screw by an additional screw flight in the compression zone (barrier flight). It serves to separate the solid material in the material current from the melt. This is achieved by making the molten material flow from the solid material channel across the barrier flight into the melt channel. As a consequence, the "lubrication and insulation material" is extracted from the solid part with the result of increased heat input into the solid material, which speeds up the melting process.

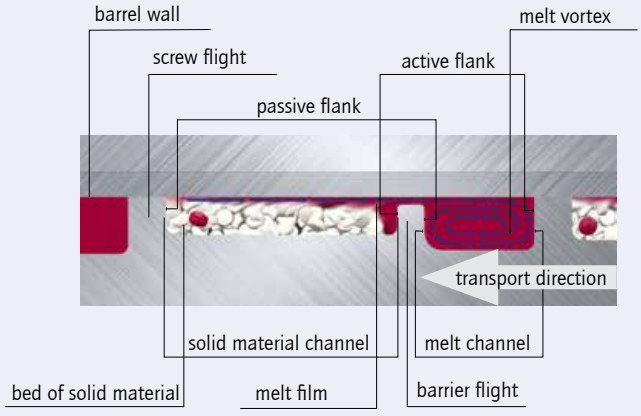
In this way, a barrier screw enables an increase of up to 20 to 30 percent in throughput for PE and PP compared to a standard 3-zone screw. Another advantage is the "filter effect" of the barrier flight. It holds back residues of solid material, drops of colorant and air bubbles which may have entered, so that the solid particles cannot pass the barrier flight until after they have melted, and the air can easily escape via the solid material channel through the feed throat.

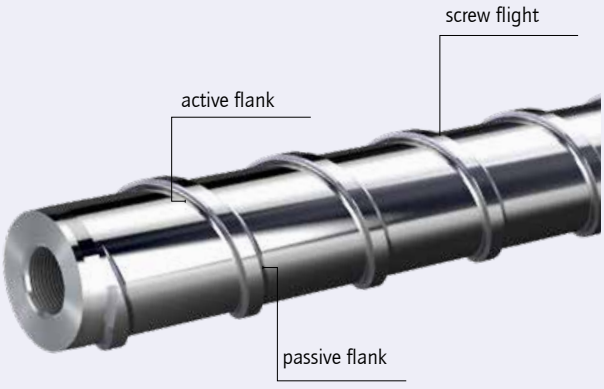
Plasticizing concept according to Maddock

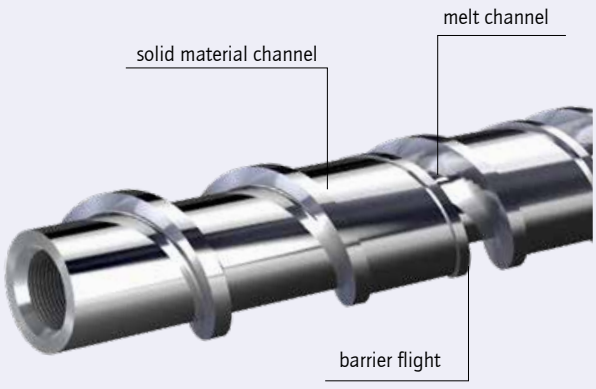
for 3-zone screw



for barrier screw





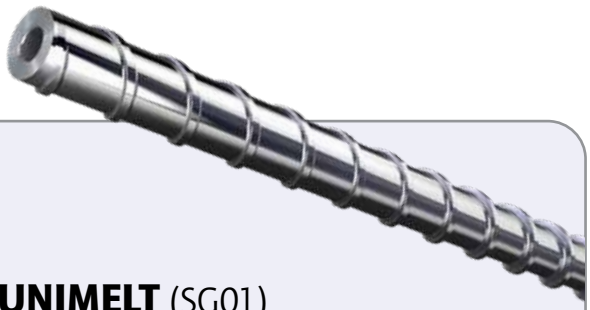


* MeltPro™ barrier screw geometry is a trademark of Nordson Xaloy Incorporated.

THE PLASTICIZING SCREW
For maximum efficiency

WITTMANN BATTENFELD offers a wide range of plasticizing screws.

» Standard 3-zone screws (UNIMELT) – universal applications
» Mixing screws (COLOURMELT) – excellent material homogenization, especially when colorants have been added
» Barrier screws (MeltPro™) – higher throughput with the same screw diameter
» Customized screws – e.g. PVC, thermoset or elastomer screws, or CELLMELT for N_2-assisted foam injection molding



UNIMELT (SG01)

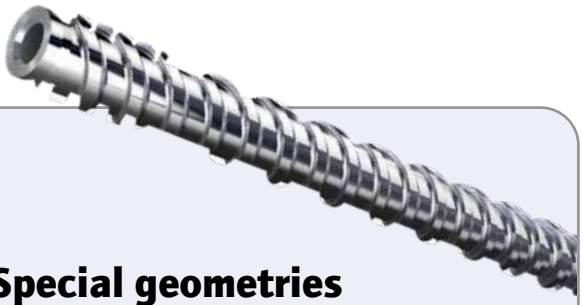
Universal 3-zone screw for processing thermoplastics without fillers. The constant L/D ratio of 22:1 delivers excellent melt quality even with larger metering strokes.

COLOURMELT (SG02)

When processing color additives in the form of liquid colorants or Masterbatch, use of the COLOURMELT compounding screw leads to substantially improved homogeneity and blending in of the colorant. Mixing elements promote both radial and tangential distribution of the color pigments.

Barrier screw MeltPro™

Barrier screw laid out for low shear stress and maximum material homogeneity, simultaneously with a significant increase in plasticizing performance. Available with or without a mixing section.



Special geometries

WITTMANN BATTENFELD offers a great variety of specialized screws. It includes equipment for processing thermosets, powder injection molding (PIM) feedstocks, hard PVC and elastomers (rubber or liquid silicone). Screws designed for special process technologies are also available, such as the low compression screw SG16 and the CELLMELT for CELLMOULD® foam injection molding.

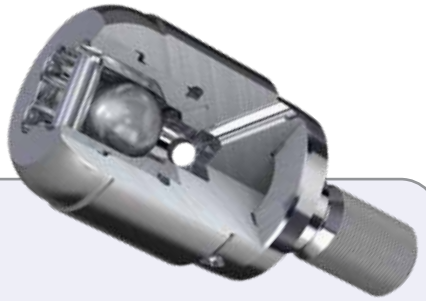
THE CHECK VALVE
Vital for good quality

The check valve is a valve placed at the front end of the plasticizing screw. In the open position, it allows the plastic melt to flow through into the screw antechamber. In the closed position, it prevents the melt from flowing back into the screw, and the screw thus becomes a piston to inject the melt. Opening and closing is triggered without a separate mechanism, solely by the screw's direction of movement and the current of the plastic melt. Various types of barrier design are available to fit the many different operating conditions. The decisive criteria for selecting a design are its closing and wear attributes.

Ring check valve (CG01)

» Universal model
» Locking mechanism: closing with longitudinal stroke in combination with the screw tip
» Large flow cross-section

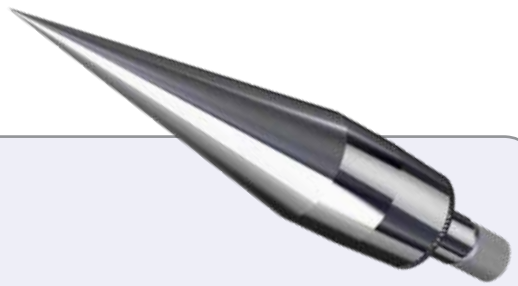
Advantages:
» Fast closing reaction
» Minimal material stress
» Good wear resistance



Ball check valve (CG02)

» Better closing behavior, small quantity of plastic inside the locking channel
» Locking mechanism: ball valve
» Small flow cross-section

Advantages:
» Well suited for large screw diameters
» Optimized closing behavior when processing e.g., PP and PE



PVC tip (CG04)

» Screw tip
» Without check valve

Advantages:
» Closeness to gating
» Low shear stress for the material
» Favorable flow geometry
» Deep plunge into the nozzle and complete material discharge

Special solutions

Customized solutions such as the cross bolt check valve are suitable for processing plastic materials extremely sensitive to shearing, and come with the relatively largest flow cross section.

» Specialized model for minimal shear stress
» Locking mechanism: locking ring with longitudinal stroke, combined with a cylindrical screw tip with cross bolt

THE PLASTICIZING SYSTEM
Diversity in detail

	L/D=22	3-ZONE SCREW					MIXING SECTION GEOMETRY		BARRIER GEOMETRIES		Check valve geometry
		UNIMELT (SG01)					COLOURMELT (SG02)		MeltPro™ + Z-Mixer (SG07)	MeltPro™ + Pulsar-Mixer (SG08)	
		STD	AK+	AK++	AKCN	K++	AK+	AKCN	AK+	AK+	
Materials	Screw D≤30 mm	SM01	SM04	SM05	SM08	SM06	SM04	SM08	–	–	–
	Screw 35 mm≤D≤65 mm	SM01	SM04	SM13	SM08	SM06	SM04	SM08	SM10	SM10	–
	Screw D≥75 mm	SM09	SM09	SM13	SM12	–	SM10	SM12	SM10	SM10	–
	Check valve	CM09	CM09	CM08	CM06	CM09	CM09	CM06	CM09	CM09	–
	Barrel	BM02	BM02	BM04	BM02	BM03	BM02	BM02	BM02	BM02	–
	Nozzle head	HM01	HM01	HM03	HM03	HM06	HM01	HM03	HM01	HM01	
Standard thermoplastics	PP	o	+	++	o		o			o	CG01
	HDPE	o	+	++	o		o				CG01
	LDPE	o	+	++	o		o				CG01
	HIPS	o	+	++	o		o				CG01
	PS, transparent										CG01
	PVC-P										CG01
Engineering thermoplastics	ABS		+	++	o		o				CG01
	ASA		+	++	o		o				CG01
	COC										CG01
	SAN		+	++	o		o				CG01
	EVA		+				o				CG01
	PA		+	++							CG01
	PC		(+)	++	o		o				CG01
	PMMA		+	++							CG01
	PET		+	+						++	CG01
	PBT		+	+						++	CG01
	POM Homo		+	+	o						CG01
	POM Copo		+	+	o						CG01
	TPE		+	++			+				CG01
	TPU		+	++			+				CG01
Polymer blends	PPE + PS		+								CG01
	PPE + PA		+								CG01
	PC + ABS		+								CG01
	PC + ASA		+								CG01
High-performance plastics	PPA		+	++							CG01
	PPS		+	++							CG01
	PSU		+	++							CG01
	PESU		+	++							CG01
	PPSU		+	++							CG01
	PVDF			+							CG01
	PTFE			+							CG01
	PFA/ETFE			+							CG01
	LCP		(+)	++							CG01
	PEEK		(+)	++							CG01
	PEI		+	++							CG01

	L/D=22	SPECIAL GEOMETRIES								Check valve geometry
		Rigid PVC (SG09)	MIM (SG12)	CIM (SG12)	Thermoset (SG10)		LIM (SG11)	Transparent materials (SG16)		
		AK+	AK+	AK++	AK+	AK++	AK+	AK+	AKCN	
Materials	Screw D≤30 mm	SM04	SM04	SM14	SM04	SM05	SM04	SM04	SM08	–
	Screw 35 mm≤D≤65 mm	SM04	SM04	SM13	SM04	SM13	SM04	SM04	SM08	
	Screw D≥75 mm	SM10	–	–	SM09	SM13	–	SM09	SM12	–
	Check valve	CM03	CM09	CM08	–	–	CM02	CM09	CM06	–
	Barrel	BM02	BM02	BM05	BM02	BM04	BM02	BM02	BM02	–
	Nozzle head	HM01	HM01	HM07	–	–	HM01	HM01	HM03	–
Special applications	PVC-U	+								CG04
	PAI	+								CG04
	MIM		++							CG05
	CIM			++						CG05
	PF				+	++				–
	EP				+	++				–
	MF				+	++				–
	LSR									CG06
	SAN optical							+		CG07
	PMMA optical							+		CG07
	PC optical							+		CG07

Legend

Color codes and symbols

change and adhesion propensity	
	Limited suitability
	Suitable
	Excellent suitability

Symbols	
	Without filler
o	≤ 20% filler
+	< 35% filler
++	≥ 35% filler
( )	Customized layout

Abbreviations for materials and geometries

Barrel materials	
BM02	Bimetallic barrel with Fe-based alloy (10% chrome)
BM03	Bimetallic barrel with Ni-Co-based alloy
BM04	Bimetallic barrel with Ni-based alloy, with premium-quality tungsten carbide
BM05	Bimetallic barrel with hard metal insert

Screw materials	
SM01	Nitriding steel, nitrided
SM04	Powder metallurgical steel, hardened and tempered
SM06	Nickel-based alloy
SM08	PM – Stahl – Vollmaterial + CrN
SM09	Q+T with flight armoring, nitrided
SM10	Q+T with flight armoring and hard chrome plating
SM12	Q+T with flight armoring and CrN coating
SM13	Full tungsten carbide coating
SM14	Hard metal

Screw geometries	
SG01	UNIMELT
SG02	COLOURMELT
SG07	MeltPro™ + Z-Mixer
SG08	MeltPro™ + Pulsar-Mixer
SG09	Hard-PVC, PVC-U
SG10	DUROMELT
SG11	LIM screw
SG12	PIM screw
SG16	Screw for transparent and/or highly viscous thermoplastics

Check valve materials	
CM02	Cold-work steel, nitrided
CM03	Powder metallurgical steel, Q+T
CM06	High-chrome plastic mold steel, casement-armored, CrN-coated
CM08	Plastic mold steel with hard metal
CM09	High-chrome plastic mold steel, casement-armored

Check valve geometries	
CG01	Ring check valve
CG04	PVC tip
CG05	PIM-optimized
CG06	LIM-optimized
CG07	Optimized for SG16

Nozzle head	
HM01	Nitriding steel, nitrided
HM03	High-chrome plastic mold steel, Q+T
HM06	Ni-Co-based alloy
HM07	Nitriding steel, nitrided with hard metal insert

EQUIPMENT PACKAGES

Where protection against wear is a priority

Standard Package

Low-cost anti-wear protection for standard applications

Applications: plastics without reinforcement (filler content < 20 %), without flame retardants and/or colorants

Examples: PP, PE, PS

Component	Composition/attributes	Designation
Screw	Nitriding steel, nitrided, from Ø 75 mm Q+T steel with flight armoring, nitrided	≤ ø 65 mm SM01 from ø 75 mm SM09
Check valve	High-chrome plastic mold steel, casement-armored	CM09
Barrel	Bimetallic barrel with martensitic Fe-based alloy	BM02

Composition of bimetallic barrel (BM02) with armor coating structure

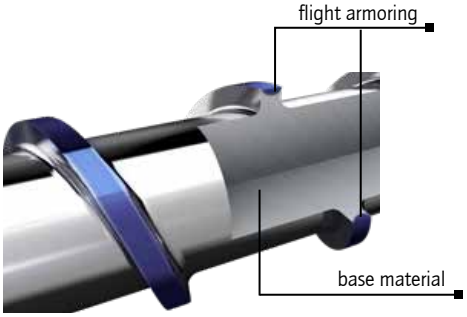
AK+ Package

Optimal balance between abrasion- and corrosion-resistance

Applications: reinforced plastics with up to 35 % filler content
Example: PA6 GF30

Component	Composition/attributes	Designation
Screw	Powder metallurgical steel, hardened and tempered, from Ø 75 mm Q+T steel, with flight armoring and nitrided or with hard chrome coating	≤ ø 65 mm SM04 from ø 75 mm SM09 or SM10
Check valve	High-chrome plastic mold steel, casement-armored	CM09
Barrel	Bimetallic barrel with martensitic Fe-based alloy	BM02

Structure of powder-metallurgical screw (SM04)



Flight armoring of a screw (SM09; SM10)

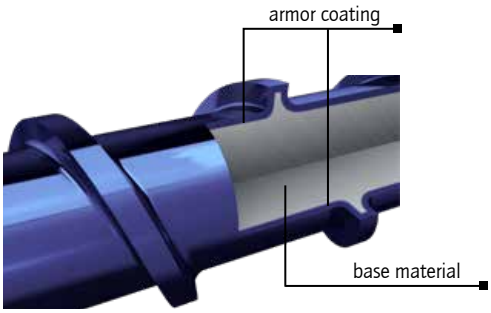
AK++ Package

Maximum resistance against abrasive and corrosive wear

Applications: reinforced plastics with more than 35 % filler content
Examples: PA6 GF 35 VO, PA66 GK50

Component	Composition/attributes	Designation
Screw	Powder metallurgical steel, Q+T and plasma nitrided, from Ø 35 mm, fully armored with a 0.2 to 0.3 mm layer consisting of a nickel-based tungsten carbide alloy	≤ ø 30 mm SM05 from ø 35 mm SM13
Check valve	Protected by hard metal inserts and a solid hard metal ring	CM08
Barrel	Bimetallic barrel with extremely corrosion-resistant Ni-matrix alloy with thermally stable, premium-quality tungsten carbide	BM04

Check valve (CG01; CM08)



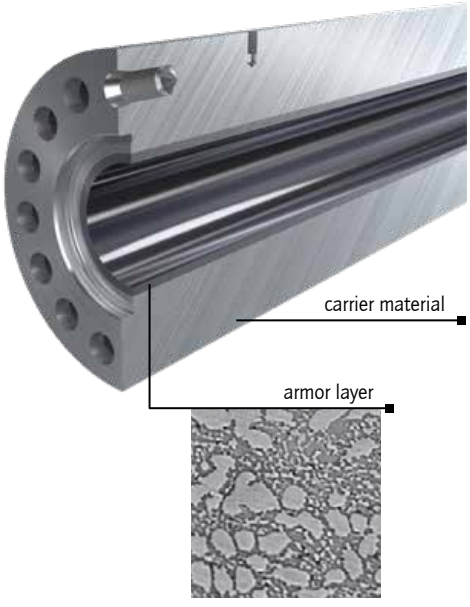
Fully encapsulated screw (SM 13)

K++ Package

For extremely corrosive applications

Applications: plastics with a strongly corrosive reaction
Examples: fluoride polymers and materials with a high flame retardant content

Component	Composition/attributes	Designation
Screw	Nickel-based alloy	SM06
Check valve	High-chrome plastic mold steel, casement-armored	CM09
Barrel	Bimetallic barrel with Ni-Co based alloy	BM03



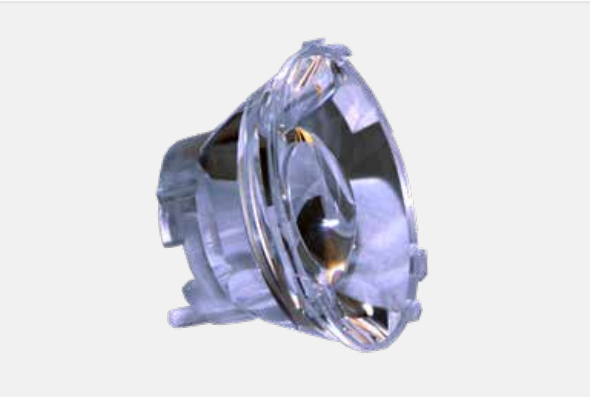
Composition of bimetallic barrel (BM03) with armor coating structure

SPECIALIZED EQUIPMENT PACKAGES
Solutions for specific tasks

AKCN PACKAGE
Transparent parts

For transparent thermoplastic parts with stringent optical requirements, especially PC and PMMA, which are prone to form deposits on the screw surface.
Advantages: crystal-clear parts, excellent protection against adhesion of the melt

Package highlights:
» bimetallic barrel
» PVD-coated screw
» PVD-coated check valve
» corrosion-resistant nozzle head and nozzle
» Multiple screw geometries available



Lenses and lighting elements

PVC PACKAGE
Stable PVC processing

The material's requirements for high corrosion resistance, a geometry designed for minimal shear stress and high drive torques are the essential equipment factors in a PVC plasticizing system.

Package highlights:
» bimetallic barrel
» screw consisting of corrosion-resistant steel
» corrosion-resistant nozzle head and nozzle

Photo: Krona Tubos e Conexões

PVC-U fittings

LIM PACKAGE
Liquid Silicone

Liquid Injection Molding (LIM) utilizes the injection molding process for producing elastic parts from 2-component liquid silicone rubber (LSR). In the LIM process, the two-component raw material is pumped into the barrel via a multi-component metering and compounding system, then injected into the heated mold.

Package highlights:
» liquid-cooled barrel and pneumatic needle shut-off nozzle to exclude cross-linking reactions
» plasticizing screw with LSR-optimized geometry
» check valve for repeatable shot volumes
» screw sealing to prevent material leakage

Sealing rings, medical products

THERMOSET PACKAGE

Thermoset for maximum component strength

Processing thermoset materials places the most stringent requirements on the surface hardness and wear resistance of the plasticizing unit. Due to compounds with extremely high filler content and considerable injection pressures, the load-bearing capacity of the surface is a vital prerequisite for the durability of the processing unit.

Package highlights:

» bimetallic barrel, watercooled
» screw made of abrasion-resistant steel alloy with tip

Photo: Winkelmann Powertrain Components GmbH & Co. KG

Pulley wheel

MIM PACKAGE

Metal Injection Molding

Metal injection molding (MIM) is a process for making metal parts, in which an injection molding compound consisting of a metal powder, polymer binder and various additives is used. This compound is first formed by an injection molding process and then sintered. The sintering process removes the binder and gives the component its final strength. Due to the use of metal powder, the plasticizing system is subjected to extreme abrasive and adhesive wear.

Package highlights:

» bimetallic barrel
» screw made of abrasion-resistant steel alloy
» specialized check valve and screw geometry for processing powder injection molding compounds

Milling tool with coolant channels

CIM PACKAGE

Ceramic Injection Molding

Similar to metal injection molding (MIM), a compound consisting of a binder and some additives is used, but this time combined with ceramic powder. The greatest impact MIM compounds have on plasticizing units is abrasion, due to the hard ceramic particles in the compound.

Package highlights:

» bimetallic barrel
» screw made of a special, extremely abrasion-resistant material
» specialized check valve and screw geometry for ceramic powder compounds

Cogwheel made of ceramic compound

SELF-PRODUCTION AND APPLICATION TECHNOLOGY
Quality and expertise from a single source

In addition to the development and optimization of drive and application technologies, the continuous improvement of plasticizing systems is a top priority at WITTMANN BATTENFELD.

In-house production at WITTMANN BATTENFELD, using optimized manufacturing processes, is geared to satisfying the most stringent quality requirements. High-tech manufacturing centers and a fully equipped technical lab, which are continuously further extended, are at our disposal for comprehensive quality management and constant further development.

» **Production and quality**
WITTMANN BATTENFELD insists on a high level of vertical production in the interest of optimal response to our customers' wishes using our broad and diverse in-depth knowledge. To promote the further advancement of know-how, we regularly invest in new manufacturing technologies. Our production equipment includes a stock of machinery consisting of manufacturing centers and heat treatment furnaces as well as automatic grinding and polishing systems. All system-relevant components undergo 100 % quality inspection in our measuring room, which is equipped with 3D measuring machines.

- Production of high-precision components such as screws, check valves and barrels
- In-house nitrating plant
- In-house rough and fine polishing stations for high-gloss surface finish
- Multi-axis manufacturing centers
- 3D measuring machines

» **Application technology assistance**
WITTMANN BATTENFELD ranks among the pioneers in injection molding technology and has made substantial contributions to the development of standard and specialized processes, in particular the processes listed below.

- AIRMOULD® – a complete solution for gas injection technology
- COMBIMOULD – customized multi-component technology solutions
- CELLMOULD® – a physical foaming process developed in-house
- WPC (Wood Plastic Compounds)
- Co-injection (sandwich) molding
- BFMOLD® – variothermal mold tempering
- VARIOMOULD® – variothermal process with hot water temperature controllers

RESEARCH AND DEVELOPMENT
Efficiency through innovation

To meet the ever more stringent market demands and continuously increase the efficiency of our products, we engage in fundamental research and development.

To advance the fundamental research for plasticizing systems, we have established cooperation partnerships with the Plastics Technology Department at the University of Leoben, the Institute for Material Sciences and Technologies of the Vienna University of Technology, and the Austrian Center of Competence for Tribology (AC2T research GmbH).

» **Technical lab for development and application technology**
In our corporate R&D department, the plasticizing components are subjected to systematic, continuous further development and improvement. The performance of all new developments is verified by practical tests.

In our technical lab, machines and peripherals of various sizes from many different series are available to our customers for feasibility studies and test runs. In this way, it is possible to validate customized solutions in practice.

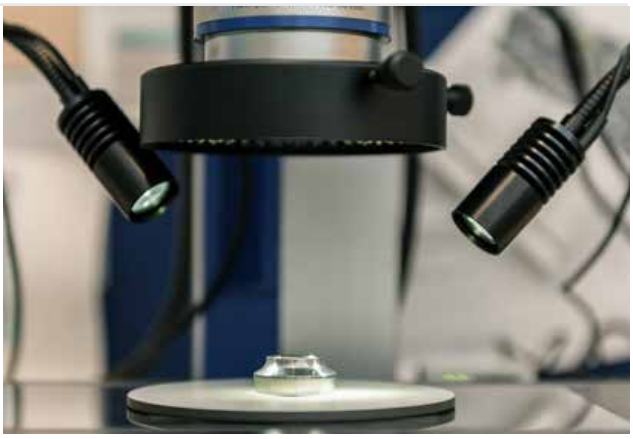
- Machines from a great variety of series and various peripheral systems including complete production cells
- Screw operation simulators with comprehensive measurement data acquisition
- Equipment for screw measurement and inspection of plasticizing components

» **Material testing and development**
Laboratory and testing equipment is available at WITTMANN BATTENFELD and cooperating partners. Our customers and business partners can use these resources to answer their individual questions.

The findings gained from our regular research and development projects are continuously utilized in systematic further development of our serial production technology.

Various types of special tools and equipment are available internally or externally (via our cooperation partners), such as

- Stereoscopic microscope
- Endoscope
- Hardness testing equipment
- Metallographic equipment
- Material testing equipment
- Tribometer
- Scanning electron microscope (SEM)
- many more



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