BÖHLER

PLASTIC
MOULD STEEL

HIGH PERFORMANCE MOLD STEELS FOR INJECTION OF FIBER-REINFORCED PLASTICS

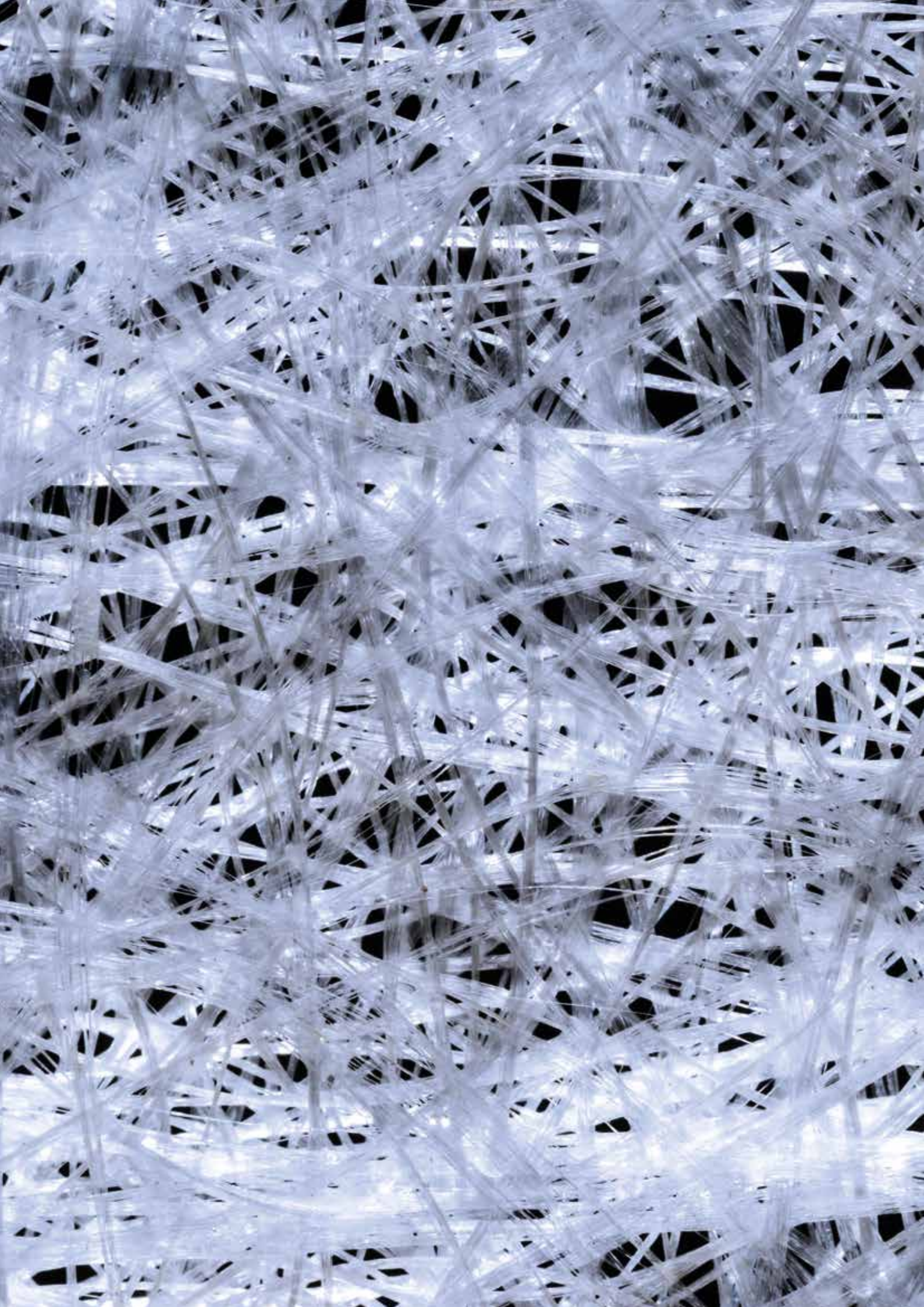
voestalpine BÖHLER Edelstahl GmbH & Co KG
www.voestalpine.com/bohler-edelstahl

voestalpine
ONE STEP AHEAD.

HIGH PERFORMANCE MOLD STEELS FOR INJECTION OF FIBER-REINFORCED PLASTICS

Modern industrial parts production in mainly automotive and electronic industries is characterized by the trend to substitute metals by fiber-reinforced plastics. Being much lighter and therefore weight-saving, such plastic components help to reduce CO_2 emissions, which is a clear ecologic focus worldwide. Intricate geometries, thin wall-thicknesses and large areas of the parts are characteristics that call for a growing amount of glass or carbon fibers in the plastics to obtain sufficient stability.

Plastics reinforced by fibers tend to be much more abrasive than conventional plastics and thus may cause premature wear of an injection mold. In order to counteract excessive and early wear in molds, voestalpine BÖHLER Edelstahl is offering a wide variety of high-quality tooling steels that are setting new standards in the production of heavy-duty components made from fiber-reinforced plastics.



TRENDS AND REQUIREMENTS

» New types of high performance plastics (GF, CF, fibre length, filler material)

» Increasing wear resistance requirements on mold material

» Increasing corrosion resistance of mold material (e.g. phosphoric flame-retardants)

» Complexity of parts increased (light weight construction)

» Increase productivity through shorter cycle times (thermal conductivity)

» Higher closing pressures and processing temperatures

PLASTIC MOLDING

EXAMPLE OF „POLYMERIC LEIGHT WEIGHT CONSTRUCTION“

Prototype:
Plastic steering case

» Equal cost part made of 50% glass fiber reinforced PA (Ultramid® A3R) with metal inserts
» Special FEM –Design modification
» Service temperature: max. 125 °C
» **50% weight savings**

Source: ThyssenKrupp techforum 1/2014

Steering casing
Al- HPDC part
(Symbolic picture)

HIGH PERFORMANCE PLASTICS

AUTOMOTIVE INDUSTRY

PA6 – GF65

PA66 – CF35

HOUSEHOULD INDUSTRY

PA66 – CF35

PC+ABS – GF40

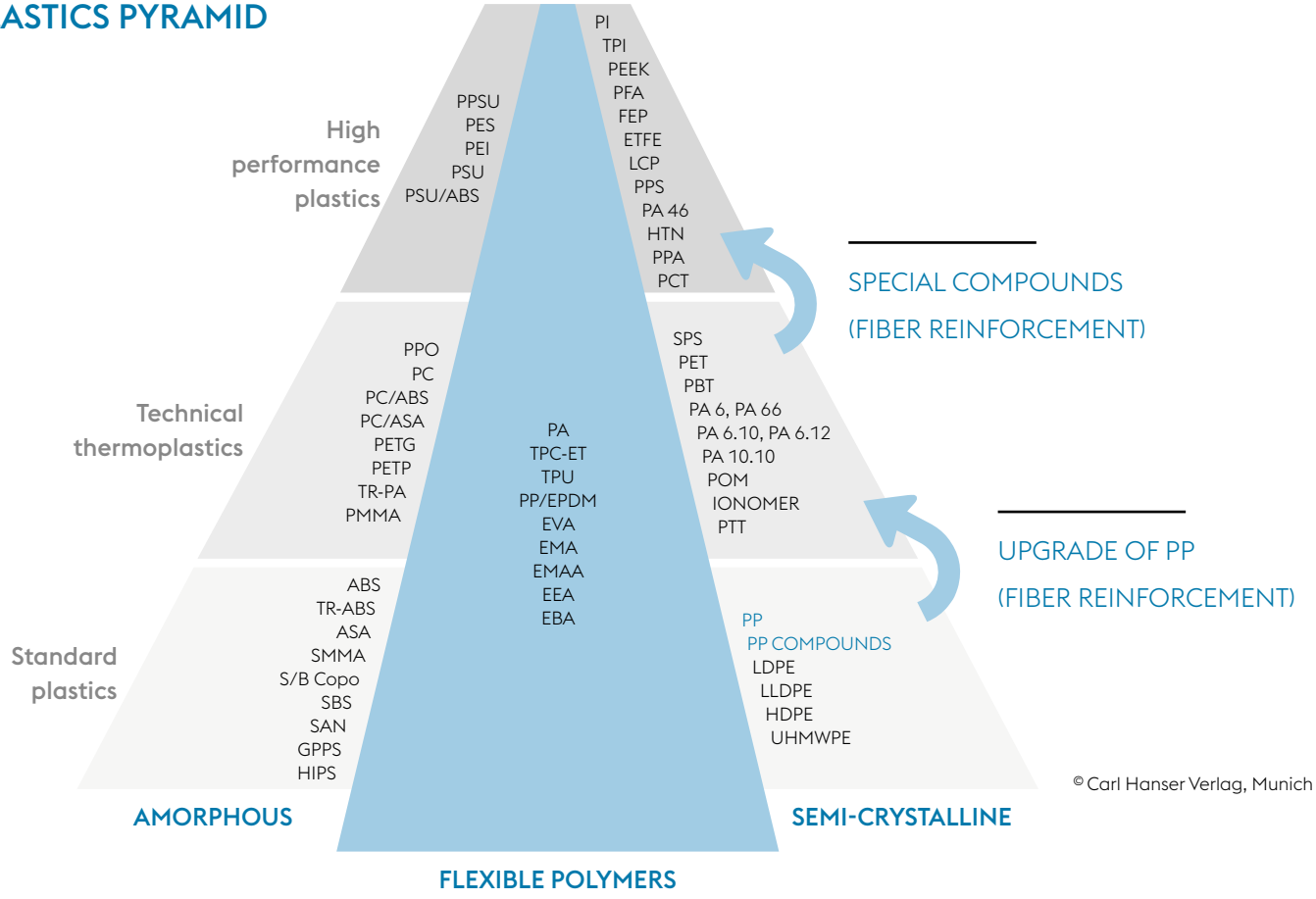
PA6 – GF40

ELECTRONICS INDUSTRY

PBT – GF45

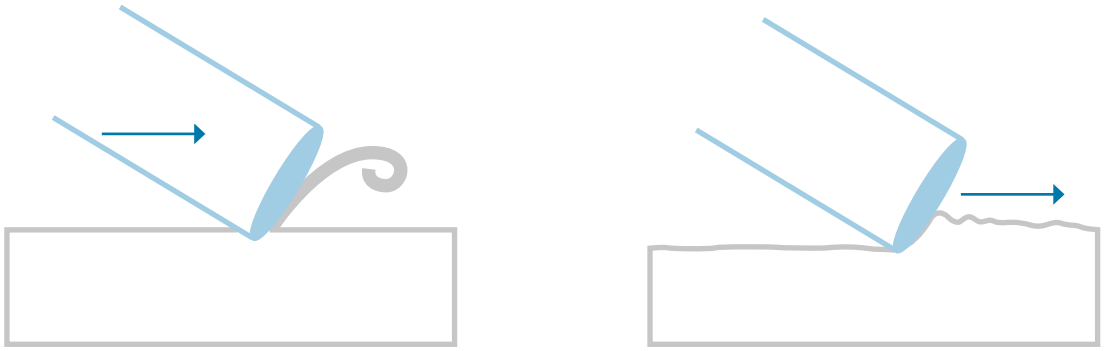
PA66 – GF30

PLASTICS PYRAMID



WEAR MECHANISM

Fiber motion causes abrasive wear by

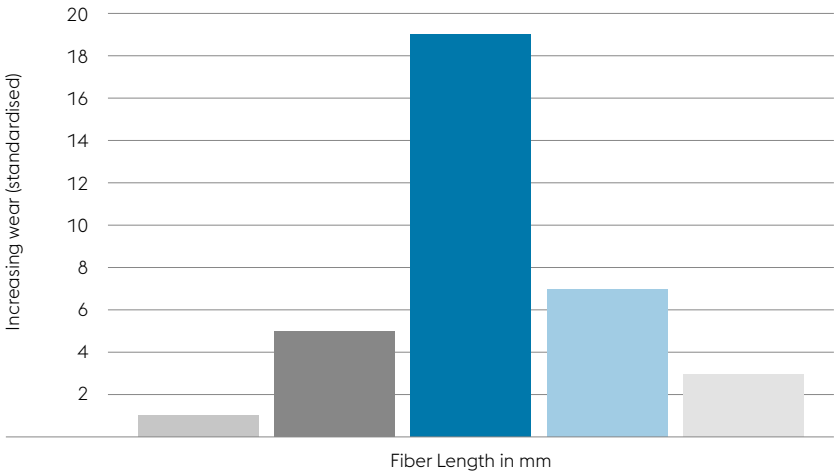


Beside glass fibers also glass balls, metal oxides (titanium oxide, chromium oxide), calcium carbonates, silica components (sand, quartz), ceramics .... are forcing abrasive wear.

Source: Department of Injection Moulding of Polymers, University of Leoben

INFLUENCING FACTORS

Fiber Length

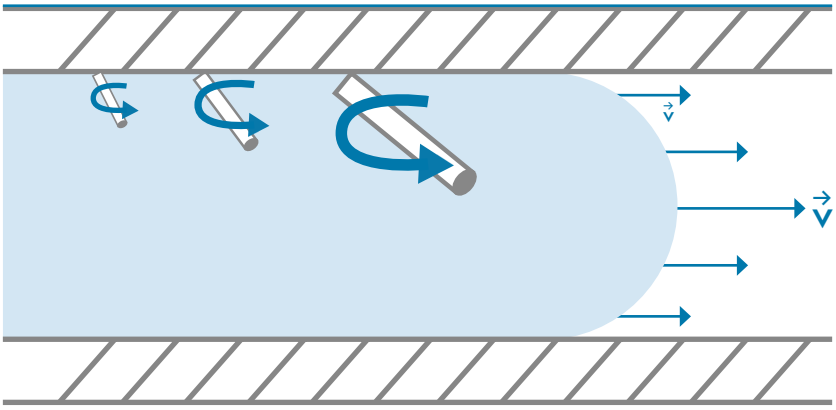


Typical fiber diameter: 10 µm

- Length up to 200 µm
- 200 µm < L < 500 µm
- 500 µm < L < 1000 µm
- 1000 µm < L < 2000 µm
- Length > 2000 µm

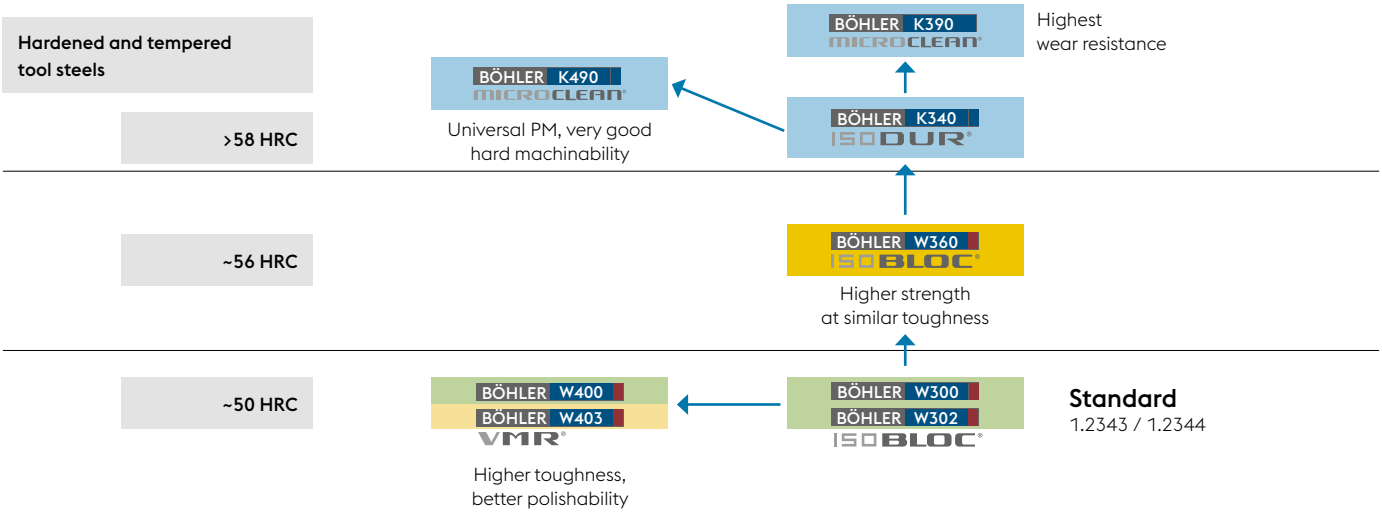
Source:
Department of Injection Moulding of Polymers, University of Leoben

Polymer melt with glass fibers



PRODUCT SELECTION – HIGH PERFORMANCE MOLD STEELS

Non corrosion resistant steels



- up to ~20% GF
- up to ~30% GF
- up to ~60% GF
- up to ~65% GF

Examples for processed plastics
PA6 - GF50
PA66 - GF40
PA66 - GF35
PA66 - GF30
PC+ABS-GF40
POM - CF35
PA6 - GF65
PA6 - CF45

MICROCLEAN®
Powder metallurgical steels

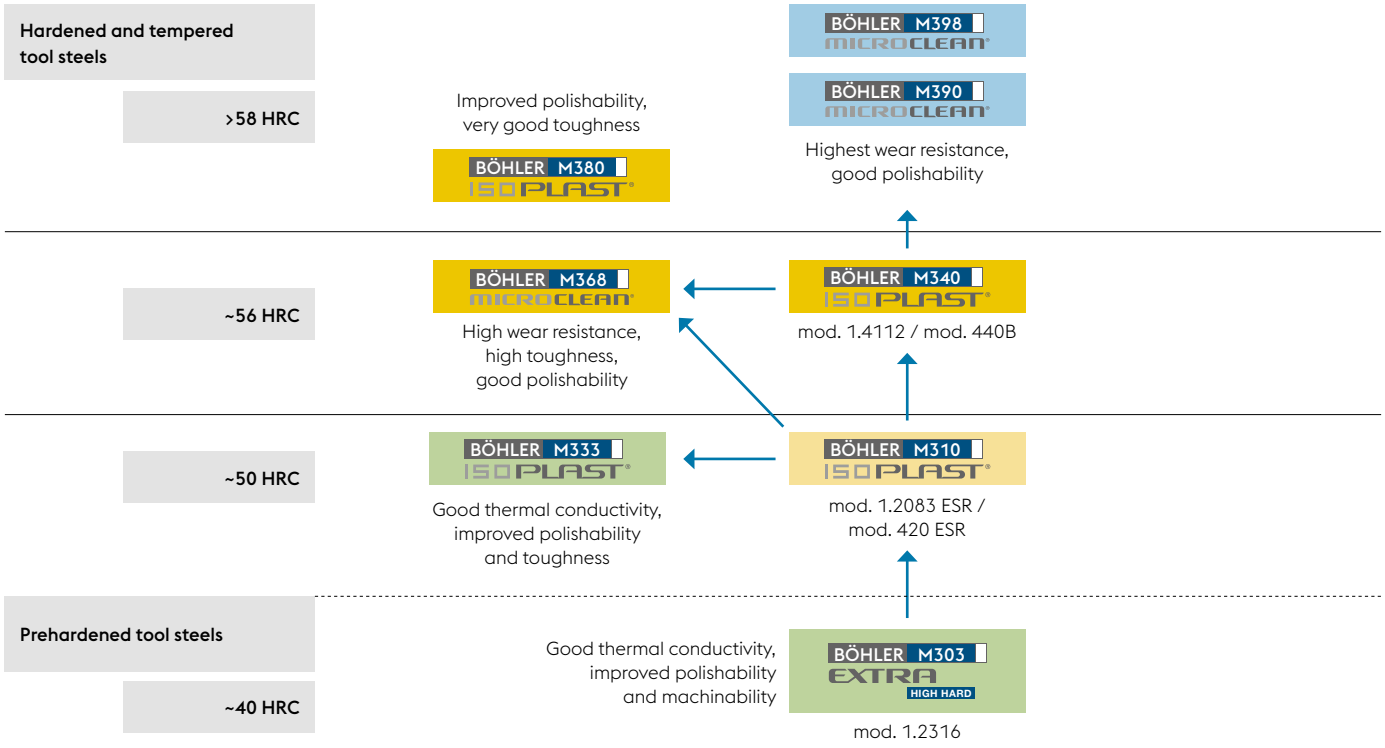
VMR®
Special materials subjected to vacuum refining or melting during at least one stage of manufacture.

ISODUR®
Cold work tool steels in ESR quality

ISOBLOC®
Hot work tool steels in ESR quality with special heat treatment

BÖHLER grade	Chemical composition in weight %					Others	Standard	Carbide vol-[%] hardened	Wear resistance
	C	Cr	Mo	Ni	V				
BÖHLER W300 ISOBLOC	0.4	5.0	1.3	0.4	–	–	1.2343 / H11	< 1	★
BÖHLER W302 ISOBLOC	0.4	5.2	1.4	1.0	–	–	1.2344 / H13	< 1	★
BÖHLER W400 VMR	0.4	5.0	1.3	0.5	–	–	1.2340 / ~H11	< 1	★
BÖHLER W403 VMR	0.4	5.0	2.8	0.7	–	–	1.2367	< 1	★
BÖHLER W360 ISOBLOC	0.5	4.5	3.0	0.6	–	–	–	< 1	★★
BÖHLER K340 ISODUR	1.1	8.3	2.1	0.5	–	+Al, Nb	–	8.5	★★★
BÖHLER K490 MICROCLEAN	1.4	6.4	1.5	3.7	3.5	+ Nb	–	10	★★★★
BÖHLER K390 MICROCLEAN	2.5	4.2	3.8	9.0	1.0	+ 2.0 Co	–	17	★★★★★

Corrosion resistant steels (minimum free chromium content in the matrix of 13 %)



- up to ~10% GF
- up to ~15% GF
- up to ~60% GF
- up to ~65% GF

Examples for processed plastics
PVC, CPVC, PES, PSU, PVDF, ABS

MICROCLEAN®
Powder metallurgical steels

ISOPLAST®
Plastic mould steels in ESR quality

EXTRA
Special property and/or achievement characteristics

BÖHLER grade	Chemical composition in weight %					Others	Standard	Carbide vol-[%] hardened	Wear resistance
	C	Cr	Mo	Ni	V				
BÖHLER M303 EXTRA HIGH HARD	0.27	14.50	1.00	0.85	–	+N	~1.2316	< 1	★
BÖHLER M333 ISOPLAST	0.24	13.25	+	+	+	+N	~1.2083 / ~420	< 1	★★
BÖHLER M310 ISOPLAST	0.38	14.30	–	–	0.20	–	~1.2083 / ~420	1.5	★★
BÖHLER M340 ISOPLAST	0.54	17.30	1.10	–	0.10	+N	–	ca. 8%	★★★
BÖHLER M368 MICROCLEAN	0.54	17.30	1.10	–	0.10	+N	–	ca. 8%	★★★
BÖHLER M380 ISOPLAST	0.30	15.00	1.00	–	–	+N	1.4108	ca. 5%	★★★
BÖHLER M390 MICROCLEAN	1.90	20.00	1.00	–	4.00	W=0.60	–	ca. 20%	★★★★★
BÖHLER M398 MICROCLEAN	2.70	20.00	1.00	–	7.20	W=0.70	–	ca. 30%	★★★★★

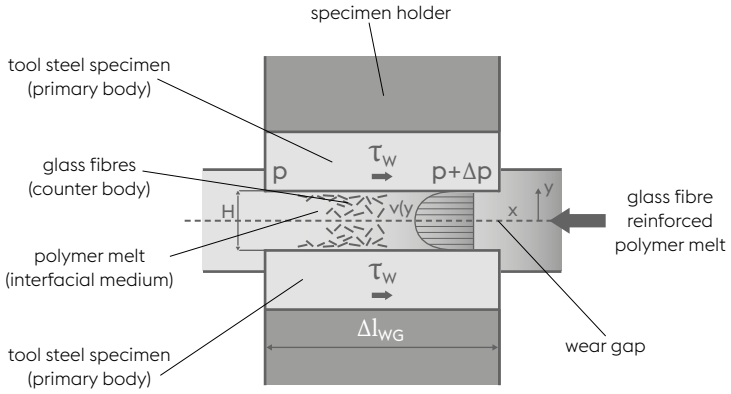
HEAT TREATABLE,
WEAR RESISTANT MOLD STEEL

The wear is determined either by mass loss or volumetrically by 3D measurement of the sample surfaces before the test and after injection of, for example, 25 kg or 50 kg of glass fiber reinforced plastic molding compound.

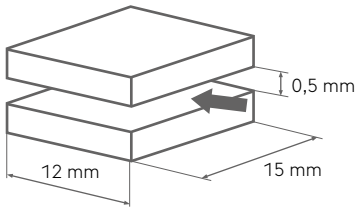
The wear apparatus for testing the abrasive / corrosive wear on the tribosystem polymer melt / steel is installed in the injection molding machine in the form of an injection molding tool. The wear samples, which have the same temperature as the melt, form a rectangular gap in which large local shear stresses and shear rates can be generated. The melt is injected through the wear gap and generates the material removal on the surfaces of the two wear samples (each 15 x 12 x 5 mm). The entire dosing volume of the plasticized molding compound is injected at a defined injection pressure, defined injection rate and a specified melt temperature.

The wear is determined by the material removal (mg / cm^2) or the material removal height (µm) before and after injected a defined amount of plastic melt.

Small Plates Wear Tests

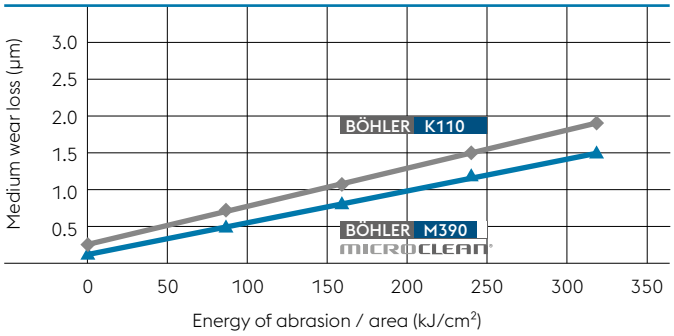


Mean depth of abrasion or weight loss of the testing plates indicates the wear resistance.

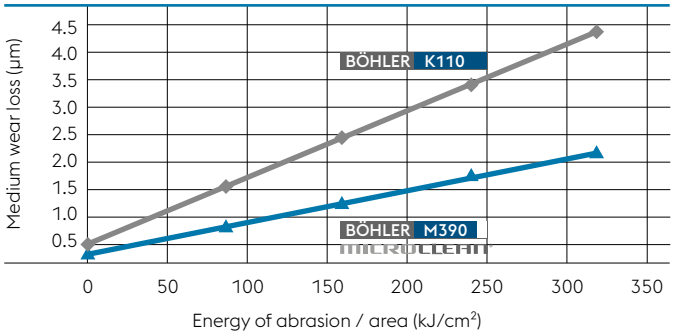


EFFECT OF CORROSION AND ABRASION – LABORATORY TEST RESULTS K110 VS. M390 MICROCLEAN, RESULTS FROM PLATES WEAR TESTS

PA 66 + 30% GF/ 300°C



PES + 30% GF/ 400°C



Hardness

Abrasion

Free Cr

Corrosion + Abrasion

Facts

» Filling materials and additional fibers in various plastic materials have an abrasive effect

» Together with corrosive media (fission products,...) tribochemical wear system emerges

%	C	Cr	Mo	V	W
K110	1.55	11.80	0.80	0.95	
M390PM	1.90	20.00	1.00	4.00	0.60

	Hardness (HRC)
K110*)	58
M390PM	61

Beside wear and corrosion resistance further important factors to choose the right material are:

» Tool design (complex/simple, deep/shallow cavity, ...)

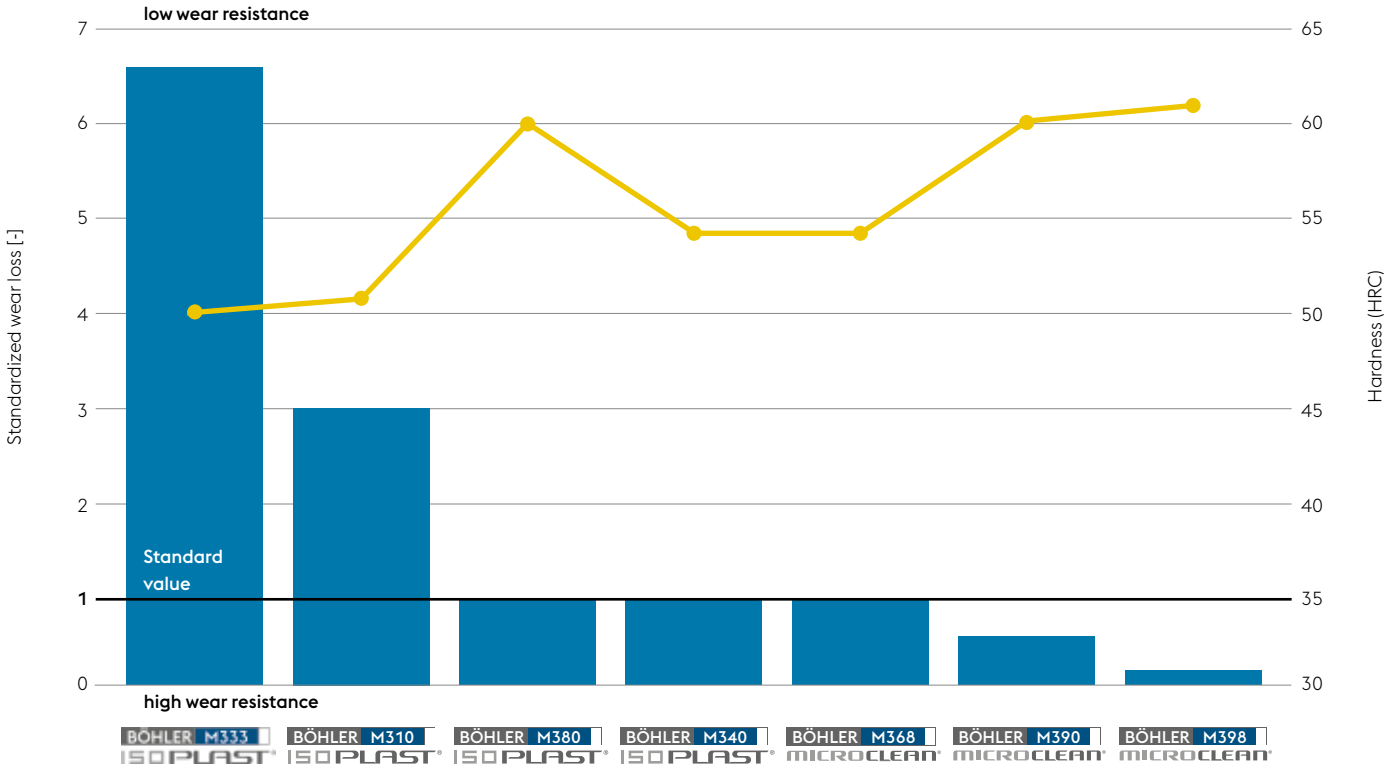
» Tool size

» Surface requirements on the mold

Additional aspects are for instance dimensional stability, edge stability, machinability, ability for coating....

Detailed recommendations have to be checked case by case.

WEAR RESISTANCE WITH PLATE-WEAR TEST



wear

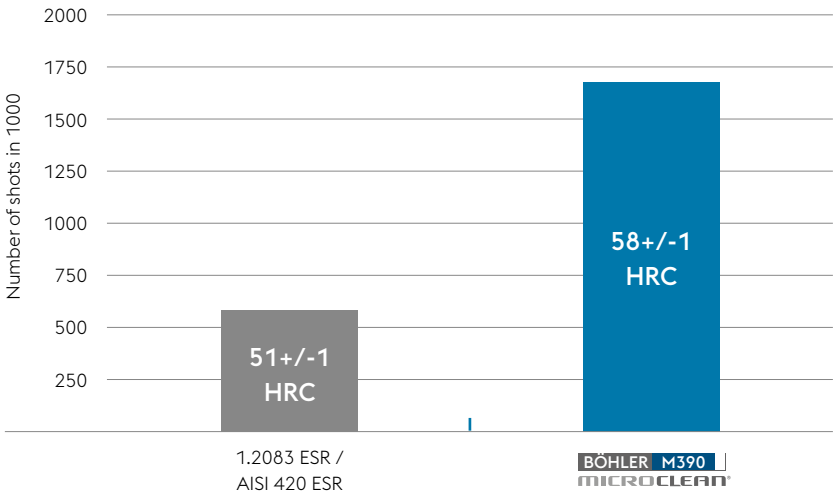
hardness

Glass fiber reinforced polymer melt:
PA 66 + 50 % GF

CASE STUDIES

ELECTRICAL COMPONENTS
BASE PLATES FOR RELAYS

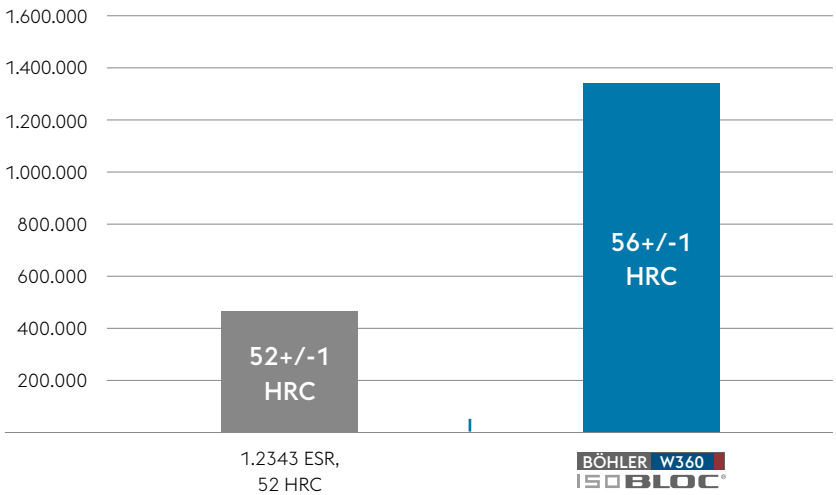
BÖHLER M390 MICROCLEAN



Processed material:
PBT Vestodur X7212 NF + 45% GF
Cause for tool damage: Wear

HOUSEHOLD COMPONENTS
GEARS

BÖHLER W360 ISOBLOC



Processed material: PA66 + GF35
Cause for tool damage: Wear

QUALITY LEVELS TECHNOLOGIES

Conventional Production

THE „STANDARD“ MATERIAL FOR ORDINARY STRESS, NORMAL LEVEL WITH:
Structural conditions
Carbide distribution
Homogeneity
Individual carbides
Degree of purity
Toughness

Microstructure
BÖHLER M303

Pressure Electro Slag Remelting Production

ISOPLAST® ISODUR® ISOBLOC®

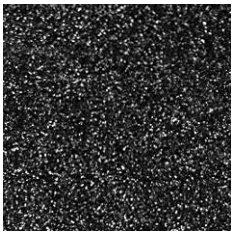
IMPROVED SERVICE LIFE DUE TO:
Least possible inclusion content
Lower micro and macro segregation
Good homogeneity and a higher degree of purity
Homogenic structure throughout the entire cross-section and bar length
Producing larger bar dimensions at a constant carbide distribution
Uniform dimensional stability
Broad range of application owing to a high degree of toughness

Microstructure
BÖHLER M340
in ESR quality

Powder Metallurgical Production

MICROCLEAN®

FOR THE HIGHEST DEMANDS:
Segregation free high performance steel
Finest carbide distribution
Highest metallurgical purity
Isotropic properties
Maximum wear resistance with a simultaneously higher toughness
High degree of hardness
Very good dimensional stability
High compressive strength



Microstructure
BÖHLER M390
MICROCLEAN

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