
# 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 compressed air must be dried.

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 phase, 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 the adsorption capacity of adsorbents decreases with increasing temperature and decreasing pressure, moisture can be desorbed again by heat supply or pressure reduction.

The adsorbents used in such a drying process are high-tech desiccants and have an inner surface area of up to 1000 $m^2/g$, due to their pore structure of macro-, meso- and micropores, where condensed water vapor can accumulate. For the drying of compressed air, silica gels, aluminum oxides (activated alumina) and zeolitic molec-ular sieves are most commonly used. These desiccants reach dynamic adsorption capacities above 20 % by weight and dew points down to -100 °C.



# 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 alumino-silicate 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. $N_2$, $O_2$). 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).

## Activated alumina

BASF F-200 is a smooth sphere of activated alumina produced by BASF's unique manufacturing process. F-200 is an excellent adsorbent for drying a wide variety of liquids and gases. Although all molecules are adsorbed to some extent on F-200 activated alumina, those molecules having the highest polarity are preferentially adsorbed. Stream conditions such as pressure, concentration and molecular weight of the molecules, temperature and site competing molecules affect the efficiency of adsorption.

## BASF-Molecular Sieves

BASF 4A Molecular Sieve is a synthetic crystalline aluminosilicate with a regular micropore structure and a widely used adsorbent for many different applications. BASF 4A exhibits high water adsorption capacity at low partial pressures and at temperatures up to 100 °C. BASF 4A Molecular Sieve is commonly used for drying of organic liquids (solvents, oils, gasoline and other saturated hydrocarbons), air, liquid gases (propane, butane), as well as noble and other gases ($H_2$, $N_2$, He, Ar, etc.).

***Table 1***

| Typical Properties | | Sorbead® Air | | Activated Alumina | BASF Molecular Sieve |
|---|---|---|---|---|---|
| | | R 2050 | WS 2050 | F 200 | 4 A |
| Chemical composition | | $Al_2O_3$ 3 %, $SiO_2$ 97 % | | $Al_2O_3$ | $Na_{12}[(AlO_2)12(SiO_2)_{12}]\cdot 27H_2O$ |
| Specific surface area | $m^2/g$ | 700–750 | 630–650 | 340 | 800 |
| Pore volume | ml/g | 0.41–0.43 | 0.43–0.45 | 0.5 | 0.30 |
| Equilibrium capacity for water vapor at 25 °C and relative humidity 80 % | % by weight | 40.0 | 36.0 | 30.0 | 21 |
| Packed bulk desity | kg/l | 0.8 | 0.7 | 0.8 | 0.7 |
| Grain size [1] | mm | 2–5 | 2–5 | 4.7 (3/16") | 2.5–5 |
| Water (liquid) resistant | | no | yes | (yes) | no |
| Typical desorption temperature | °C | 120–150 | 120–150 | 170–200 | 200–250 |
| Pressure dew point down to | °C | -60 | -60 | -40 | -100 |

***[1] Typical for compressed air drying***

# Applications: 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 consumption (purge air), depending on the pressure dew point with low desorption temperatures (120 to 150 °C) and are now delivered in different versions.

Pressure dew point: -25 to -60 °C
Adsorbent: Sorbead® Air R/WS

**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 desorption. These systems are among the most energy-saving compressed air dryers and show how efficiently dried compressed air can be produced.

Pressure dew point: -15 to -40 °C
Adsorbent: Sorbead® Air WS

Sorbead® Air WS meets the special requirements of this procedure to a continuous regenerability at high temperature and high humidity of the desorption air (dew point +60 °C).

***Figure 1** Compressed-air dryer with purgeless regeneration*

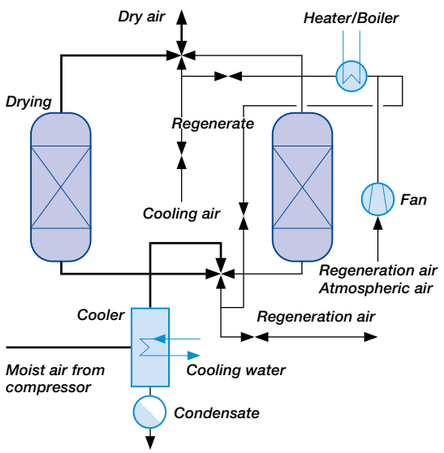
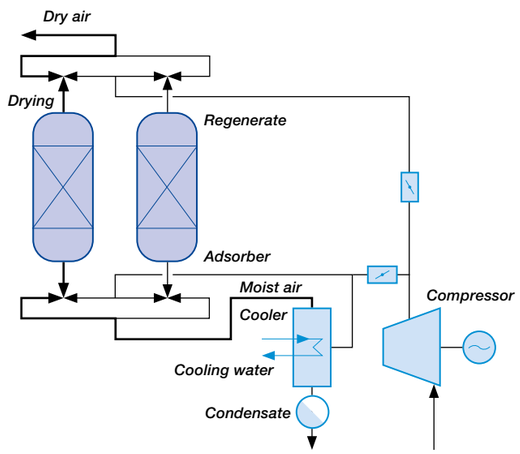



***Figure 2** Compressed air dryer with Heat-of-Compression (HOC)*




## Standard systems

**Cold regenerated (heatless)**

Cold-regenerated dryers (so-called heatless driers) 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 [1]
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° to 200 °C.) and a larger quantity of dry regeneration air.

Pressure dew point: -25 to -40 °C
Adsorbent: Activated Alumina F 200

[1] Molecular sieve 4 A

## 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*

| Compressed air adsorption dryer Regeneration process | | PDP [1] (down to) | Sorbead® Air | | Activated Alumina | BASF Molecular Sieve |
|---|---|---|---|---|---|---|
| | | | R | WS | F 200 | 4 A |
| Cold regenerated | Heatless | -25 °C | | | ● | |
| | | -40 °C | | | ● | |
| | | -70 °C | | | | ● |
| External Heat regenerated | Standard systems | -25 °C | ●[2] | ● | ● | |
| | | -40 °C | ●[2] | ● | ● | |
| | | -70 °C | | | | ● |
| | Economic systems | -25 °C | ●[2] | ● | | |
| | | -40 °C | ●[2] | ● | | |
| | | -60 °C | ●[2] | ● | | |
| Compressor-warming | Heat of compression | -15 to -40 °C | | ● | | |

*[1] As a function of the desorption temperature, PDP – Pressure dew point*
*[2] 80 % 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.

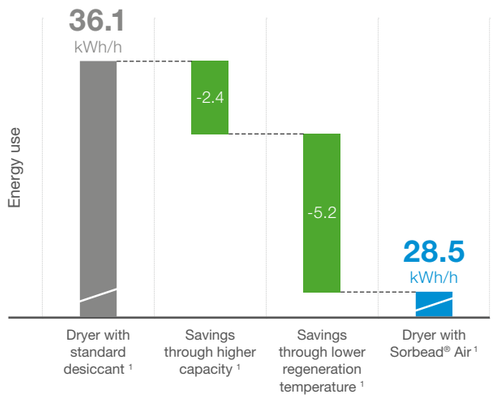
## Sorbead® Air – High efficiency

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 environmental 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.

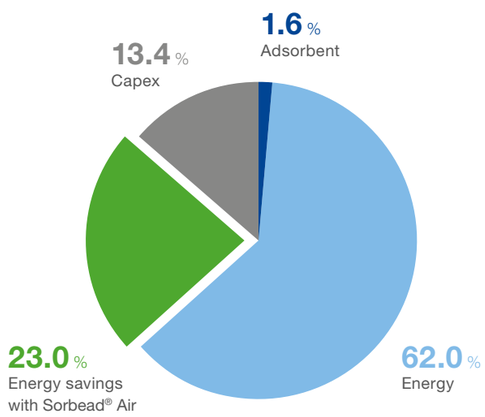
Sorbead® Air is used in almost all industrial areas with different pressure dew points and regeneration methods, with sometimes an above-average lifetime of up to 10 years *(see Figure 5)*.

***Figure 3** Sorbead® Air energy saving benefits*



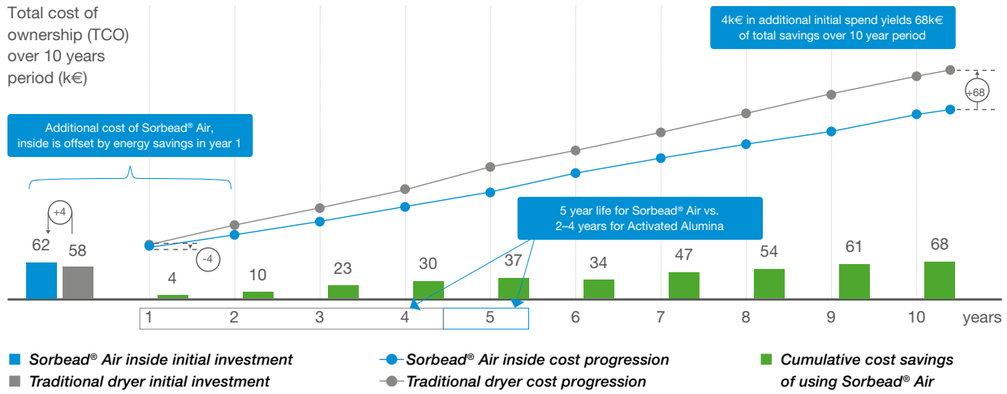

*[1] Average energy consumption and energy savings at a compressed air unit, externally heat regenerated 66 m³/min, 7 bar, 35 °C, -40 °C PDP*

***Figure 4** Total cost of ownership (TCO) of compressed air dryer*




***Adsorbent spend accounts for 1.6 % of TCO over 10 year span, but saves 23 % of TCO.***

***Figure 5** Sorbead® Air cost savings vs. activated alumina*




***Longer life and enhanced operational performance = Substantial cost savings***

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.

Sorbead® Air meets the highest quality requirements and can be clearly identified by its CAS-Register number. In addition, it meets the requirements of the European Chemicals Regulation REACH, which is intended to ensure a high level of protection for human beings and the environment.

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.

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