

WACKER

SILICONES

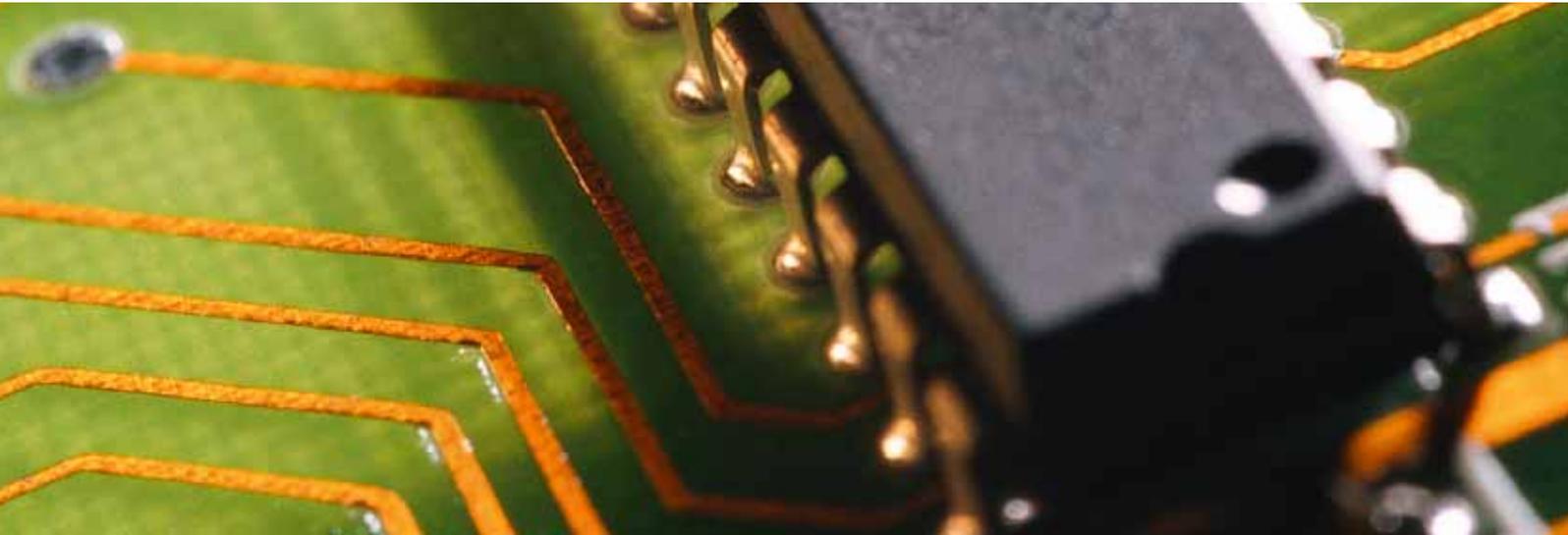
HDK®

PERFECT ADHESIVES AND SEALANTS
HIDE A SECRET:
HDK® – PYROGENIC SILICA

CREATING TOMORROW'S SOLUTIONS

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LET US SAY LOUD AND CLEAR WHAT
GIVES ADHESIVES AND SEALANTS
OPTIMAL PROPERTIES: HDK®

TARGETED OPTIMIZATION BRINGS OUT THE BEST FROM YOUR PRODUCTS

Since the application-specific characteristics required of adhesives and sealants can vary considerably, HDK® has been developed with an equally varied range of talents. Whether for individual rheological properties, reinforcement or thickening, this highly dispersed pyrogenic silica achieves remarkable results in every respect. And precisely this little secret allows HDK® to bring out the best in thousands of products.

Targeted Product Performance

WACKER began producing pyrogenic silica more than thirty years ago and has been steadily improving on its unique properties ever since. As a result, HDK® is a veritable all-round talent able to effectively and selectively optimize designated properties in countless products. These include adhesives and sealants, and many more.

Industrial and craft uses of adhesives and sealants benefit from WACKER's unique range of hydrophobic and hydrophilic HDK® grades – they cover all ways of controlling reinforcement, thickening and rheological characteristics. We additionally develop modified and functional silicas for customer-specific solutions, such as reinforcing filling agents for better hardness and scratch-resistance, and crosslinking building blocks for reactive systems.

Concentrated Expertise

An innovative, motivated partner to the adhesives and sealants industry, WACKER SILICONES backs up its outstanding products with first-class service. To this end, we respond to the needs of the market and our customers by researching, developing and producing suitable raw materials and additives. By tailoring HDK® grades to each specific case, we aim to help our customers optimize the properties of their end products and applications. We work closely with customers and machinery manufacturers and play an active role at conferences, in the German industrial association for adhesives and in the association of European adhesives manufacturers. Our customers can always count on expertise and customized support as well as comprehensive technical service at any time. We have a local presence worldwide.

ONLY TOP PERFORMANCE CAN SATISFY MAXIMUM EXPECTATIONS



Adhesives and sealants can only meet their specific performance requirements if all the system components are designed for maximum performance. The finely divided pyrogenic silica HDK® is a top performer in many respects and offers the best chance of producing end products that have been optimized for their respective applications.

Perfect Properties

The production process which our engineers have developed for WACKER HDK® yields a product of extremely high purity, and leaves the concentration of metal ions at the detection limit. As a result, the adhesive or sealant system is protected against unwanted reactions catalyzed by metals and ions. A further advantage of HDK® is that it is color-neutral and therefore does not influence the shade of the final formulation. For transparent systems, we have developed particular HDK® grades with a large surface area that allow the formulation to transmit visible light.

Since HDK® can be readily incorporated and takes effect immediately after dispersion, pre-activation by catalysts or heating during the formulation process can be eliminated. It is even easy to use it in processing heat-sensitive substances. On the other hand, HDK® itself is extremely heat-stable and non-combustible, which can lead to an improvement in the fire and flame-retardant properties of the end products.

Custom Rheology

HDK® can customize the rheological behavior of adhesives and sealants by imparting shear-thickening and pseudo-plastic properties. One special feature of HDK® compared to other thickeners in this respect is the high thixotropic action (the gradient between the viscosity at rest and under shear).

The Benefits:

- The pronounced thixotropic performance
- The viscosity is precisely tailored to requirements
- The yield point can be varied to ensure good anti-slump properties
- The coating does not show sagging after application
- The formulation can be stored for a long time and is easy to process

Lasting Hydrophobicity

In addition to the hydrophilic standard products, WACKER SILICONES has hydrophobic HDK® grades available that are very water-repellent. This repellency is achieved by attaching the hydrophobizing agents firmly to the HDK® silanol groups during the production process, so that extractable amounts of silanes and silicones are just detectable by analytical methods. Special sealants for outdoor use and dispersion adhesives have improved, lasting water resistance and can nevertheless be over-painted in most cases.

HDK® Applications and Effects

Field of Use	HDK® Effect
Additive for liquid formulations	Thickening, structural viscosity, thixotropy, setting yield point, preventing running off, redispersal aid, antisedimentation, self-leveling, long storage life
Adsorbent for liquids and powders	Better processing, easy metering
Thermoplastics, rubber	Improving mechanical properties, higher tensile strength and toughness, better hardness and abrasion resistance
Processing additive for solids	Optimizing flow properties in powders and granules

Good Antisedimentation

At low shear rates, such as occur during storage and transportation of adhesives and sealants, filling agent and pigment settling can occur and individual components can separate. Especially in filled systems, HDK® can prevent or at least delay this, thanks to its good antisedimentation action. Systems which have been stored for a long time can be readily redispersed with HDK® as additive.



GETTING THE RHEOLOGY RIGHT IS A DELICATE JOB

HDK® improves the production, processing and application characteristics of adhesives and sealants in a wide variety of ways. Especially as it can be used to modify the rheological properties and adjust them precisely.

Optimizing Products

The fact that the rheology can be finely adjusted with HDK® perfects the characteristics of adhesives and sealants in many respects:

- The products can be sprayed, brushed and applied better
- There is less tendency to show uncontrolled flow and settling
- The bead of adhesive has good non-sag properties
- Settling of the filler agents is reduced and redispersion is better
- There is less strike-through to the substrate, e.g. paper, textiles, fibers and fabrics
- The internal strength and viscosity (cohesive forces) of adhesive films and sealant joints is higher
- The viscosity is less affected by heat influences
- Pronounced pseudoplasticity of the formulation
- Flow properties are tailored precisely to the application
- High yield point

Controlling Flow Properties

The production and use of adhesives and sealants can generate high shear rates that call for the lowest possible viscosities. After application, however, the need is not so much for long flow times, but rather for good non-sag properties in most cases; sometimes, the product has to have moderate flow to provide smooth surfaces. During formulation, it is therefore particularly important to find the ideal compromise between high viscosity during storage, low viscosity during processing and the right flow characteristics for the application. In this respect, HDK® is the product of choice.

Thixotropy and Product Portfolio

The right choice and quantity of HDK® grade allows the desired rheological properties to be controlled precisely to specification. A decisive factor here is the time of thixotropic recovery in the freshly applied adhesive or sealant. WACKER SILICONES offers a comprehensive range of products for this purpose that contains hydrophilic, partially hydrophobized and highly hydrophobized grades.

The Rheology Is Also Influenced by:

- The viscosity of the polymer solution
- Amount of HDK® added (volume fraction)
- Volume fraction of the pigments and filling agents
- Particle-particle and polymer-particle interactions, especially in the case of hydrophilic particles or polymers
- Polymer composition and polarity
- Molecular weight and molecular weight distribution
- Solvent and solvent polarity
- Specific formulation (e.g. order in which the raw materials are added)
- Use of surface-active products (wetting agents, etc.)
- How well the HDK® is incorporated and dispersed

Formulation developers should also take these parameters into account.

SIMPLE PROCESSING MAKES PRODUCTION MORE EFFICIENT



Economical and smooth workflows enhance the efficiency of your production. HDK® has clear benefits to offer – in the form of products which are tailored to the adhesive and sealant systems concerned and which are easy to process.

Supplied Ready for Processing
HDK® is not known to pose health risks to employees or to harm the environment. It can be processed efficiently. It is integrated into the production process in the form supplied, without the need for any further pre-treatment. No particular working temperature is needed for incorporation.

Easily Dispersible

The consistently high and uniform product quality of HDK® facilitates formulation. Its rheological efficiency does, however, depend on how well the pyrogenic silica is dispersed. This can mean that, if it is inadequately dispersed, the viscosity can rise or fall in storage, and that in turn usually has negative consequences for processing. In other words, the dispersion process is also partly responsible for the application characteristics, the time of thixotropic recovery and the stability of the end product's viscosity.

With better dispersing machines, it is possible to achieve higher viscosity levels with the same HDK® concentration. The decisive aspect here is not the actual dispersion time but the optimization of the shear energy input. HDK® grades with high surface areas (>150 m²/g) should be dispersed with powerful batch dissolvers, planetary dissolvers or continuous rotor-stator systems. In some cases, it makes sense to disperse a masterbatch perfectly and to then mix it in. The quality of dispersion can also often be seen from the transparency of the system.

Dispersing Machines for HDK®

+ -	Moderately suitable	Straight-bladed stirrer, butterfly
+	Suitable for high-viscosity formulations	Planetary dissolver, Molteni mixer, extruder
+	Suitable for low-viscosity formulations	Toothed disk dissolver
++	Very suitable for low-viscosity formulations	Rotor-stator mixers, bead mill, three-roll mill

Worldwide Presence

WACKER is one of the global leaders in the manufacture of pyrogenic silica and has standardized, state-of-the-art production facilities around the globe. These 24/7 "world-scale facilities" guarantee consistent product quality for our customers. At all times, you can rely on high production and delivery capacities, short delivery times thanks to local warehousing, favorable import possibilities via distributors, and logistics advice. In addition, we can offer you special units and container sizes, ideal, cost-saving solutions and simplified recycling. That, too, boosts your efficiency.

STRONG BONDS ARE PRECISION WORK



Only if all parameters of an adhesive system are perfectly matched to the application can it develop the desired strength. The HDK® range is comprehensive enough to impart exactly the right rheology profiles, levels of reinforcement and force distribution to the system.

Selective Viscosity Control

When materials are bonded, they are held together by the surface forces of the adhesives. For this purpose, the substrates are joined via adhesive joints that contain the greater part of the adhesive. The forces acting at the interfaces of the adhesive and the substrate (adhesion) and within the adhesive itself (cohesion) may be both physical and mechanical in nature. In the case of chemical reactive adhesives, covalent chemical bonds are also created.

Structural adhesive bonds are mainly used in such sectors as the automotive and aviation industries, in apparatus engineering and equipment manufacturing; they are characterized by the following factors:

- High-strength substrates (metal, wood, ceramics, composite materials)
- Forces transmitted and absorbed by the adhesive, with no geometrical effects
- Durable adhesive joints which are stable under load

HDK® offers a wide product portfolio for solvent-based and solventless adhesives and enables the viscosity of reactive structural adhesives to be selectively controlled.

Strong Characteristics

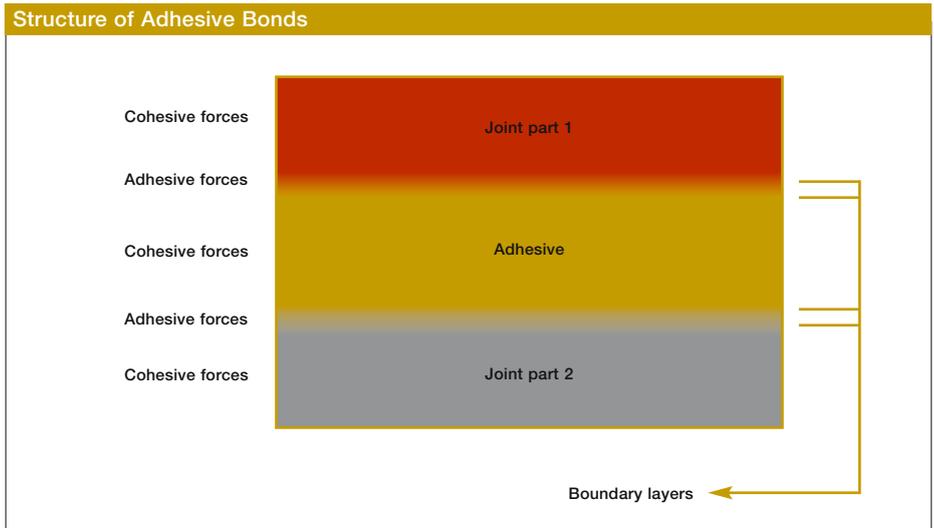
The cohesive strength of the substrates and adhesive, and the bonding strength of the adhesive to the substrate determine the quality of a bond. Since adhesion is influenced to a major extent by the physical and chemical properties of the boundary layers, it has consequences for the entire system if the boundary layers are very thick or the diameters of the joints are small.

In order to withstand the varying effects of heat, water, light, oxygen and chemicals, the boundary layers, substrate and adhesive have to be sufficiently stable. This stability can be achieved with an adhesive that has good wetting properties, and thus lower viscosity during application, because that leads to uniform, improved adhesion and distribution of forces in the adhesive.

As a solution focused company, WACKER has developed firstly additives and silanes for technical surfaces that act as adhesion promoters and improve wetting considerably, and secondly a very wide range of HDK® grades with which the optimum viscosities and rheology profiles can be set. By inducing a shear-thinning, pseudoplastic behavior in the fluid matrix, HDK® makes it possible to achieve low processing viscosities and at the same time excellent storage and application behavior. Through its reinforcing properties, HDK® also improves the toughness and strength of adhesives and sealants.

Classification of Adhesives and Sealants

Adhesives can be classified according to their chemical nature, polarity, and bonding mechanism. All three aspects should be taken into account when the appropriate HDK® grade is being selected.



Classification According to the Bonding Mechanism

Adhesives

Chemical Reaction Curing

- Polymerization: Cyanoacrylates, methacrylates, unsaturated polyester resins, anaerobic adhesives, radiation-curing adhesives
- Polyaddition: Epoxies, polyurethanes
- Polycondensation: Silicones, formaldehyde resins and hybrid adhesives

Physical Curing

- Solvent-based adhesives: Polyacrylates, natural rubber, nitrile rubber, butyl rubber, PVC, polystyrene and copolymers, polyvinyl acetate and copolymers
- Contact adhesives: Chloroprene, neoprene, SBS, ABN rubber
- Dispersion adhesives: PVAc, rubber latices, PVdC, acrylates, PU
- Hot-melt adhesives: EVA, polyesters, polyamides, polyurethanes, polyureas
- PVC plastisols
- Pressure-sensitive adhesives (PSAs): Acrylates, SBS, SIS, natural/butyl rubber

Sealants

In general, similar raw materials are used for adhesives and sealants. Major sealants are silicones, polyisobutylene and butyl rubber, acrylates, polyurethanes, silane-terminated polymers, and polysulfides.

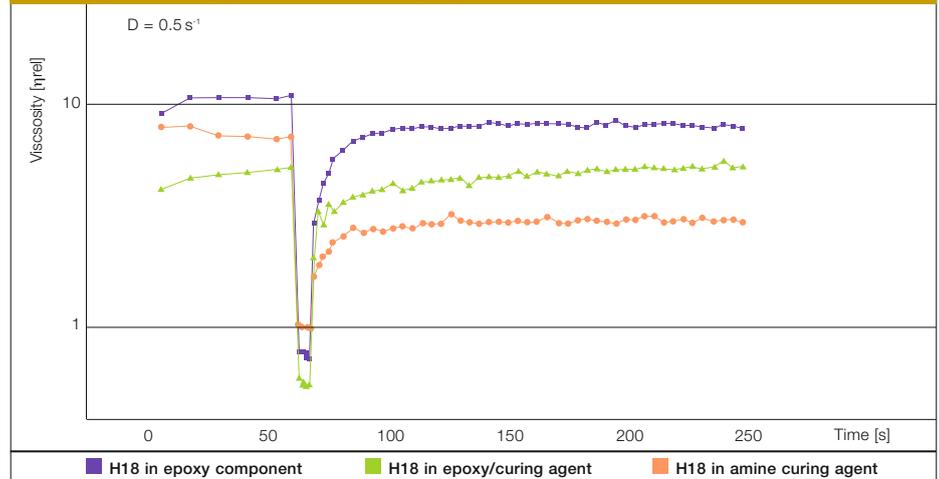
THE RIGHT SOLUTION FOR EVERY ADHESIVE SYSTEM

Ready-to-use adhesive formulations contain a wide range of raw materials. Since these can differ widely in their chemical composition and polarity, the choice of HDK® grade depends on the specific formulation and the effect which it is intended to achieve.

Hydrophobic HDK® for Epoxy Resins

Epoxy resins consist of epoxy components and hardening agents, usually a free or blocked amine component. Epoxy resins are mainly formulated with bisphenol A, and softer epoxy adhesives, with bisphenol F. Amine-hardening agents are usually multifunctional polyamines, though flexibilized systems may also have bifunctional amine polymers. Hydrophobic HDK® is particularly suitable for adjusting the thixotropic characteristics of one-pack and two-pack epoxy adhesives.

Rheology: Thixotropy of HDK® H18 in Epoxy Adhesive

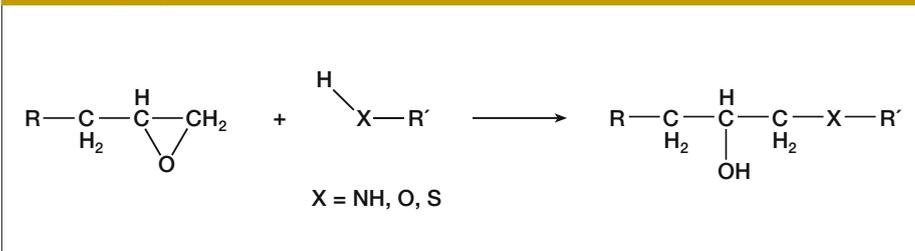


Hydrophilic HDK® in Epoxy Resins

Because of its high inherent reactivity, the epoxy function can also be opened by polar groups, such as the silanol in HDK® and adsorbed water molecules. Addition of surfactants that form hydrogen bonds, such as PEG or Tween 20, has a positive influence on the rheology of the systems thickened with hydrophilic HDK®. If the concentration of substances forming hydrogen bonds is too large, however, the SiOH groups of hydrophilic HDK® become blocked and are unable to impart adequate thixotropy.

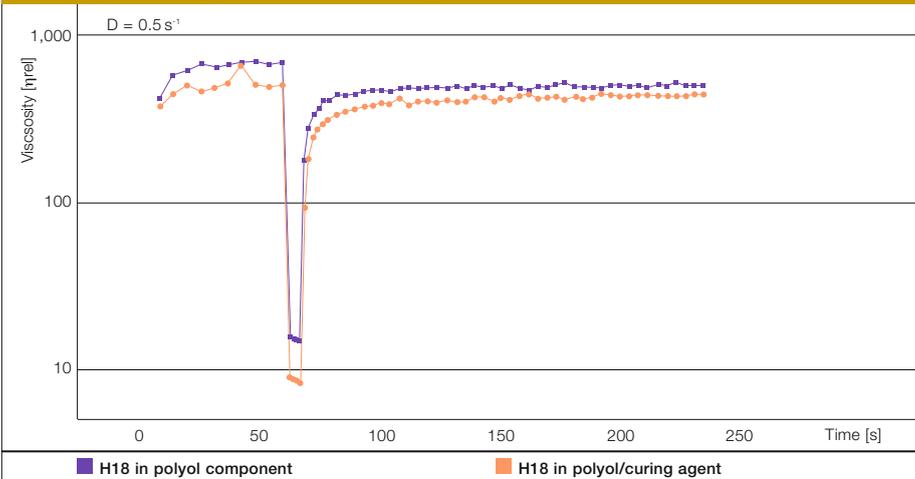
In the case of epoxy resins thickened with hydrophilic HDK®, the viscosity can rise dramatically when the hardening agent is added. This may be an intentional effect, but in many cases it is not. It is caused when polyamine molecules form bridges between silica particles; the polyamine is then displaced by the polyols that form in the subsequent curing process. Because of the instability of these systems, which has often been observed, it is not advisable to use hydrophilic HDK® for all pure epoxy systems, though it will work for most aqueous epoxy formulations.

Curing of Epoxy Adhesives



The most suitable grades for conferring thixotropy on epoxy-based adhesives are highly hydrophobized HDK® grades such as H18 or H20RC. In some cases, where the formulations are not sensitive, hydrophilic HDK® N20 can also be used.

Rheology: Thixotropy of HDK® H18 in Polyurethane-Urea Adhesive

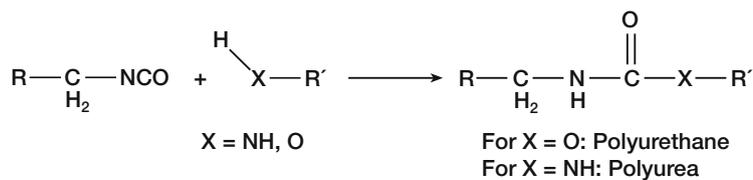


HDK® for Polyurethanes

Moisture-curing adhesives and sealants often consist of one-pack polyurethane systems. These use isocyanate-blocked prepolymers, which condense when they come into contact with atmospheric moisture. The use of HDK® allows the viscosity to be varied progressively until it is non-sag. Two-pack systems consist of a polyol component and polyisocyanate curing agent, as well as HDK® for conferring thixotropy.

Isocyanates will also react with silanol groups or adsorbed water on the surface of hydrophilic HDK® grades, whereas polyols will block these silanols and impair thickening. For polyurethanes and chemically related adhesives, it is therefore advisable to use exclusively hydrophobically modified HDK® grades, such as H20, H30RM and H18.

Curing of Polyurethane and Polyurea





HDK® for Polysulfides

Moderately to highly hydrophobized HDK® grades such as H20 or H18 are the most suitable for thickening standard polysulfide systems based on short-chain polyethylene glycols. In the case of a relatively non-polar polymer backbone and non-polar solvents, it is also possible to work with hydrophilic HDK® under certain circumstances.

Solvent-Based Adhesives and Composite Resins

The polarity of both the solvent and the adhesive, as well as the active content of the formulation govern whether hydrophilic or hydrophobic HDK® should be used for obtaining the desired rheological properties. For non-polar systems, hydrophilic grades are usually preferred, while hydrophobic ones are better for polar systems. PVC plastisols and unsaturated polyester resins are adjusted with hydrophilic HDK® N20.

Phenolic, Urea and Melamine Resins

It is easy to confer thixotropy on these highly polar systems with hydrophobic HDK®. Preliminary tests are needed for establishing which grade will disperse at the concentration of the aqueous solution and with the shear equipment used. In granulated resin and powder curing agents, HDK® acts particularly as a flow improver.

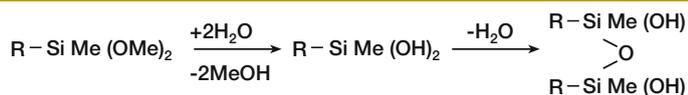
Hot-Melt Adhesives and Thermoplastics

The choice of HDK® grade for these adhesive systems depends on the underlying chemistry and the field of application. The best-quality reinforced products are achieved with structurally modified hydrophobic HDK® H2000.

HDK® Dispersions – Physicochemical Properties

	D1515 B	D2012 B	D3017 B	A2012	A3017	XK 20030
BET surface [m²/g]						
Silica ISO 9277/DIN 66132	150 ± 20	200 ± 30	300 ± 30	200 ± 30	300 ± 30	200 ± 30
Solids content [%]	15	12	17	12	17	30
pH	4–6	4–6	4–6	8–10	8–10	9–11
Viscosity [mPa·s at 200 s⁻¹]	< 100	< 100	< 100	< 100	< 100	< 100
Zeta potential [mV]	< -10	< -10	< -10	< -10	< -10	< -10

Curing of MS Polymers and Hybrid Systems



R = polypropylene glycol, polyurethane, etc.

Silane-Modified Polymers

The vast majority of these polymers are formulated as one-pack moisture-curing systems and usually consist of polypropylene glycol bearing moisture-crosslinking alkoxy silane terminal groups. These can also be hydrolyzed by silanol groups of hydrophilic HDK® or adsorbed water, a fact which makes hydrophobic HDK®, such as H20 or H18, well suited for adjusting the viscosity of hybrid systems.

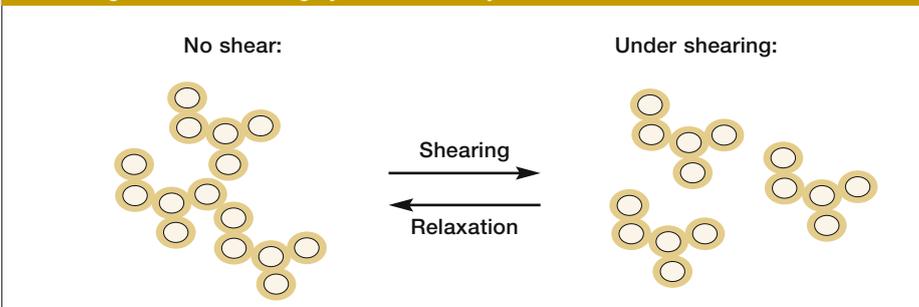
Other Highly Polar Systems

The principles described for epoxies and urethanes also apply similarly to other highly polar adhesives formulations that form hydrogen bonds, such as hydroxy-acrylate, vinyl ester resin and cyano-acrylate.

HDK® for Dispersion Adhesives

Hydrophilic and partially hydrophobic HDK® grades are successfully used to optimize the rheological properties of dispersion adhesives. Aqueous HDK® dispersions are also suitable additives for this purpose.

Thickening Mechanism in Highly Polar Resin Systems



Percolating cluster network

Particle-particle interactions due to:

- PDMS polymer chain interpenetration
- Hydrophobic interactions = phase separation

lead to

- Large volume of immobilized liquid
- High viscosity or yield point



Sealants need viscosities suitable for processing, they have to seal joints reliably and they must balance out major compressive loads and tensile stresses. With HDK®, the desired characteristics can be adjusted perfectly in every respect.

Broad Performance Profile

Joint sealants are frequently used as one-pack systems and need to satisfy strict demands on viscosity, elasticity and durability:

- Easy to press out of the cartridge
- Easy to process and smooth out
- Stability even after long storage and transport times
- No flow or sagging in vertical joints
- Vulcanization appropriate to the application
- Compensation for compressive loads and tensile stresses
- Minimal gas and liquid diffusion in joints
- Additional stability for joined parts
- Coatings of uniform thickness, e. g. for soundproofing and automotive underseals

HDK® gives sealants the desired performance by adjusting the rheological properties of uncrosslinked compounds and giving crosslinked compounds the necessary mechanical strength. Hydrophobic grades also impart high moisture resistance.

Fields of Use for HDK®:

- Plastic sealants such as acrylic resins and butyl rubbers
- Elastic sealants such as polysulfides, polyurethanes, natural and synthetic rubbers
- Silicone sealants

SO THAT SEALANTS DO MORE THAN SEAL

Reinforcing Effect

It takes reinforcing (active) filling agents to give elastomers the best mechanical characteristics. As a highly active filling agent, HDK® achieves particularly good results in this respect, because its reinforcing effect is directly linked to its large specific surface area, which makes numerous interactions with the polymer chains of the elastomer network possible. Thanks to its specific particle structure, HDK® also offers ideal conditions for satisfying other sealant requirements:

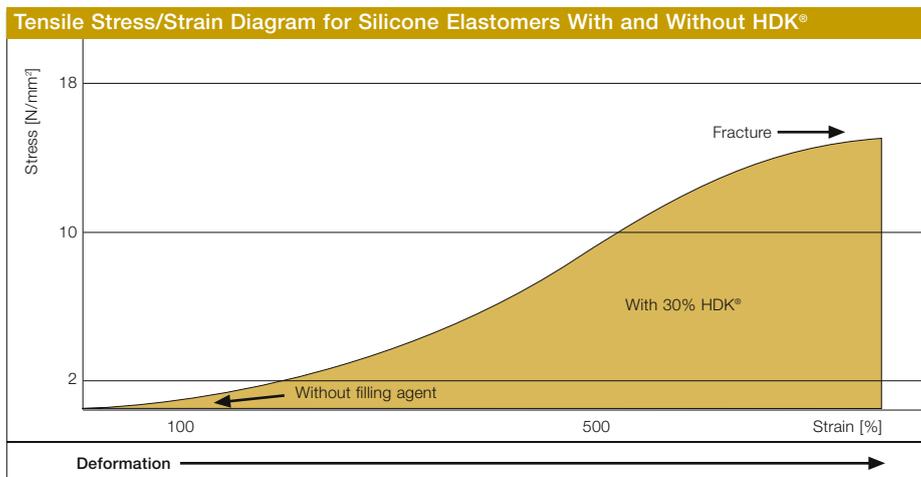
- Optimized distribution of the mechanical stresses and forces in the elastomer network
- Better tensile strength, elongation at break and tear propagation resistance
- Control over the temperature dependence of the mechanical characteristics

High Thickening Action

Hydrophilic HDK® has a particularly pronounced thickening action in non-polar silicone rubber. This is especially beneficial in low-viscosity systems, since the sealant is given the necessary non-sag properties and therefore does not flow on vertical parts.

The pronounced thickening effect of hydrophilic HDK® may restrict its processability in highly filled silicone elastomers. This effect can be countered with processing aids such as low-molecular-weight plasticizers, which block the particle-particle interaction by adsorption of the HDK® surface.

In contrast, hydrophobic HDK® can readily be used to obtain high loading levels and easy processing combined with low viscosity. Here, the surface silanol groups are converted and hydrophobized with silylating agents to dimethylsiloxy or trimethylsiloxy groups.



AN ALL-ROUND TALENT THAT IS ALSO ACTIVE IN OTHER SYSTEMS



Thanks to its outstanding property profile, HDK® lends itself to an extremely wide range of applications and also serves to optimize user-specific parameters in powders, powder curing agents, pellets, granules, dispersions, plastisols and thermoplastics.

Processing Aids and Anti-Caking Agents

Even in low concentrations of 0.1 to 0.3 wt %, HDK® acts as an efficient processing aid in powders and powder curing agents. In polymer granules and pellets, and in hot-melt formulations, HDK® is used as an anti-caking agent.

When mixed with powders and granules, the pyrogenic silica is distributed evenly on the surface and acts as a spacer between the individual granules by reducing the mutual attractive forces. In addition, the large HDK® surface area adsorbs the moisture in the air, physically drying the raw material. Hydrophobic HDK® also reduces sensitivity to moisture and improves the anti-corrosion properties.

This yields a number of practical benefits:

- Better, stable fluidization of the powders
- Better extrusion properties of thermoplastics and hot-melts
- No caking in powders and granules
- Powder drying
- Hydrophobic finishing and water-proofing in the final application

Additive for Dispersions

The rheology of emulsions and dispersions depends on many different factors, so that there are no general recommendations regarding the choice of HDK[®] grade and the amount to be used. These factors include:

- Electrostatic effects (stabilization)
- Zeta potentials of the pigments and filler agents
- pH levels and electrolytes (salts influence the ionic strength)
- Surface-active oligomeric/polymeric substances (dispersants)
- Adsorption of binders and curing agents

Both hydrophobic and hydrophilic HDK[®] make suitable additives for water-based polymer dispersions and emulsions – the choice depending on the intended characteristics of the end product.

For this reason, it is advisable to determine the desired performance empirically by means of preliminary tests on the existing system. Predispersed HDK[®] masterbatches can be added to shear-sensitive emulsions and dispersions.

Processing Aid and Filling Agent

In thermoplastics, elastomers and plastisols, HDK[®] serves as a processing aid and filling agent to improve various properties in use. General effects in these systems are:

- Pseudoplasticity of the formulation
- Viscosity adjustment and thixotropy
- Enhancement of dielectric properties

Other Effects of HDK[®]

PVC plastisols:

- No dripping or running of the formulation
- Antisedimentation properties

Thermoplastics and hot-melts:

- Extrusion aid
- Anti-caking agent and flow improver
- Reinforcement and thickening

Rubbers and elastomers:

- Reinforcement and toughness modification
- Increase in tear strength

HIGHLY ADVANCED GRADES FOR DIFFERENT POLARITIES

The rheological effect of HDK® in adhesives varies particularly with the polarity of the matrix, i.e. the system of polymer and solvents. In order that the right HDK® grade for a specific application may be chosen, the polarity needs to be defined in advance.

Defining Polarities

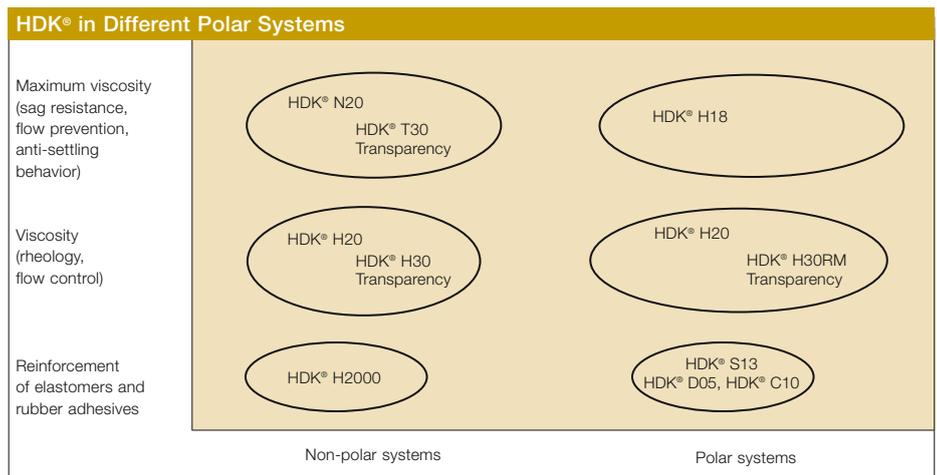
One good way of assessing the polarity of a polymer solution is to evaluate the Hansen solubility parameters of the solvents and polymers used. Hydrophobic HDK® grades are used in two-pack PUR and epoxy systems that are based on relatively polar resins and curing agents and on polar solvents such as an alcohol (epoxy) and an ester (PUR). If large quantities of non-polar solvents such as aromatics are used, the rheology can in most cases also be adjusted with hydrophilic HDK®.

Choice of HDK® According to Solvent				
Solvent	Hansen solubility parameters			Recommended HDK® class
	Dispersion	Polar	H bonding	
1,3 Butanol	16.6	10	21.5	hydrophobic
Ethyl acetate	15.8	5.3	7.2	hydrophobic
Isobutyl acetate	15	3.7	7.6	hydrophobic
Cyclohexanone	17.8	6.3	5.1	hydrophobic
MIBK	15.3	6.1	4.1	hydrophobic
MEK	16	9	5.1	hydrophobic
Xylene	17.6	1	3.1	hydrophilic
Styrene	18.6	1	4.1	hydrophilic
Cyclohexane	16.8	0	0.2	hydrophilic
Octane	15.5	0	0	hydrophilic

Choice of HDK® According to Polymers and Resins					
	Resins	Hansen solubility parameters			Recommended HDK® class
		Dispersion	Polar	H bonding	
HMMM	CYMEL300	19.3	12.8	12.9	hydrophobic
PMMA	Perspex	18.6	10.5	7.5	hydrophobic
Polyol	Desmophen 651	17.7	10.6	11.6	hydrophobic
Polyol	Desmophen 850	21.5	14.9	12.3	hydrophobic
Polyisocyanate	Desmodur N	17.6	10	3.7	hydrophobic
Epoxy	EPON 1001	17	9.6	7.8	hydrophobic
Epoxy	EPON 828	21.3	14.2	6.1	hydrophobic

Highly Polar Polymers

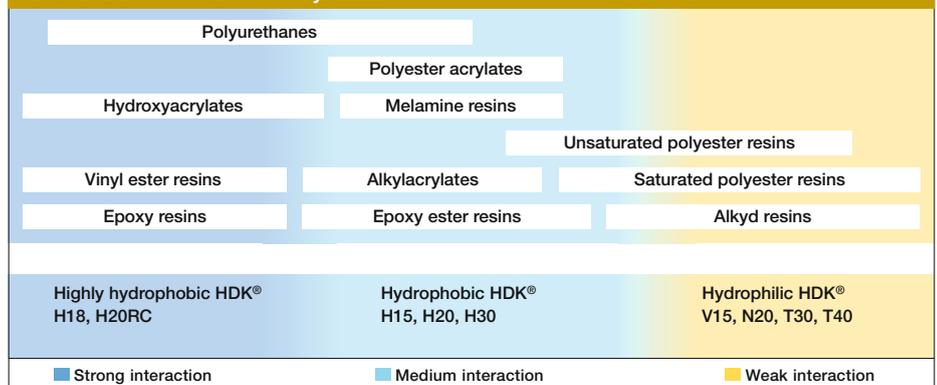
Many highly polar polymers which are used in reactive, solventless adhesive systems have a higher surface energy because of the presence of polar groups. This is particularly true of many epoxy resins, hydroxyacrylates, polyurethanes and MS polymers. If hydrophilic HDK® is used in these polymers, it can lead to unwanted wetting phenomena and that has a negative influence on the thickening effect and storage stability. The use of surface-active wetting agents and dispersants must be examined critically with regard to long-term viscosity during storage, since bridging effects or in situ hydrophobizing of the hydrophilic HDK® can occur. Hydrophobic HDK® is usually a reliable alternative here because it can generate the desired rheological characteristics, even in highly polar polymers.



HDK® as a Rheological Additive

Adhesive resin	Polar/non-polar	HDK® additive
<ul style="list-style-type: none"> Alkyd resins Saturated polyester resins 	Non-polar	<ul style="list-style-type: none"> Hydrophilic HDK® N20 Hydrophobic HDK® H20
<ul style="list-style-type: none"> Unsaturated polyester resins Alkyl acrylates 	Non-polar to medium polar	<ul style="list-style-type: none"> Hydrophilic HDK® N20 Highly hydrophobic HDK® H18
<ul style="list-style-type: none"> Vinyl ester resins Melamine resins Polyester acrylates 	Medium polar to highly polar	<ul style="list-style-type: none"> Highly hydrophobic HDK® H18 Hydrophobic HDK® H20
<ul style="list-style-type: none"> Epoxy resins Polyurethanes Hydroxy acrylates 	Highly polar	<ul style="list-style-type: none"> Highly hydrophobic HDK® H18

HDK® in Different Adhesive Systems



HDK® PRODUCT GUIDE

FOR ADHESIVES AND SEALANTS

Products/Grades According to General Criteria				Step 1
Requirement	Highly hydrophobic	Hydrophobic	Hydrophilic	
Adhesive rheology/thickening				
Organic, non-polar/hydrophobic			●	
Organic, polar	●			
Aqueous, highly polar/hydrophilic		●	●	
Adhesive reinforcement without thickening				
Non-polar/hydrophobic	●			
Polar		●	●	
Highly polar/hydrophilic			●	
Transparency of the adhesive				
Excellent (300 – 400 m ² /g)	HDK® H30RM	HDK® H30	HDK® T30, HDK® T40	
Good (200 m ² /g)	HDK® H18, HDK® H20RC	HDK® H20	HDK® N20	

A more intense thickening effect can generally be achieved by using a larger surface-area HDK®. The exception is

HDK® N20, which has been specially designed for maximum thickening effect.

Products Specifically for Adhesive Systems (Thickening and Rheology)				Step 2
Solvent-based adhesives depending on the polarity of the overall system (polymer + solvent):				
Non-polar systems/solvents ¹			HDK® S13, HDK® V15, HDK® N20, HDK® T30, HDK® T40	
Polar and aprotic systems/solvents ²	HDK® H18, HDK® H30RM, HDK® H20RC	HDK® H20, HDK® H30		
Polar protic systems/solvents ³ and aqueous solutions	HDK® H18	HDK® H20, HDK® H30	HDK® N20, HDK® T30, HDK® T40	
Solventless adhesives				
Non-polar systems (PVC plastisol, polyester resins, alkyl acrylates, polyolefins, alkyd resins)			HDK® N20, HDK® T30	
Polar systems (PU, EP, MS, sulfide, vinyl ester, hydroxyacrylates)	HDK® H18, HDK® H20RC, HDK® H30RM	HDK® H20		

1 = Hydrocarbons, non-polar esters

2 = Polyethylene glycol, polypropylene glycol, ketones, esters, etc.

3 = Alcohols, aqueous polymer solutions, dispersions

■ Highly hydrophobic ■ Hydrophobic ■ Hydrophilic

Products/Grades and Their Effects
Step 3

Grade	Characteristic feature	Application properties	Typical matrix	Sample uses
Hydrophilic Grades				
HDK® D05	High filling ratios, non-thickening	Reinforcement, scratch resistance, extrusion aid	Highly filled elastomers and sealants, thermoplastics, thermosets	Reinforcement of rubber and thermoplastics
HDK® C10	High filling ratios, hardly thickening	Reinforcement, scratch resistance, leveling, extrusion aid	Elastomers and sealants, highly filled silicone systems, thermoplastics, thermosets	Reinforcement of rubber and thermoplastics
HDK® S13	Slightly thickening	Reinforcement, thixotropic agent	Elastomers and sealants	RTV silicone, rubber
HDK® V15	Moderately thickening	Reinforcement, anti-caking and flow aid, thixotropic agent	Solvent-based and non-polar formulations, powders, granules	All adhesives and sealants
HDK® N20	Transparency, effective thickening	Reinforcement, anti-caking and flow aid, extrusion aid, adsorbent, thixotropic agent, thickening	Non-polar organic systems of all kinds, dispersion adhesives, powders, granules	All adhesives and sealants
HDK® T30	Good transparency	Flow aid, adsorbent, thickening and thixotropic agent for non-polar organic systems and aqueous dispersions	Film adhesives, films, adhesives and sealants, powders, granules, dispersion adhesives	Transparent polyester and acrylate resins
HDK® T40	Best transparency, high moisture absorption	Thixotropic agent, thickening for non-polar organic systems, powder drying	Film adhesives, films, dispersions	Highly transparent polyester and acrylate resins
Hydrophobic Grades				
HDK® H15	Hydrophobic	Reinforcement, flow aid for powders, antisedimentation additive, anti-slumping additive	Moderately polar sealants and adhesives of all kinds, RTV systems, solvent-based and solventless systems	Silicones, polymer dispersions
HDK® H20	Hydrophobic, well thickening	Rheology control, antisedimentation, thickening of organic systems and dispersions, flow aid	Moderately polar sealants and adhesives of all kinds, dispersions, aqueous polymer solutions	Polysulfides, acrylates, polyether-based adhesives
HDK® H30	Hydrophobic, transparency	Rheology control, antisedimentation, thickening of organic systems and dispersions, flow aid		PSA, polyethylene glycol, transparent films and films, adhesive tapes
Highly Hydrophobic Grades				
HDK® H18	High performance thickening	Thickening, thixotropic agent, improving anti-sag properties of highly polar org. systems, high layer thicknesses and bead diameters	Highly polar adhesives and sealants composite materials, solventless systems	EP, PU, MS, PS, acrylic
HDK® H30RM	Transparency, special additive	Antisedimentation, pigment stabilization, adjustment of complex rheology in adhesives and sealants, flow aid in organic powders, adjustment of self-spreading coatings and bonded joints	Polar adhesives and sealants with spreading properties	EP, PU, MS, PS, acrylic
HDK® H20RC	Special additive	Adjustment of problem-oriented complex rheology in adhesives and sealants, and composites, plasticizing aid, pigment additive	Polar adhesives and sealants, organic powders	Powder curing agents, EP, PU, MS, PS, acrylic, struct. bonding
HDK® H2000	High tamped density structurally modified, very little thickening	High hardness and reinforcement without thickening effect, high filling ratios possible, easy to incorporate, scratch resistance, flow aid	Adhesives and sealants, self-spreading compounds	High-strength rubber, silicone (HTV)

Choice of Product According to Effect

Step 4

Recommended applications according to effects	Hydrophilic				Hydrophobic			Highly hydrophobic			
	S13	V15	N20	T30/T40	H15	H20	H30	H18	H2000	H30RM	H20RC
Flow improvers											
Inorganic filler agents and pigments			●	◐		◐	◑		◐	◑	
Powder curing agents for 2-component adhesive systems, organic and hydrophobized powders			◐			◐	◑		●	◑	◐
Pigment additive											
Grinding and dispersing aid		◐	●		◐	●			◐		
Pigment stabilization (solvent-based)		◐	◐		◐	●			◐		
Pigment stabilization (aqueous)		◐	●		◐	◐					
Anti-blocking agent, anti-caking agent											
Thermoplastic and adhesive films			◐	●	◐	◐	●		◐	◑	◐
Foamed plastics					◐	●			◐		◐
Polymer granules and powder					◐	●			◐		◐
Adsorbent											
For polar liquids			●	◐			◐				
For non-polar liquids			◐	◐	◐	◐	●		◐	●	◐
Polymer and surface properties											
Hardness (coatings, adhesives, resins, composite materials, laminating resins)	◐								●		
Scratch resistance (flooring, composites, films)	◐								●		
Transparency											
Adhesive films, adhesive tapes, PSAs		◐	◐	●	◐	◐	●	◐	◐	●	◐
UV-curing adhesive formulations, highly transparent adhesive systems			◐	●		◐	●	◐	◐	●	◐
Reinforcement of cast resins, adhesives and sealants											
Achieving high filling ratios with rheology largely constant	◐						◐		●	◐	
Silicone compounds	◐	●	◐	◐	●	◐	◐	◐	●	◐	
Adhesives: PU, EP, acrylic, PSAs, PVC, UP	◐	◐	●	◐	◐	◐	◐	◐	●	◐	◐
Sealants: PU/MS, acrylic, sulfide, rubber, butyl	◐	◐	●	◐	◐	◐	◐	◐	●	◐	◐
Fluorinated rubber	◐	◐	◐	◐	◐	◐	◐	◐	●		
Rheology control in non-polar systems (e.g. rubbers, polyolefins, PVC, UP resins)											
Increasing viscosity in solutions	◐	◐	●	◐		◐		◐			◐
Non-sag properties of coatings, adhesives, beads and dams	◐	◐	●	◐		◐		◐			◐
Antis sedimentation of filler agents, yield point, storage stability	◐	◐	●	◐	◐	◐		◐			◐
Hot-melt adhesives, thermoplastics, PSA	◐	◐	●	◐	◐	◐	◐	◐		◐	
Spreading properties, but avoiding dripping from sloping surfaces and ceilings	◐	◐	●	◐	◐	◐		◐		◐	

Recommended applications according to effects	Hydrophilic				Hydrophobic			Highly hydrophobic			
	S13	V15	N20	T30/T40	H15	H20	H30	H18	H2000	H30RM	H20RC
☐ ☐ ☐ ●											
Rheology control in polar systems (with OH/NH groups such as EP and PU resins)											
Increasing viscosity in solutions			☐	☐		☐	☐	●			☐
Non-sag properties of coatings, adhesives, beads and dams			☐			☐		●			☐
Antis sedimentation of filler agents, yield point, storage stability			☐	☐		☐		●			☐
Hot applications (hot-melt adhesives, thermoplastics, PSA)		☐	☐	☐		☐	☐	●			☐
Some spreading, but avoiding dripping from sloping surfaces and ceilings			☐	☐		☐	☐	☐		☐	●
Rheology control in water-soluble systems (PEG, glycerol, aqueous polymer solutions)											
Increasing viscosity, thickening, gelling			☐	☐	☐	●	☐				
Antis sedimentation of filler agents, yield point, storage stability		☐	●	☐	☐	☐					
Avoiding dripping and sagging on vertical surfaces and ceilings		☐	☐	●	☐	☐	☐				
Controlling spreading, self-leveling											
Lay-flat adhesives, sealants, sound-proofing	☐	☐	☐		☐	☐	☐		●		☐
Dispersion adhesives		☐	●	☐	☐						
Self-leveling flooring compounds (epoxy, urethane)	☐	☐	●		☐	☐					
Fine tuning of complex rheological compounds											
Adjusting thixotropic relaxation time						☐				●	●

Ideally suited ● Very well suited ☐ Well suited ☐ Suited ☐

CUSTOM SERVICE FOR SOLUTIONS APPROPRIATE TO THE APPLICATION



Compelling Performance

This brochure has demonstrated what HDK® can do for adhesives and sealants of all kinds. To find out more about HDK® technical data, ask for our product data sheets. WACKER SILICONES can, of course, offer far more in the field of adhesives and sealants. For our complete range in this area, see our product overview. We will be glad to send you a copy on request. Or just visit us on the internet at www.wacker.com/hdk

Customer-Friendly Service

Individual challenges require individual solutions. That is why our technical service engineers are here for you in person. They understand your production flows and requirements as well as our products and their wide range of talents. With this background, we can draw up exactly the solution you need. In addition, our technical centers in Europe, the USA and Asia have advanced testing and measuring sys-

tems available for optimizing your products. Just call us. We will be glad to help you. Wherever you are located.

Our Services Comprise:

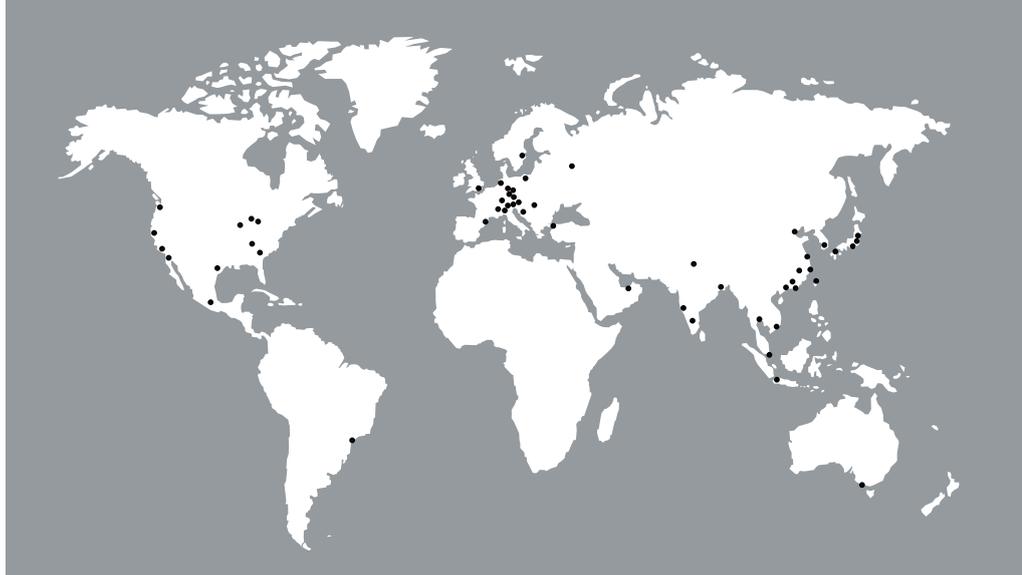
- Innovative product solutions
- Regional technical service
- Development of optimum formulations for all kinds of adhesives
- Sample formulations with and without HDK®
- Selection of appropriate HDK® grades to optimize rheology
- Development of modified silica grades to meet customers' needs
- Rheometry measurements of adhesive formulations
- Bonding tests and application testing
- Development of additives and silanes for adhesion promotion
- Delivery in economical container sizes, such as big bags

Global Presence

WACKER is represented throughout the world with production sites, technical centers and sales offices. You can therefore count on the fact that we are familiar with the regional situation on the markets and can offer you precisely the products and services you need. Quickly, flexibly and professionally.

Our logistical network also extends across the globe. In all our locations we work together exclusively with highly qualified, certified carriers who use the latest equipment. Furthermore, all delivery and transport movements are recorded and evaluated by WACKER. As a result, we can offer short delivery times and absolute reliability. After all, for us, quality means that you are satisfied in every way.

WACKER AT A GLANCE



WACKER is a technological leader in the chemical and electrochemical industries and a worldwide innovation partner to customers in many key global sectors. With around 14,400 employees, WACKER generated sales of EUR 2.76 billion in 2005. Germany accounted for 21% of sales, Europe (excluding Germany) for 31%, the Americas for 22% and Asia-Pacific, including the rest of the world, for 26%. Headquartered in Munich, Germany, WACKER has some 20 production sites worldwide and a global network of over 100 sales offices. With R&D spending at 5.3% of sales in 2005, WACKER is among the world's most research-intensive chemical companies.

WACKER SILICONES

is a leading supplier of complete silicone-based solutions that comprise products, services and conceptual approaches. As a provider of solutions, the business division helps customers press ahead with innovations, exploit global markets fully, and optimize business processes to reduce overall costs and boost productivity. Silicones are the basis for products offering highly diverse properties for virtually unlimited fields of application, ranging from the automotive, construction, chemical, electrical engineering and electronics industries, through pulp and paper, cosmetics, consumer care and textiles, to mechanical engineering and metal processing.

WACKER POLYMERS

is the global leader for high-quality binders and polymer additives. This business division's activities encompass construction chemicals and functional polymers for lacquers, surface coatings and other industrial applications, as well as basic chemicals, i.e. acetyls. Products such as dispersible polymer powders, dispersions, solid resins, powder binders and surface coating resins from WACKER POLYMERS are used in the construction, automotive, paper and adhesives industries, as well as by manufacturers of printing inks and industrial coatings.

WACKER FINE CHEMICALS

is an expert in organic synthesis, silane chemistry and biotechnology, providing tailored solutions for its customers in the life sciences and consumer care industries. The range of innovative products includes complex organic intermediates, organosilanes, chiral products, cyclodextrins and amino acids.

With its comprehensive expertise, WACKER FINE CHEMICALS is a preferred partner for highly challenging custom-manufacturing projects in the fields of chemistry and biotechnology.

WACKER POLYSILICON

has been producing hyperpure silicon for the semiconductor and photovoltaics industries for over 50 years. As one of the largest global manufacturers of polycrystalline silicon, WACKER POLYSILICON supplies leading wafer and solar-cell manufacturers.

Siltronic

is one of the world's leading producers of hyperpure silicon wafers, supplying many major chip manufacturers. Siltronic develops and produces wafers up to 300 mm in diameter at facilities in Europe, the USA, Asia and Japan. Silicon wafers form the basis of state-of-the-art micro and nanoelectronics used, for example, in computers, telecommunications, motor vehicles, medical technology, consumer electronics and control systems.

WACKER

CREATING TOMORROW'S SOLUTIONS

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