APPLICATION INFORMATION

ADDITIVES FOR EPOXY APPLICATIONS

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Introduction to epoxy applications

Epoxy resins are used today in a wide variety of different products. This is attributed to good commercial availability of raw materials and also because of specific properties such as:

- Excellent electrical insulating values
- Outstanding adhesion
- Excellent chemical resistance
- Good mechanical properties

These properties can be modified depending on the type of resin and hardener system that is chosen and even further influenced by the choice of other raw materials used, such as fillers, reinforcements, and additives.
The selections made lead to reinforced products, such as wind blades, pipes, automotive parts, and sporting goods (ski, surfboards, etc.), or to non-reinforced applications, such as flooring, mineral cast, putties, paints, adhesives, and resins for electrical casting and insulation.

Along with this broad range of final applications comes a variety of different application techniques:
Reinforced parts could be made by simple manual lay-up, but also by RTM or infusion technology, and several casting or spraying technologies are available for non-reinforced systems.

For additional information on additives and technical topics, please contact us:
Thermosets.BYK@altana.com

Note

To ensure the best appearance and full functionality, please open in Adobe Acrobat.

Air release

Entrapped air bubbles are a common challenge in manufacturing or applying epoxy based systems. They are difficult to remove, especially in highly thixotropic and pseudoplastic formulations or high wet film thickness. These same air bubbles ultimately develop into pinholes, which increases porosity and dramatically reduces the overall performance of the final part. Defoamers as well as air release additives can prevent:

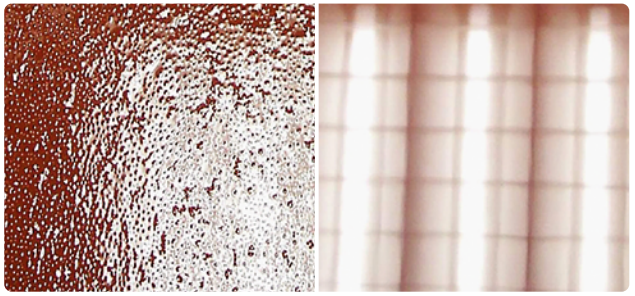
- Blisters in gelcoats
- Pinholes
- Loss of insulation properties in electrical casting systems
- Weakening of the composite structure
- Poor appearance
- Porosity

of the final part.

The additive is added to the resin or the hardener at the beginning of the manufacturing or mixing process. This guarantees that it is active during the production of each component as well as during the mixing process of the resin and hardener prior to the application.

Air release in a solvent-free, 2-pack epoxy casting system

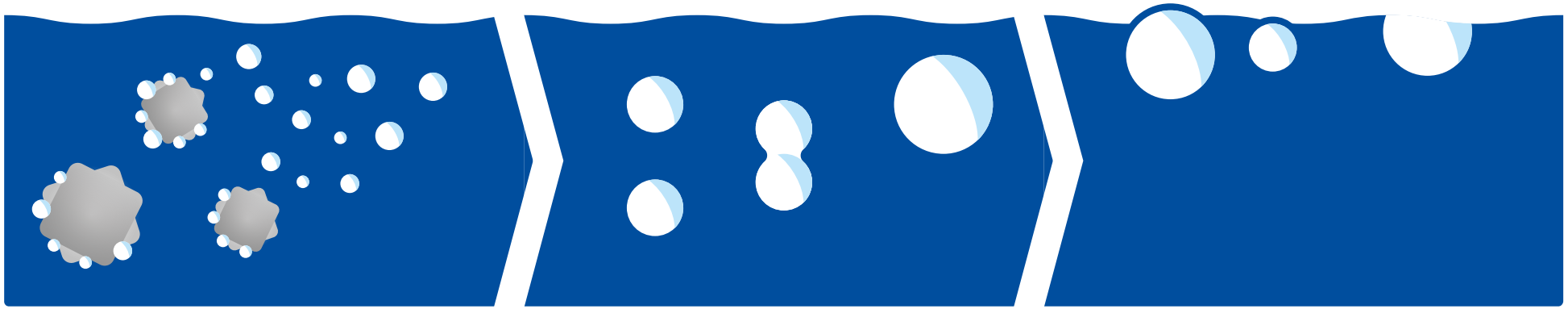
Without additive **With 1 % BYK-A 530**



G.01

Air release additives work in three steps

Step 1 **Step 2** **Step 3**



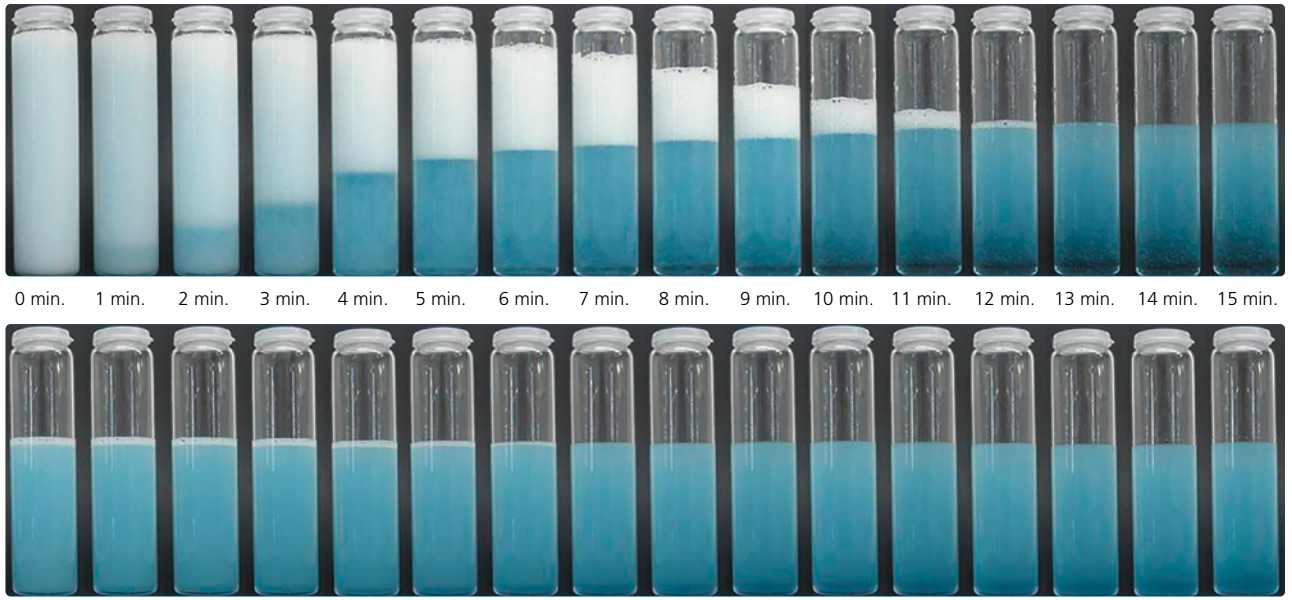
G.02

Defoamers and air release additives can be based on (modified) polysiloxanes, silicon-free polymers, or a combination of both. Whether or not a particular polymer can destroy foam bubbles depends on the product compatibility and solubility in the liquid medium. All defoamers and air release additives must have some degree of incompatibility – managing that delicate balance between compatibility and incompatibility. This is achieved by adjusting the molecular weight and/or polarity of the polymeric structures.

Some additives are especially designed for specific requirements, e.g. potable water, FDA, AgBB, PIM, high voltage, clear, etc. As regulations can change, please refer to the relevant documents on our webside or contact our product safety department.

Air release performance after the production process

Control



0.3 % BYK-1788

G.03

Additives to prevent air entrapment, foam, and pinholes

System	Product	Remarks
Silicone-based	BYK-077	Very effective, universal
	BYK-A 525	Universal
	BYK-S 732	Solvent-free, universal
Silicone-free, polymer-based*	BYK-1788	VOC-free
	BYK-1790	Solvent free, for food contact applications (PIM)
	BYK-A 501	Universal
Silicone/polymer combination	BYK-A 530	Best air release effect in epoxies
	BYK-P 9920	VOC-free, fiber wetting performance

* For incorporation into the amine component, silicone-free products are recommended.

T.01

Wetting and dispersing

One of the most important steps in producing filled or pigmented epoxy systems is the homogeneous distribution of the solid pigments and filler within the liquid resin solution. If this step (grinding) is not optimized, a wide range of defects such as flocculation, flooding and floating (pigment separation), and settling can occur as well as poor flow behavior during application.

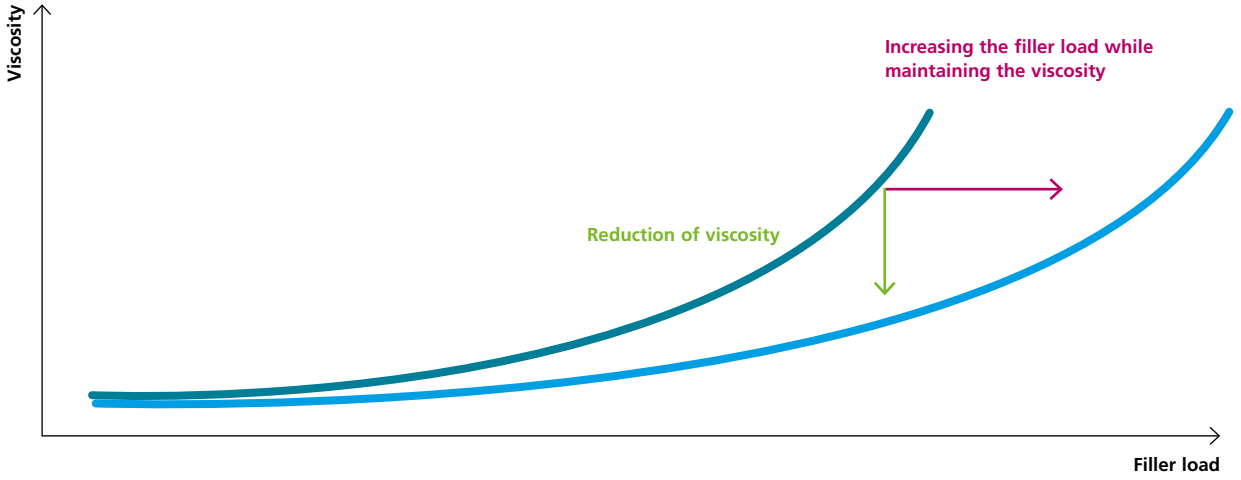
Wetting and dispersing additives are added prior to the incorporation of the filler/pigment. They will accelerate the wetting of solid particles, stabilize them, and can provide the following benefits:

- Viscosity reduction
- Improved flow
- Increased filler load
- Reduced filler sedimentation
- Color homogeneity

By using wetting and dispersing additives, a lower viscosity can be obtained. When the viscosity is reduced, the choice between better flow or an increase of filler load can be made (G. 04).

Selecting the correct additive is dependent on the application requirements and the raw materials. Different types of fillers require different wetting and dispersing additives (G. 06 and G. 07). A combination of wetting and dispersing additives with air release additives will improve the final result.

Wetting and dispersing additive: lower viscosity or higher filler load

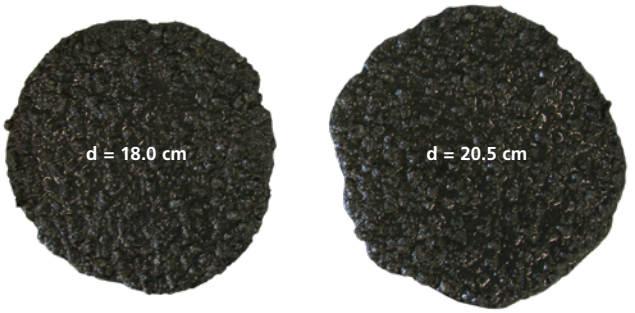


Reference Formulation including wetting and dispersing additive

G. 04

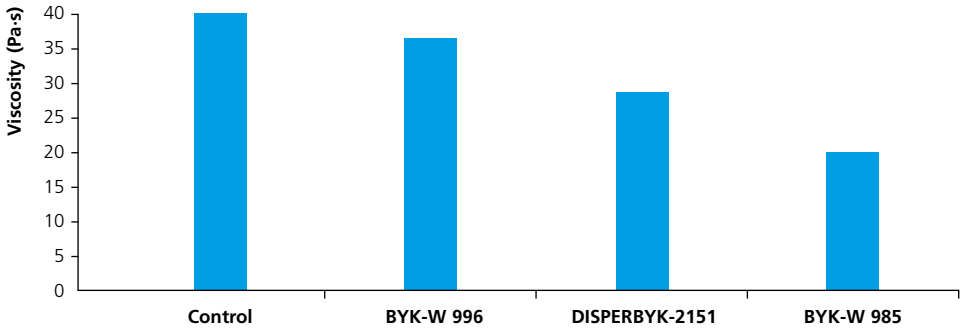
Better flow with BYK-W 985 in a mineral casting filled with quartz

Without additive **2 % BYK-W 985 on resin**



G. 05

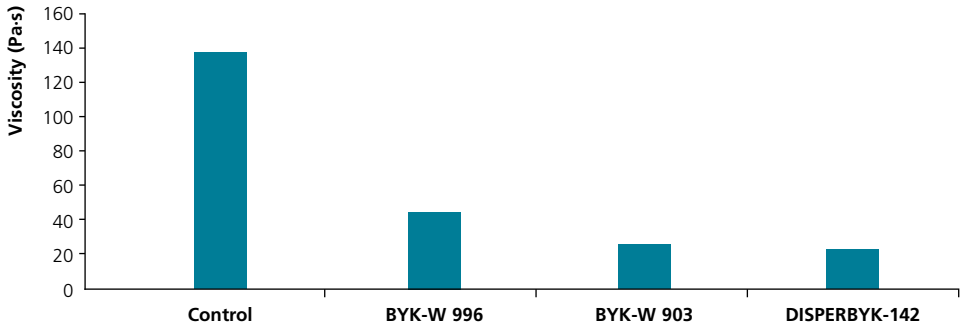
Viscosity reduction with quartz



Additive dosage: 1 % on filler

G.06

Viscosity reduction with aluminum hydroxide



Additive dosage: 1 % on filler

G.07

Recommendations regarding viscosity reduction depending on filler type

Filler type	Product
Quartz	BYK-W 985 ● DISPERBYK-2151 ○
Calcium carbonate	BYK-W 996 ● BYK-W 985 ○
Ammoniumpolyphospate	BYK-W 903 ● BYK-W 996 ○
Aluminium hydroxide	DISPERBYK-142 ● BYK-W 903 ○
Bariumsulfate	BYK-W 985 ● BYK-W 996 ○

● First recommendation ○ Second recommendation

T. 02

Recommendations for wetting and dispersing additives

Application	Product	Remarks
Strong viscosity reduction	BYK-W 903	Very effective with APP, suitable for anhydride systems
	BYK-W 985	Very effective, universal
	BYK-W 996	Very effective with $CaCO_3$
	DISPERBYK-142	Very effective with ATH
Viscosity reduction combined with anti-settling properties	BYK-W 980	Very effective, universal
Pigment stabilization and viscosity reduction	BYK-9076	Very stable in epoxy resin even at higher dosage
	DISPERBYK-2151	
	DISPERBYK-2152	
Silicone/polymer combination	ANTI-TERRA-204*	Suitable for amine hardener
	BYK-W 940	Universal

* Additives with higher amine values, like ANTI-TERRA-204, can cause viscosity increase when used in epoxy part

T. 03

Rheology

Rheology is impacting many properties of epoxy resin systems, e.g. flow behavior, air release or sagging and settling issues. Furthermore, the rheological profile of epoxy systems is considerably affected after mixing resin with hardner due to the mixing ratio and polarities of the components. It is therefore very important to formulate the rheological profile of single components as well as the final system. To adjust rheology, BYK offers different types of rheological additives:

- Liquid rheology additives
- Solid rheology additives
- Thixotropy booster

All of them modify the sagging and/or settling properties. Higher viscosity at low shear in combination with a high yield point can substantially reduce both sedimentation and sagging. This results in a longer shelf life with less settling and better sag resistance during application.

During storage, pigments and fillers in a system can settle and form sediments that are difficult to re-disperse. This depends on the filler load, type of filler, and the storage conditions (e.g. temperature).

During application on inclined and vertical surfaces, running and sagging frequently occur at higher film thicknesses.

Liquid rheology additive

Liquid rheology additives are self-sufficient. They are used to adjust anti-settling and anti-sagging properties. They can be added to the epoxy resin as well as to the hardener.

Examples for this additive family are RHEOBYK-7410 ET and RHEOBYK-430.

RHEOBYK-7410 ET is a modified urea that forms strong, three-dimensional network structures, thereby creating thixotropy.

RHEOBYK-430 is based on polyamides modified with compatibility-enhancing groups (alkyl and polyether segments) to optimize the incorporation as well as the rheological activity. It creates a pseudoplastic flow behavior.

Solid rheology additives

Solid thixotrope additives are mainly used for anti-settling. They build up a network between the single particles, and are easy to incorporate.

In the correct combination with a thixotropy booster (e.g. RHEOBYK-R 605, RHEOBYK-R 607), they also show an excellent sag resistance.

GARAMITE-1958 and GARAMITE-7305 are solid thixotropes based on the Mixed Mineral Technology (MMT), and can be easily incorporated into in epoxy resins as well as into epoxy hardeners.

Thixotropy booster

Optimum processability coupled with high sag resistance requires a perfectly adjusted rheology profile, and often mixed minerals or fumed silica are used for this. However, if the amine hardener is added to the epoxy resin with the solid thixotropes, the viscosity spontaneously drops. A combination of modified solid thixotropes, especially GARAMITE-7305, or hydrophilic fumed silica in the resin and RHEOBYK-R 607 in the hardener can prevent this.

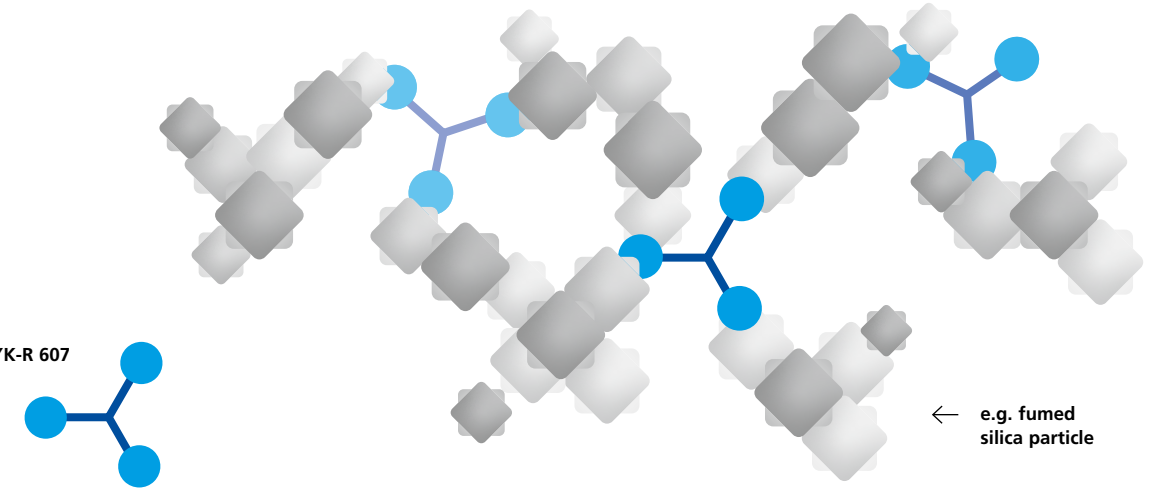
RHEOBYK-R 607 enhances the network of the solid thixotrope and leads to a better sag resistance.

An additional benefit can be found in reduced air entrapments compared to hydrophobic fumed silica.

VCT – viscosity control technology

Viscosity Control Technology is a new processing technology to achieve a special rheological profile of an epoxy system, and is explained in the processing chapter.

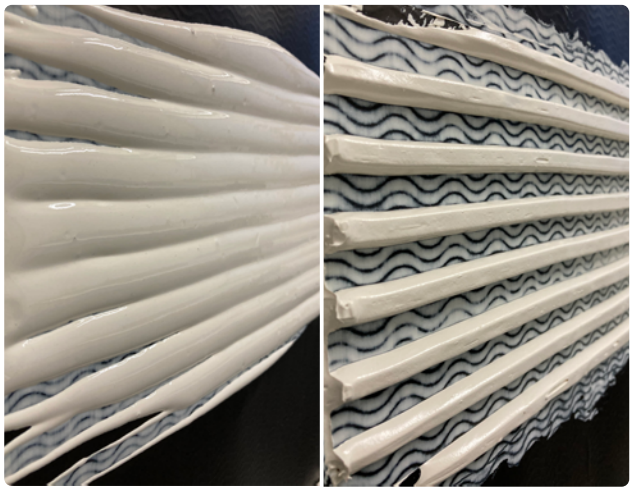
RHEOBYK-R 607 – mode of action



Multiple functional groups effectively enhance the solid thixotropic network.

G. 08

Higher sag resistance with RHEOBYK-R 607 and an additive based on mixed mineral technology (MMT)



G. 09

RHEOBYK-R 607 – less air entrapment

Hydrophobic FS **Hydrophilic FS + RHEOBYK-R 607**

G. 10

Recommendations for rheology additives

Product type	Product	Remarks
Liquid rheology additives	RHEOBYK-7410 ET	Anti-sagging, anti-settling
	RHEOBYK-410	
	RHEOBYK-430	Anti-settling, suitable for anhydride systems
Solid thixotropes	GARAMITE-7305	Anti-sagging, anti-settling, combination with BYK-R 607 required
	GARAMITE-1958	Anti-settling
Thixotropy booster*	RHEOBYK-R 605	Anti-settling for epoxy resin
	RHEOBYK-R 607	Anti-sagging, anti-settling; to be added only to the amine component

* In combination with fumed silica or additives based on MMT

T. 04

Surface additives

Whenever an epoxy system is applied in a certain layer on a substrate, defects such as craters, Bénard cells, pinholes, orange peel, and others can appear on the surface.

One very significant parameter that has an impact on all these defects is the surface tension, or more specifically, the surface tension differences. The following additives could be used to prevent or minimize these differences in surface tension.

Easy-to-clean

Depending on the application field of the epoxy system, it could be that it becomes exposed to a variety of contaminants such as dust and grease, and needs to be fast, easy, and inexpensive to clean so as to save maintenance costs.

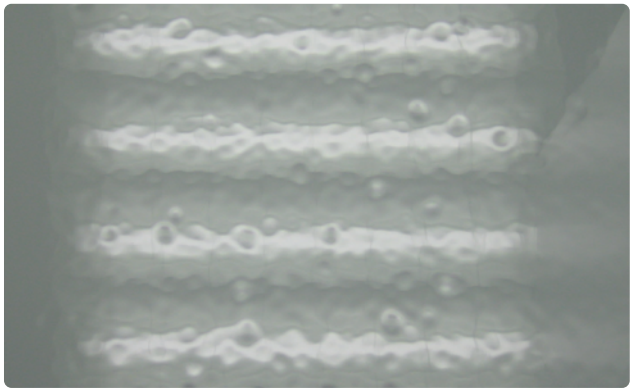
BYK has developed a silicone-containing surface additive specifically to improve cleanability (easy-to-clean effect). BYK-SILCLEAN 3701 is a liquid product with 100 % active substances. The additive achieves a permanent effect as it reacts with the polymer matrix and, as such, does not lose its effectiveness over time, like other silicone-based surface additives.

Surface additives

System	Product	Remarks
Modified polysiloxane	BYK-306	Strong surface tension reduction; anti-cratering
	BYK-310	
	BYK-A 525	Low surface tension reduction
Acrylate copolymer	BYK-361 N	Improved leveling
	BYK-S 706	
Silicone acrylate copolymer	BYK-3550	Improved leveling and substrate wetting

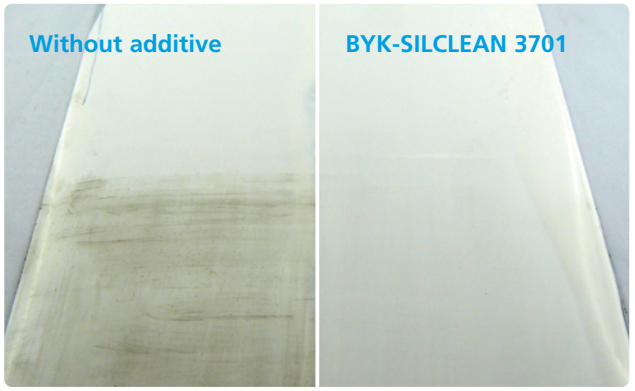
T. 05

Cratering and poor leveling



G. 11

BYK-SILCLEAN 3701 – better cleanability regardless of the contamination



Test system: conventional epoxy resin coating
Dosage: 1 % additive on total formulation
Contamination with carbon black

G. 12

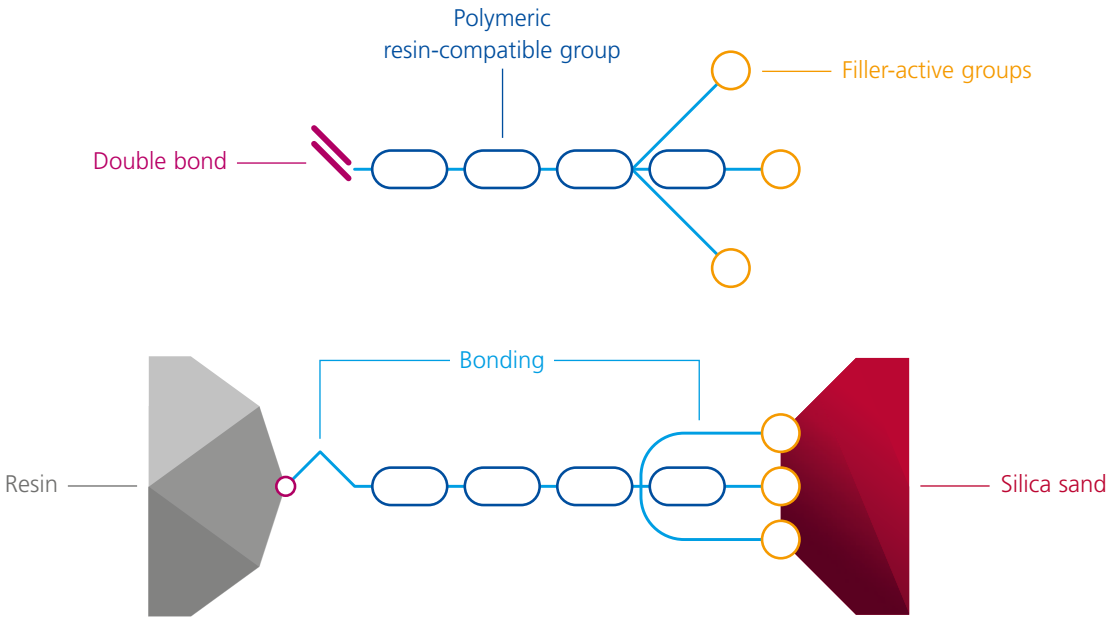
Coupling agents

Coupling additives are used wherever strength needs to be increased or the structural degree of freedom enhanced. Adhesion promoters are required when adhesion to a substrate needs to be improved.

Coupling additives improve both the static and the dynamic resilience of the component through improved filler/fiber-matrix bonding. The chemical composition of the additives enables bonding to the fibers or fillers and simultaneously to the resin matrix. This unique characteristic allows for changes in the component design and the production of more resilient components. Another key benefit is a cost saving due to a targeted reduction in wall thickness, whilst maintaining the necessary strength. Coupling agents are typically applied in hand laminates, filament winding, pultrusion, and infusion applications.

BYK-C 8001 is a polymeric coupling agent and specially developed for use in reinforced epoxy resin systems. The additive results in improved mechanical properties of the component through increased filler/fiber-matrix bonding. The additive is designed for glass fiber, non-treated glass spheres or quartz filler. The extent of the improvement depends on the choice of the glass fiber and epoxy resin system.

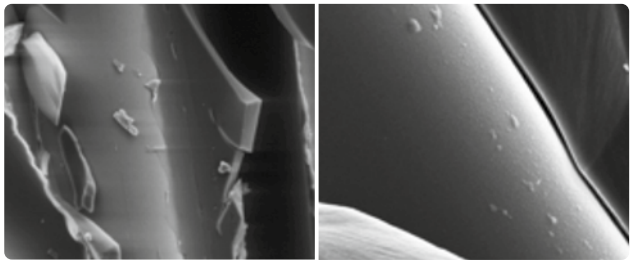
Mode of action



Filler is usually only mechanically embedded in the resin. Under stress, filled parts break at the interface filler/resin. Coupling agents can strengthen the interface between filler and resin by forming bonds, resulting in a remarkable improvement of mechanical properties.

G. 13

Without BYK-C 8001

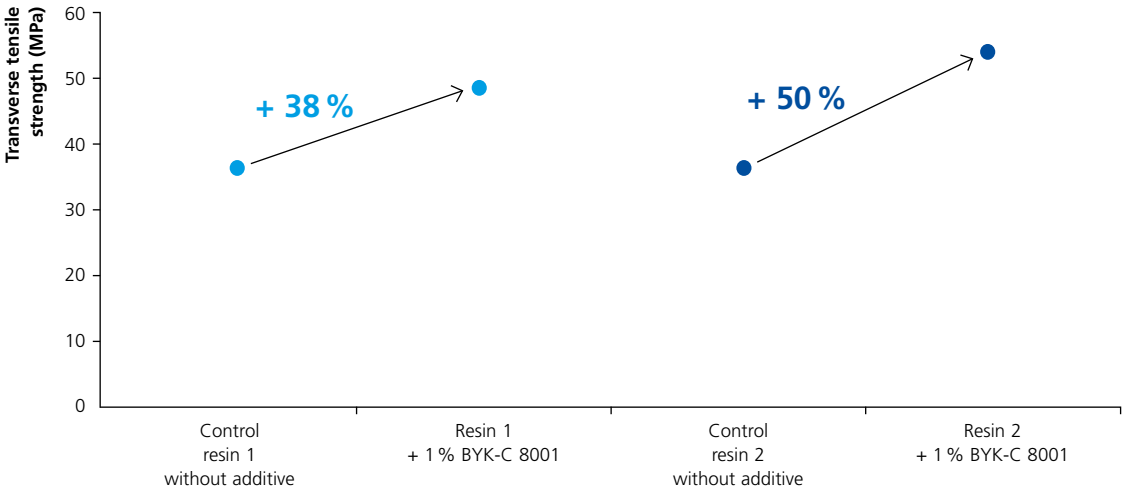


G. 14

The use of the correct coupling additive in glass fiber reinforced composites is necessary to maintain a high quality of the final part in terms of mechanical properties. This is particularly true in structural parts like wind blades or automotive components. Fiber sizings lose their performance over time depending on the storage conditions, e.g. temperature, humidity, and therefore the quality of the final part is not guaranteed. By using a coupling agent, it is possible to regain mechanical properties and maintain quality.

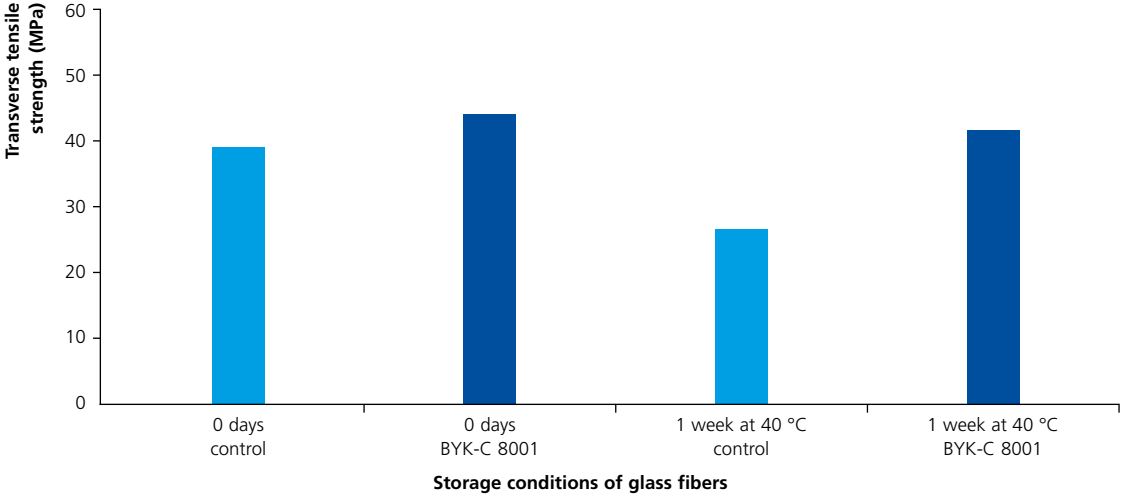
BYK-C 8001 either has to be added to the amine hardener or can be incorporated during the mixing of amine hardener and epoxy resin. The additive can be stored in standard amine hardeners. The maximum storage time is affected by the hardener composition and the additive dosage.

Improvement of mechanical properties with BYK-C 8001



G. 15

Maintaining the performance of aged glass fibers with BYK-C 8001



G. 16

Processing additives

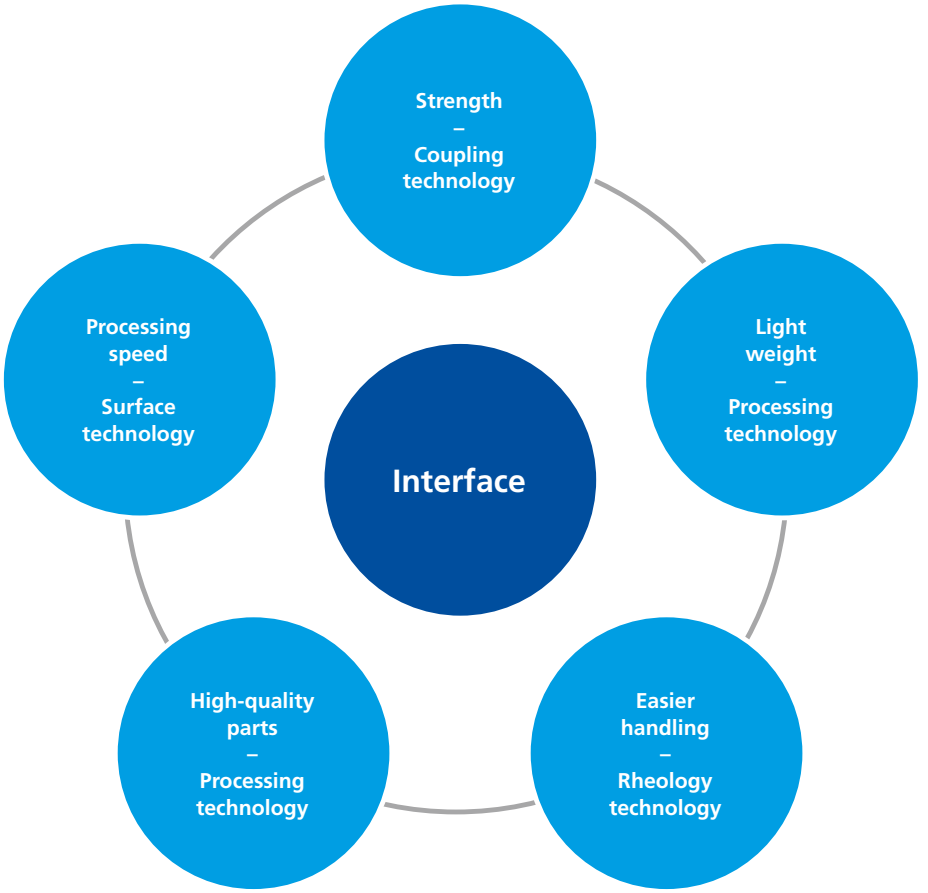
Faster production cycles and new types of production need a new generation of additives with a couple of functionalities to improve processing and quality aspects.

Faster cycle time and improved quality

Processing additives are developed in order to reduce the cycle time and accelerate the RTM or HP-RTM process by ensuring good demolding after curing in conjunction with external release agents. The external mold release application frequency is prolonged. This results in an improved potential output of the production process (G. 18).

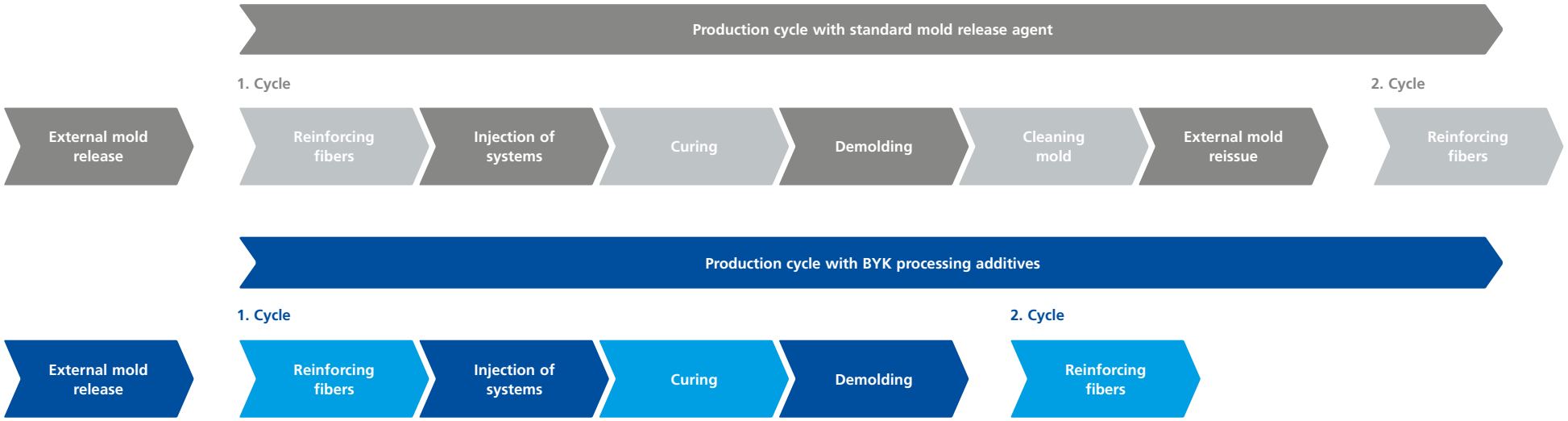
BYK-P 9912 is a processing additive with internal release properties for unfilled, filled, and fiber-reinforced systems. This results in an improved potential output of the production process with regard to a reduced downtime of the mold. BYK-P 9912 has no negative impact on processing parameters such as viscosity and reactivity. The final part provides a ready-to-coat and ready-to-bond surface at the same composite specification but with improved quality.

Interface chemistry is key for advanced composites



G. 17

Optimized production cycle



G. 18

Improved wetting and faster processing

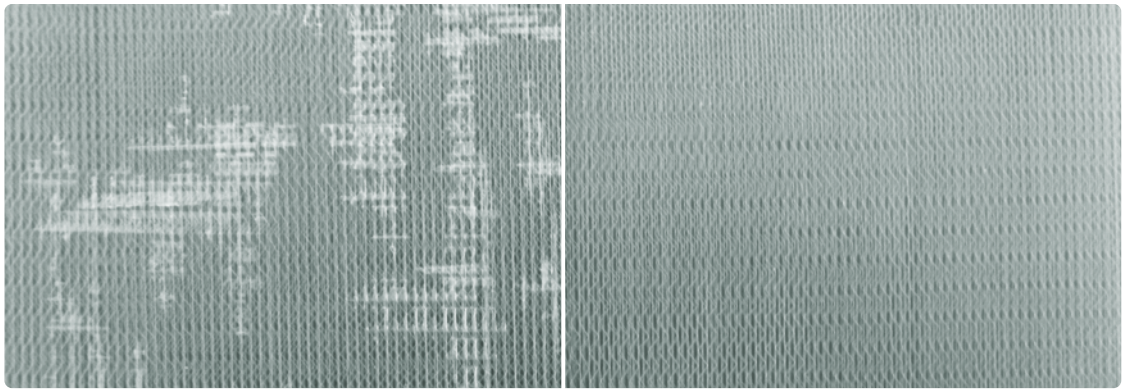
Processing additives are used to improve the wetting process of epoxy resin systems and different kinds of fiber in a multitude of fiber-reinforced applications. Besides the optimized fiber wetting, the additives reduce the processing time.

BYK-P 9920 is an emission-free wetting agent for fiber-reinforced plastics with defoaming properties. The combination leads to a faster processing and a higher quality in the final compound. By using the additive, a better fiber impregnation with no dry spots and no air entrapment will be achieved.

Resin transfer molding (RTM)

Improved quality with better fiber wetting
Glass fiber

Without additive **BYK-P 9920**



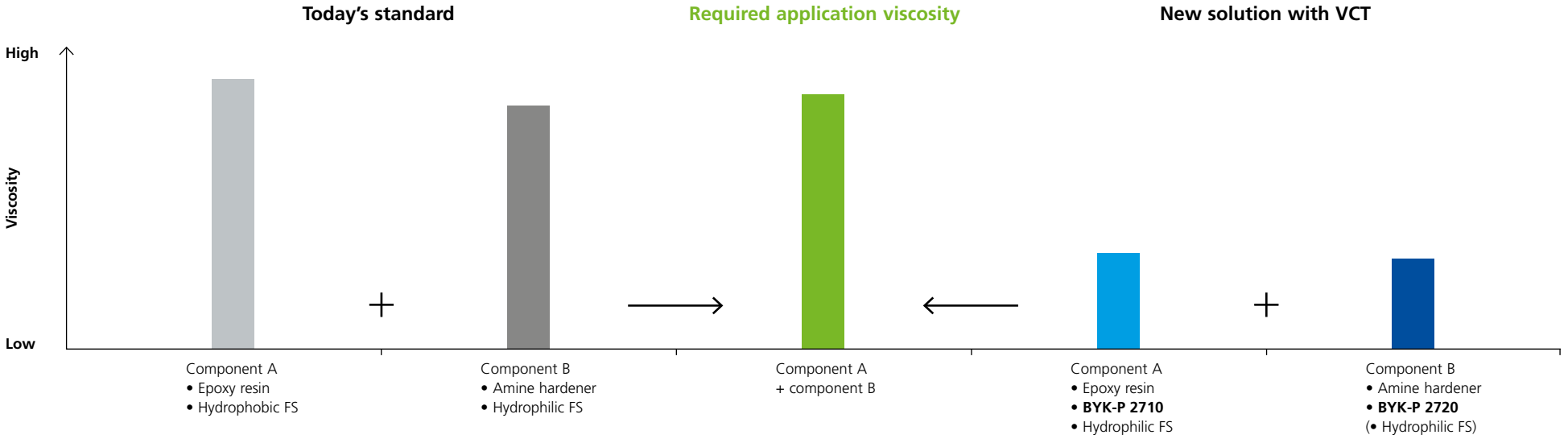
G. 19

Faster processing and cost saving with VCT

Viscosity Control Technology (VCT) is a new technology that is based on a pair of well-engineered processing additives to design the viscosity of 2-pack systems and their components to an optimum level for every single process step. There is one processing additive (Thixbreaker) for the resin system and a matching one for the hardener component (Thixbooster). The perfectly synchronized interaction of the two processing additives that comes into effect when the components are mixed together ensures that the final application viscosity is exactly as required.

BYK-P 2710 (Thixbreaker) + BYK-P 2720 (Thixbooster) are the processing additives of Viscosity Control Technology for solvent-free and solvent-borne epoxy resins containing hydrophilic fumed silica for anti-sagging properties in medium/high viscous systems. They are designed to achieve low viscosity levels of thixotropic epoxy resin and amine hardener components by gaining a high viscosity immediately while mixing the resin and hardener for application (G. 20).

Comparison between industry standard and the use of VCT technology



The new formulation only needs hydrophilic fumed silica, BYK-P 2710 (Thixbreaker, it blocks the structural build up of the hydrophilic fumed silica) in the resin component, and BYK-P 2720 (Thixbooster, it reanimates and enhances the structural build-up of the hydrophilic fumed silica) in the amine hardener to achieve low viscosity during production (G. 21) but high application viscosity after mixing (G. 22).

The concept of Viscosity Control Technology has a highly beneficial effect on the total value chain.

VCT optimizes cost, time, and quality in formulation, production, transportation, and application, and provides benefits in:

Process + quality
- Faster and improved incorporation of hydrophilic fumed silica
- Low viscous components are faster to process and to fill
- Less air entrapment and faster evacuation
- Adjusted viscosities lead to a better mixing quality
- Lower viscosities permit lower pressure and higher output in the metering machine

Cost saving
- Use of cheaper hydrophilic fumed silica instead of hydrophobic fumed silica
- New packaging and transportation opportunities
- Shorter production time

Viscosity in production

G. 21

Viscosity at application

G. 22

Additive recommendations for epoxy applications

Application	Air release	Viscosity reduction	Flow/leveling, anti-cratering	Anti-settling	Rheology	Pigment stabilization	Processing	Fiber wetting	Coupling	Substrate wetting	Viscosity control technology (VCT)
Gel coats	BYK-A 530 ● BYK-1790 ○	BYK-W 980 ●	BYK-306 ● BYK-310 ○ BYK-320 ○	RHEOBYK-R 605*1 ● RHEOBYK-410 ○ RHEOBYK-7410 ET ○	GARAMITE-7305 ● RHEOBYK-R 607*2 ●	DISPERBYK-2152 ● BYK-W 940 ○	BYK-P 9912 ●				
Casting systems, polymer concrete, mineral cast	BYK-A 501 ● BYK-A 530 ● BYK-1790 ○	BYK-W 985 ● BYK-W 996 ● BYK-W 980 ○		GARAMITE-7305 ● RHEOBYK-410 ● RHEOBYK-7410 ET ● GARAMITE-1958 ○							
Lay-up, spray-up	BYK-A 501 ● BYK-A 530 ● BYK-A 525 ○	BYK-W 980 ● BYK-W 996 ●			RHEOBYK-R 605*1 ● RHEOBYK-R 607*2 ●						
Infusion techniques, RTM	BYK-A 530 ● BYK-1788 ○		BYK-310 ● BYK-A 525 ○				BYK-P 9912 ●	BYK-P 9920 ● BYK-9076 ○	BYK-C 8001*3 ●		
Lining, flooring	BYK-A 501 ● BYK-A 530 ● BYK-1790 ○	BYK-W 985 ● BYK-W 980 ○	BYK-306 ●	GARAMITE-7305 ● RHEOBYK-410 ● RHEOBYK-7410 ET ● ANTI-TERRA-204 ○ GARAMITE-1958 ○	RHEOBYK-R 607*2 ●						
Electrical cast	BYK-A 530 ● BYK-S 732 ● BYK-1790 ○	BYK-W 903 ● BYK-W 985 ○	BYK-306 ●	GARAMITE-7305 ● RHEOBYK-410 ● RHEOBYK-7410 ET ● ANTI-TERRA-204 ○ GARAMITE-1958 ○	RHEOBYK-R 607*2 ●					BYK-307 ● BYK-392 ○ BYK-361 N ○	
Bonding pastes	BYK-A 530 ● BYK-P 9920 ○	BYK-W 985 ● BYK-W 903 ○		RHEOBYK-410 ● RHEOBYK-7410 ET ● GARAMITE-1958 ○							BYK-P 2710*1 (only fumed silica) ● BYK-P 2720*2 ●
Chemical anchors	BYK-A 530 ● BYK-P 9920 ○	BYK-W 996 ● BYK-W 985 ○		RHEOBYK-410 ● RHEOBYK-7410 ET ● GARAMITE-1958 ○							BYK-P 2710*1 (only fumed silica) ● BYK-P 2720*2 ●

● First recommendation ○ Second recommendation

T. 06

*1 in combination with GARAMITE or fumed silica

*2 in combination with GARAMITE or fumed silica; only for amine component

*3 only for amine component

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