MARKET OVERVIEW/SYSTEM COMPONENTS & PERFORMANCE ADDITIVES

HDK® – PYROGENIC SILICA

Product Overview
HDK® TURNS AN INTELLIGENT SOLUTION INTO BRILLIANCE
Modern products are full of intelligent features. But you also need a strong partner to realize peak performance every day. WACKER and its pyrogenic silicas offer you that already – and even more tomorrow.

Our portfolio comprises HDK® grades for an impressive and wide range of applications in different industries – from foods, cosmetics, pharmaceutical products, paints and surface coatings, composites, adhesives, sealants and elastomers to toners and paper coatings.

HDK® selectively adjusts and optimizes product properties. Specially modified hydrophilic and hydrophobic HDK® grades and HDK® dispersions enhance effectiveness, stability and handling of your systems and formulations – at all stages of production and processing.

This outstanding performance is due to a number of factors: WACKER’s extensive experience in the production of pyrogenic silica, uniform high quality worldwide, our strong commitment to research and development, customer-focused service, and our own technical centers and logistics solutions dedicated to the customer’s needs – all good reasons why you will always find optimum HDK® product solutions at WACKER.

The HDK® production sites are certified worldwide in accordance with the ISO 9001 and ISO 14001 standards, which are a constituent part of WACKER’s Group certification.

HDK® is a registered trademark of Wacker Chemie AG.
Hydrophilic HDK®
Hydrophilic HDK® is manufactured by the hydrolysis of volatile chlorosilanes in an oxyhydrogen flame. In chemical terms, it consists of highly pure amorphous silicon dioxide with the appearance of a fluffy white powder. Hydrophilic silica is wetted by water and can be dispersed in water.

Hydrophobic HDK®
Hydrophobic HDK® is produced by the chemical reaction of hydrophilic HDK® with reactive silanes, e.g. methyl chlorosilanes or hexamethyldisilazane. It has water-repellent properties and is no longer dispersible in water.

HDK® Dispersions
HDK® dispersions are produced by the dispersion of hydrophilic HDK® in water using high shear forces. They obtain their stability by electrostatic and steric stabilization.

**Typical General Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance</strong></td>
<td>Fluffy white powder</td>
</tr>
<tr>
<td><strong>Solid structure of SiO₂</strong></td>
<td>Amorphous</td>
</tr>
<tr>
<td><strong>Loss on ignition</strong></td>
<td>&lt;2% (hydrophilic)</td>
</tr>
<tr>
<td><strong>SiO₂ content</strong></td>
<td>&gt;99.8 %</td>
</tr>
<tr>
<td><strong>Density of SiO₂</strong></td>
<td>approx. 2.2</td>
</tr>
<tr>
<td><strong>Refractive index</strong></td>
<td>1.46 (hydrophilic)</td>
</tr>
<tr>
<td><strong>Silanol group density</strong></td>
<td>2 SiOH/nm² (hydrophilic)</td>
</tr>
</tbody>
</table>

1 Based on the substance dried for 2 h at 105 °C
2 Based on the substance incinerated for 2 h at 1,000 °C
HDK®: PRODUCT RANGE OVERVIEW

<table>
<thead>
<tr>
<th>HDK® Hydrophilic – General Product Range</th>
<th>D05</th>
<th>C10</th>
<th>S13</th>
<th>V15</th>
<th>N20</th>
<th>T30</th>
<th>T40</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pH in 4% dispersion</strong>&lt;br&gt;DIN EN ISO 787-9</td>
<td>approx.</td>
<td>4.3</td>
<td>4.1</td>
<td>4.1</td>
<td>4.1</td>
<td>4.1</td>
<td>4.1</td>
</tr>
<tr>
<td><strong>Tamped density</strong>&lt;br&gt;DIN EN ISO 787/11</td>
<td>[g/l] approx.</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td><strong>Loss on drying, ex works</strong>&lt;br&gt;(2 h at 105 °C) DIN EN ISO 787-2</td>
<td>[wt. %]</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>&lt;1.5</td>
<td>&lt;1.5</td>
</tr>
<tr>
<td><strong>Sieve residue</strong>&lt;br&gt;DIN EN ISO 787-18</td>
<td>[wt. %]</td>
<td>&lt;0.1</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
</tr>
</tbody>
</table>

Note: these figures are intended as a guide and should not be used in preparing specifications.
### HDK® Hydrophobic – General Product Range

<table>
<thead>
<tr>
<th>HDK®</th>
<th>H13L</th>
<th>H15</th>
<th>H20</th>
<th>H30</th>
<th>H17</th>
<th>H18</th>
<th>H2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>BET surface area of hydrophobic silica</td>
<td>[m²/g] approx.</td>
<td>110</td>
<td>120</td>
<td>170</td>
<td>250</td>
<td>90</td>
<td>120</td>
</tr>
<tr>
<td>pH in 4% dispersion (1:1 mixture of water – methanol) DIN EN ISO 787-9</td>
<td>approx.</td>
<td>4.3</td>
<td>4.3</td>
<td>4.3</td>
<td>4.3</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Tamped density</td>
<td>[g/l] approx.</td>
<td>60</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Loss on drying, post production (2 h at 105 °C) DIN EN ISO 787-2</td>
<td>[wt. %]</td>
<td>&lt;0.6</td>
<td>&lt;0.6</td>
<td>&lt;0.6</td>
<td>&lt;0.6</td>
<td>&lt;0.6</td>
<td>&lt;0.6</td>
</tr>
<tr>
<td>Sieve residue</td>
<td>[wt. %]</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
</tbody>
</table>

**Treatment/hydrophobic character**
- Silane/high
- Silane/medium
- Siloxane/very high

Note: these figures are intended as a guide and should not be used in preparing specifications.

With further specialty grades being available:

### HDK® N20 – Specialty Product Range

<table>
<thead>
<tr>
<th>HDK®</th>
<th>N20</th>
<th>N20D</th>
<th>N20P</th>
<th>N20Pharma</th>
<th>N20Nutrition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BET surface area</td>
<td>[m²/g]</td>
<td>170 – 230</td>
<td>170 – 230</td>
<td>170 – 230</td>
<td>170 – 230</td>
</tr>
<tr>
<td>pH in 4% dispersion</td>
<td>approx.</td>
<td>4.3</td>
<td>4.3</td>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Tamped density</td>
<td>[g/l] approx.</td>
<td>40</td>
<td>70</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Loss on drying, post production (2 h at 105 °C) DIN EN ISO 787-2</td>
<td>[wt. %]</td>
<td>&lt;1.5</td>
<td>&lt;1.5</td>
<td>&lt;1.5</td>
<td>&lt;1.5</td>
</tr>
<tr>
<td>Sieve residue</td>
<td>[wt. %]</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
</tr>
</tbody>
</table>

Note: these figures are intended as a guide and should not be used in preparing specifications.

Further information about HDK® grades upon request.
## THE MANY USES OF HDK®

### Applications of HDK®

<table>
<thead>
<tr>
<th>Application</th>
<th>HDK® grade</th>
<th>Amount used [%]</th>
<th>Effect achieved</th>
<th>Recommended equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unsaturated polyester composite resins</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laminating resins</td>
<td>N20</td>
<td>0.8 – 1.5</td>
<td>Thickening, thixotropy</td>
<td>Dissolvers, kneaders, roll mills, ultrasonic disperser</td>
</tr>
<tr>
<td>Gel coats</td>
<td>N20, T30</td>
<td>2.0 – 3.0</td>
<td>antisedimentation</td>
<td></td>
</tr>
<tr>
<td>Putties</td>
<td>N20</td>
<td>0.5 – 1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polar resin systems, e.g. vinyl ester resins</td>
<td>H18, H13L</td>
<td>0.5 – 3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PVC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastisols</td>
<td>N20, T30, T40</td>
<td>0.3 – 2.5</td>
<td>Thickening, thixotropy</td>
<td>Dissolvers, roll mills, fluid mixers, ultrasonic disperser</td>
</tr>
<tr>
<td>Organosols</td>
<td>N20, T30, T40</td>
<td>0.3 – 2.5</td>
<td>antisedimentation</td>
<td></td>
</tr>
<tr>
<td>Plasticized PVC compounds</td>
<td>N20, T30</td>
<td>0.1 – 0.8</td>
<td>anti-sticking, free-flow</td>
<td></td>
</tr>
<tr>
<td>Cable compounds</td>
<td>T30, T40</td>
<td>1.0 – 3.0</td>
<td>anti-blocking</td>
<td></td>
</tr>
<tr>
<td>Dry blend compounds</td>
<td>H20</td>
<td>0.05 – 0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Film &amp; sheet</td>
<td>N20, T30, H20</td>
<td>0.1 – 1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Printing inks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letterpress and gravure printing</td>
<td>N20</td>
<td>0.5 – 2.0</td>
<td>Thickening, thixotropy</td>
<td>Dissolvers, roll mills, fluid mixers, ultrasonic disperser</td>
</tr>
<tr>
<td>Screen printing</td>
<td>N20, T40</td>
<td>1.0 – 10.0</td>
<td>antisedimentation</td>
<td></td>
</tr>
<tr>
<td>Flexographic printing</td>
<td>N20, T30, H13L, H15, H20, H30</td>
<td>0.5 – 2.5</td>
<td>regulation of water content, improved brilliance and contrast, gloss, water adsorption, regulation of drying</td>
<td>Dissolvers, roll mills, fluid mixers, ultrasonic disperser</td>
</tr>
<tr>
<td>Offset printing</td>
<td>H13L, H15, H20</td>
<td>0.5 – 2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photo-glossy paper</td>
<td>N20, T30, T40</td>
<td>25 – 30</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Paints and coatings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyester coatings</td>
<td>N20, T30, T40</td>
<td>0.5 – 2.5</td>
<td>Thickening, thixotropy</td>
<td>Dissolvers, roll mills, fluid mixers, stirrers</td>
</tr>
<tr>
<td>Epoxy resin and polyurethane coatings</td>
<td>H15, H20, H30, H18, H17</td>
<td>1.0 – 4.5</td>
<td>antisedimentation</td>
<td></td>
</tr>
<tr>
<td>Alkyd resin coatings</td>
<td>N20, T30, T40</td>
<td>0.5 – 5.0</td>
<td>free flow</td>
<td></td>
</tr>
<tr>
<td>Acrylic resin coatings</td>
<td>N20, T30, T40</td>
<td>0.3 – 2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc-rich paints</td>
<td>H15, H20, N20, H18, H17, H13L</td>
<td>0.5 – 2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powder coatings</td>
<td>V15, N20, H15, H20, H2000</td>
<td>0.5 – 5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Accumulators</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery acids</td>
<td>N20, N20P</td>
<td>2.0 – 6.0</td>
<td>Thickening, thixotropy</td>
<td>Dissolvers, stirrers</td>
</tr>
<tr>
<td><strong>Insulating gels</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable and splice fillings for conventional copper and fiber-optic technology</td>
<td>N20, H15, H20, H30</td>
<td>5.0 – 10.0</td>
<td>Thickening, thixotropy, water repellency</td>
<td>Stirrers, kneaders, roll mills</td>
</tr>
</tbody>
</table>
### Application HDK® grade Amount used [%] Effect achieved Recommended equipment

#### Adhesives
- Polychloroprene-based  
  - N20, H2000  
    - 0.8 – 5.0  
    - Thickening, thixotropy, adhesion improvement  
    - Dissolvers, roll mills, ultrasonic disperser
- Epoxy-, polyurethane-, cyanoacrylate-based  
  - N20, H18, H17, H13L, H2000  
    - 0.8 – 5.0  
    - antisedimentation, processing aid,  
    - stirrers, ultrasonic disperser
- Dispersion-based  
  - N20, H2000  
    - 0.8 – 5.0  
    - adhesion improvement

#### Sealants
- RTV-1 silicone rubber  
  - S13, V15, H2000, H15, H20  
    - 3.0 – 30.0  
    - Reinforcement  
    - Planetary mixers, ultrasonic disperser
- Polyurethanes  
  - V15, H20  
    - 3.0 – 25.0  
    - thixotropy  
    - dissolvers, extruders
- Polysulfides (thiokols)  
  - V15, N20, H15, H20  
    - 0.7 – 3.0  
    - free-flow  
    - ultrasonic disperser
- Acrylates  
  - V15, H20  
    - 0.5 – 1.5  

#### Elastomers
- Natural and synthetic rubber  
    - 5.0 – 40.0  
    - Reinforcement  
    - Internal mixers, roll mills, kneaders
- Silicone elastomers  
  - S13, V15, N20, T30, H30, H2000  
    - 3.0 – 35.0  

#### Cosmetics and personal care
- Toothpaste  
  - V15, N20, N20P  
    - 1.5 – 5.0  
    - Thickening, thixotropy,  
    - Dissolvers, ultrasonic disperser
- Powders  
  - N20, H20  
    - 0.1 – 2.0  
    - antisedimentation  
    - roll mills, mechanical mixers
- Aerosols  
  - N20  
    - 0.1 – 3.0  
    - free-flow  
    - pneumatic mixers
- Suspensions  
  - V15, N20  
    - 0.2 – 3.0
- Ointments, creams  
  - V15, N20  
    - 2.0 – 10.0

#### Pharmaceuticals
- Tablets  
  - N20Pharma  
    - 1.5 – 10.0  
    - Free-flow,  
    - Dry mixer
- Dragees  
  - N20Pharma  
    - 3.0 – 12.0  
    - processing aid, disintegrant

#### Nutrition
- Spice- and vegetable powders, carbohydrates  
  - N20Nutrition, T40Nutrition  
    - 0.5 – 3.0  
    - Free-flow  
    - Dry mixer

#### Bulk materials
- Fire-extinguisher powders  
  - H15, H2000  
    - 0.5 – 1.0  
    - Free-flow, adhesion improvement  
    - Mechanical and pneumatic mixers, ultrasonic disperser
- Plastic powders  
  - N20, H15, H20, H2000  
    - 0.05 – 1.0  
    - processing aid,  
    - stirers, ultrasonic disperser
- Pigments  
  - N20, H20, H2000  
    - 0.1 – 1.0  
    - flow enhancement,  
    - ultrasonic disperser
- Salts  
  - N20, H20, H30  
    - 0.1 – 1.0  

#### Industrial
- Insulation panels  
  - V15, N20, T30  
    - 80–95  
    - Heat and sound insulation  
    - Special equipment

### Further Information
More detailed information on particular applications is given in the following application brochures: Coatings and Printing Inks, Toners, Adhesives and Sealants, Synthetic Resins and Composites, Personal Care and Cosmetics and Pharmaceuticals.

Copies of the brochures can be obtained from WACKER, from your technical support staff, or via the internet at: [www.wacker.com/hdk](http://www.wacker.com/hdk)
HDK®: PACKAGED TO YOUR NEEDS

Logistics at your service
WACKER offers compelling, innovative products, as well as customized logistics solutions. In order to fulfill your needs in your specific production environment, HDK® is offered in various packaging types and sizes. We offer rapid, dependable delivery according to your requirements – from multilayered bags and big bags to large-volume tanker trucks.

Packaging solutions: from small to mega to dispersions
In order to ensure the maximum effectiveness of your products and formulations, we offer you alternative forms of packaging that are adapted to your workflow or transport systems. Because, for us, logistics means more than just transportation.

Please find here the various standard packaging sizes available. As there are different items to take into consideration when ordering HDK® – such as the packaging size, effective protection against moisture, and your specific requirements – please do not hesitate to contact us for further detailed information.

Pallets with paper bags
HDK® is available in multilayer, valved paper bags which can contain 5–20 kg of product depending on its bulk density. The bags are delivered on pallets which are shrink-wrapped with a polyethylene film. Please be aware that the film is used to protect the HDK® effectively against moisture and allows the product to be stored with no loss in functionality.

In case of accidental damage to the shrink film, or removal of single bags, we therefore highly recommend protecting the remaining bags/individual bags against moisture uptake by either wrapping in plastic or other appropriate measures.

Big bags
The big bag solution is available for most HDK® grades, a woven polypropylene bag containing 150–200 kg of product, depending on the respective bulk density of the product. Big bags are delivered on a pallet shrink-wrapped with a polyethylene film to protect against moisture.

Bulk deliveries
For customers with higher consumption rates, we offer delivery in a silo truck. The amount of HDK® which can be sent ranges from 3,000–5,000 kg. Please be aware that bulk deliveries will require a storage silo at your site. For overseas deliveries a mega big-bag solution can be provided.

HDK® – also available in dispersion form
All HDK® dispersions are delivered in 200-liter polyethylene drums.
WACKER is one of the world’s leading and most research-intensive chemical companies, with total sales of €4.91 billion. Products range from silicones, binders and polymer additives for diverse industrial sectors to bio-engineered pharmaceutical actives and hyperpure silicon for semiconductor and solar applications.

As a technology leader focusing on sustainability, WACKER promotes products and ideas that offer a high value-added potential to ensure that current and future generations enjoy a better quality of life based on energy efficiency and protection of the climate and environment. Spanning the globe with five business divisions, operating 25 production sites, WACKER is currently active in over 100 countries. The Group maintains subsidiaries and sales offices in 29 countries across Europe, the Americas and Asia – including a solidly established presence in China. With a workforce of 17,200, WACKER sees itself as a reliable innovation partner that develops trailblazing solutions for, and in collaboration with, its customers. WACKER also helps them boost their own success. Our technical centers employ local specialists who assist customers world-wide in the development of products tailored to regional demands, supporting them during every stage of their complex production processes, if required.

WACKER e-solutions are online services provided via our customer portal and as integrated process solutions. Our customers and business partners thus benefit from comprehensive information and reliable service to enable projects and orders to be handled fast, reliably and highly efficiently.

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www.wacker.com

All figures are based on fiscal 2011.
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