Adsorbents Solutions for Compressed Air Drying

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Why drying?

The compression of humid ambient air, for example in an industrial application, produces liquid water by condensation. If the application does not allow moisture for chemical-physical reasons or danger arises due to the precipitation of the moisture, the air must be dried before compression.

The maximum water vapor content of a compressed air volume unit is caused by the temperature of the compressed air and is almost completely independent of its pressure. The water vapor content is therefore theoretically represented by the dew point, which indicates the temperature at which the actual water vapor quantity corresponds to a relative humidity of 100% and below which condensation begins.

Drying in this context means a reduction of the dew point below the actual operating temperature. To obtain ultra-dry air (ISO 8573.1 class 1, 2 or 3), essentially only the process of adsorption, in which water is bound to a solid, is suitable. Adsorption is thereby defined as the attraction of a substance (the adsorbate) to the surface of a solid body (the adsorbent) via physical binding forces. Desorption, on the other hand, refers to the release of the adsorbate from the adsorbent. Since binding forces. Desorption, on the other hand, refers to the release of the adsorbate from the adsorbent. Since the adsorption capacity of adsorbents decreases with increasing temperature and decreasing pressure, moisture can be desorbed again by heat supply or pressure reduction.

BASF Solutions for Compressed Air

Sorbead® Air

BASF Sorbead® Air is a high performance adsorbent for dehydration of air, technical gases and liquids. The patented BASF Sorbead® Air line of highly efficient adsorbents are aluminosilicate gels in the form of hard, spherical beads, with a very high resistance to crushing and a low attrition rate. Sorbead® Air adsorbents have a longer life than most other adsorbents and can reduce operating costs in most applications. Sorbead® Air R is an adsorbent with a wide range of applications. Its high level of efficiency (above-average drying capacity at low required desorption energy) and reliability (low level of product loss, high mechanical strength) is derived from a combination of unique properties. Sorbead® Air R is mainly used for the continuous drying of compressed air, technical gases (e.g. N₂, O₂, CO₂) and liquefied gases. A guard layer of Sorbead® Air WS protects the main bed against liquid water.

BASF Sorbead® Air WS water-resistant silica gel adsorbents have high capacity and protect other adsorbents and catalysts from water and moisture in a broad range of applications. Sorbead® Air WS is the only 100% water-resistant adsorbent with a high adsorption capacity. It is most frequently used as a protective layer in combination with Sorbead® Air R or other adsorbents such as molecular sieves, activated alumina, activated carbons and catalysts in order to increase the reliability of the system. The high capacity of Sorbead® Air WS enables it to be used on a standalone basis as well. With its high resistance against hydrothermal aging and low regeneration temperature, Sorbead® Air WS is ideal for applications with high moisture regeneration gas (Heat-of-Compression).

Table 1

<table>
<thead>
<tr>
<th>Typical Properties</th>
<th>Sorbead® Air R 2050</th>
<th>F 2000</th>
<th>Activated Alumina F 200</th>
<th>BASF Molecular Sieve 4 A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical composition</td>
<td>m/g</td>
<td></td>
<td>m/g</td>
<td>Na[3AlO₂]12 (SiO₂)12·27H₂O</td>
</tr>
<tr>
<td>Specific surface area</td>
<td>750</td>
<td>650</td>
<td>340</td>
<td>800</td>
</tr>
<tr>
<td>Pore volume</td>
<td>0.42</td>
<td>0.44</td>
<td>0.5</td>
<td>0.30</td>
</tr>
<tr>
<td>Equilibrium capacity for water vapor at 25 °C and relative humidity 80%</td>
<td>N, by weight</td>
<td>42.0</td>
<td>42.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Packed bulk density</td>
<td>kg/l</td>
<td>0.8</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Grain size</td>
<td>mm</td>
<td>2–5</td>
<td>2–5</td>
<td>4.7 (3/16&quot;)</td>
</tr>
<tr>
<td>Water (liquid) resistant</td>
<td>no</td>
<td>yes</td>
<td>(yes)</td>
<td>no</td>
</tr>
<tr>
<td>Typical desorption temperature</td>
<td>°C</td>
<td>120–150</td>
<td>120–150</td>
<td>170–200</td>
</tr>
<tr>
<td>Pressure dew point down to</td>
<td>°C</td>
<td>-60</td>
<td>-60</td>
<td>-40</td>
</tr>
</tbody>
</table>

1 Typical for compressed air drying
Compressed air adsorption drying

Today adsorption dryers are part of every modern compressed air and energy supply. In addition to the correct regeneration process, the adsorbent is the actual basic process component of each adsorption dryer and is responsible not only for the physical process of adsorption but also for the efficiency of the system.

**Economic systems**

Where high efficiency is required specifically due to high energy costs, an adsorption dryer filled with Sorbead® Air can achieve or even exceed the required performance with a long lifetime.

Compressed-air dryer manufacturers use Sorbead® Air for first fills and specify Sorbead® Air as the best option if a particularly low-energy operation is required. Energy efficiency and high reliability make Sorbead® Air the perfect choice in energy-efficient compressed air dryers compared to other adsorbents like Activated Alumina and Molecular Sieves.

**External heat-regenerated (purgeless)**

Low-energy external heat-regenerated adsorption dryers (Figure 1) are desorbed and cooled with drawn-in ambient air (blower air). An external electric heater, steam or another medium can be used for heating. Modern purgeless systems (zero-purge) do not require compressed air above 200 °C in order to reach the residual moisture required for very low dew points.

**Heat-of-compression (HOC)**

The Heat-of-Compression process (Figure 2) is a heat-regenerated adsorption dryer that uses the hot gas flow from an oil-free compressor for full or split stream desorption. The closed system is regenerated under pressure and the hot compressed air coming from the compressor is used for the description. These systems are among the most energy-saving compressed air dryers and show how efficiently dried compressed air can be produced.

**Standard systems**

Cold regenerated (heatless)

Cold-regenerated dryers (so-called heatless dryers) function without heat but with a lot of compressed air. These pressure swing adsorption dryers require a partial flow of previously-dried air for regeneration. The change-over takes place after only a few minutes with low water adsorption of less than 1% by weight of the drying agent. Due to the high consumption of 12 to 25% dried compressed air depending on the operating pressure, relatively high energy costs result during operation.

Pressure dew point: -25 to -40 °C, -70 °C

Adsorbent: Activated Alumina F 200, Molecular Sieve 4A

**External heat regenerated (standard)**

Standard adsorption dryers (externally heat-regenerated) are desorbed with externally heated fan air like the low-energy variants. These are used if the demands on the efficiency are not too high. In contrast to the modern purgeless systems, a partial flow of compressed air (purge air) is normally required for cooling. The standard of these systems usually includes drying agents which require a significantly higher desorption temperature (170 °C to 200 °C) and a larger quantity of dry regeneration air.

Pressure dew point: -25 to -40 °C

Adsorbent: Activated Alumina F 200

**Special systems**

In the field of compressed-air adsorption dryers, there are also special applications which require adaptation of the plant or a special adsorbent. Molecular sieves are used when particularly deep pressure dew points (up to -100 °C) are required, where the compressed air to be dried has a low relative humidity or is already pre-dried. Likewise, molecular sieves are suitable for the selective separation of gas mixtures owing to their uniform pore structure. Molecular sieves can be regenerated but require high temperatures of above 200 °C in order to reach the residual moisture required for very low dew points.

**Table 2: BASF adsorbents selection table for compressed air dryers**

<table>
<thead>
<tr>
<th>Compressed air adsorption dryer</th>
<th>PDP 1 (down to)</th>
<th>Sorbead® Air</th>
<th>Activated Alumina F 200</th>
<th>BASF Molecular Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold regenerated</td>
<td>-25 °C</td>
<td>-25 °C</td>
<td>-70 °C</td>
<td></td>
</tr>
<tr>
<td>Standard systems</td>
<td>-25 °C</td>
<td>-40 °C</td>
<td>-70 °C</td>
<td></td>
</tr>
<tr>
<td>Economic systems</td>
<td>-25 °C</td>
<td>-40 °C</td>
<td>-70 °C</td>
<td></td>
</tr>
<tr>
<td>Compressor warming</td>
<td>-15 to</td>
<td>-40 °C</td>
<td>-70 °C</td>
<td></td>
</tr>
</tbody>
</table>

1As a function of the desorption temperature, PDP = Pressure dew point

280% Sorbead® Air R and 20% Sorbead® Air WS as protection layer.
Sorbead® Air advantage: Energy savings

The efficiency of a compressed air unit is strongly influenced by the adsorption capacity, regenerability and the lifetime of the adsorbent. The lower the desorption temperature and the longer the lifetime of the adsorbent, the higher is the efficiency of a plant.

Sorbead® Air – High efficiency

Because of their high adsorption capacity and the energetically favorable regeneration conditions to achieve low pressure dew points, Sorbead® Air is the first choice for low-energy heat-regenerated adsorption dryers. Sorbead® Air is therefore the most economical and environmentally friendly adsorbent.

These benefits lead to a significant reduction in the dryer's energy cost while using Sorbead® Air compared to standard desiccants, which can be seen in Figure 3. These energy savings can result in substantial economical savings (see example in Figure 4). Sorbead Air represents only 1.6% of the total cost of owning (TCO) a compressed air dryer but can result in 23% savings of that TCO.

Sorbead® Air is used in almost all industrial areas with different pressure dew points and regeneration methods, with sometimes an above-average lifetime of up to 10 years (see Figure 5).

Operators of compressed air units appreciate the high efficiency and the long lifetime of Sorbead® Air because of the combination of the following unique properties:

- High adsorption capacity due to large specific surface area and pore volume
- Low desorption temperatures to achieve low pressure dew points and good desorption in moist regenerating air
- Abrasion resistance and low pressure drop
- Good mechanical and thermal stability and high chemical resistance
- Long lifetime and low maintenance requirements
- Known to be safe due to many years of use in heat regenerated dryers

Sorbead® Air is a registered trademark of BASF and is intended for use as an adsorbent. Sorbead® Air is made in Germany and is manufactured at the BASF plant in Nienburg/Weser.

For new adsorption units BASF recommends using one of the economical systems based on Sorbead® Air. Compressed air operators can improve the efficiency of their adsorption dryer with the support of BASF’s technical service and by the use of Sorbead® Air.
About Us

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BASF – We create chemistry

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