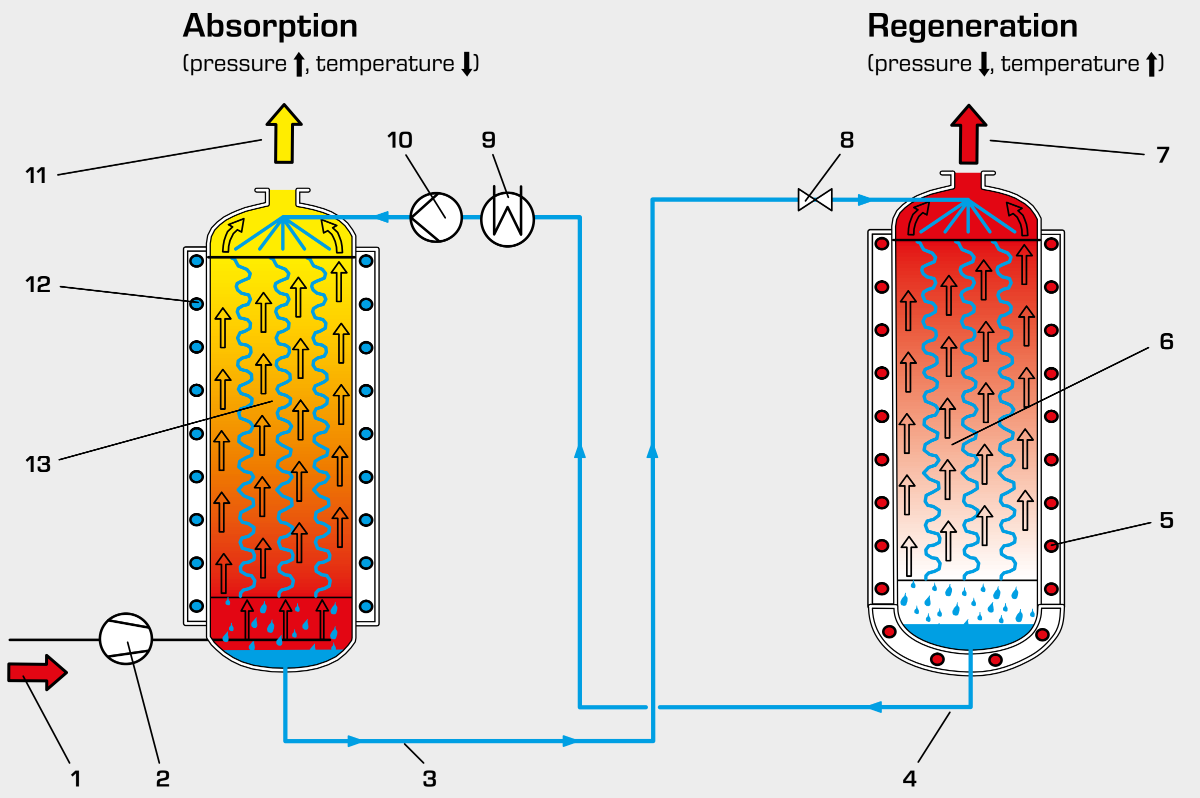
Basic knowledge
Absorption

Absorption is used to remove one or more gaseous components from a gas flow using a solvent. Absorption can have different aims:

- The gaseous component to be removed is a product that is wanted.
- The gaseous component to be removed is unwanted. This could be the case when removing contaminantes from an exhaust gas flow.
- Production of a liquid; one example would be obtaining hydrochloric acid by absorption of HCl gas in water.

At least three substances are involved in the absorption: the gaseous component to be removed (absorbate), the carrier gas and the solvent (absorbent).



Absorption system:

1 gas flow with component to be removed and carrier gas, **2** compressor, **3** solvent, charged with component to be removed, **4** regenerated solvent, **5** heating, **6** desorption column, **7** removed gaseous component, **8** expansion valve, **9** cooler, **10** pump, **11** carrier gas, **12** cooling, **13** absorption column

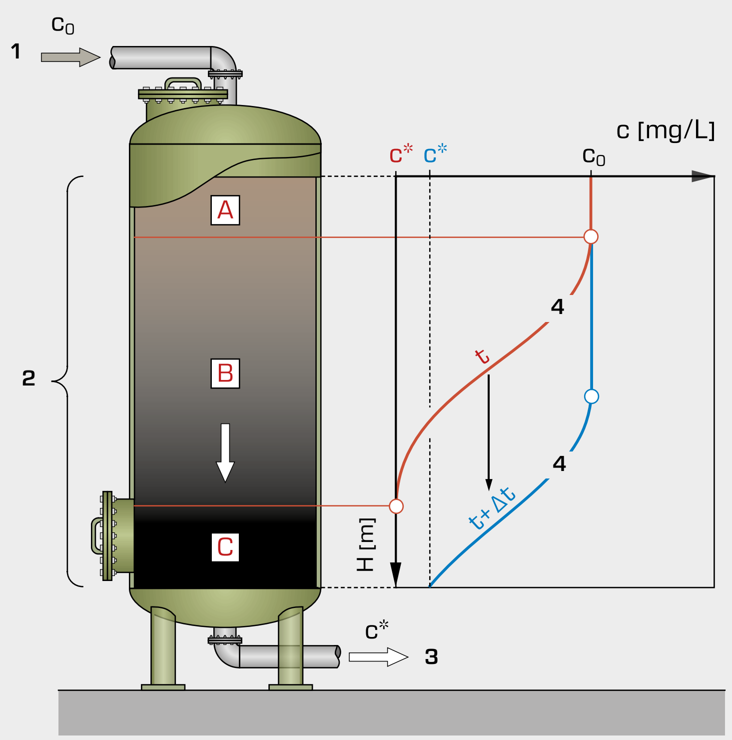
An appropriate solvent is used, depending on the gaseous component to be removed. The solvent selectively dissolves the gaseous component i.e. the solvent primarily absorbs the component(s) to be removed and not the carrier gas. High pressures and low temperatures enhance absorption. Depending on the type of solvent, the gas is either absorbed by physical dissolving (physical absorption) or chemical bonding (chemical absorption).

To remove the gaseous components from the solvent, an absorption stage is normally followed by a desorption stage for regeneration of the solvent. Here, high temperatures or low pressures are used to reduce the solubility of the gases in the solvent, thus expelling them. The solvent can therefore be recycled for further use.

Basic knowledge
Adsorption

Adsorption is used to remove individual components from a gas or liquid mixture. The component to be removed is physically or chemically bonded to a solid surface.

The solid is referred to as the adsorbent and the adsorbed component as the adsorbate. If adsorbent is brought into contact with adsorbate for long enough, an adsorption equilibrium is established. The adsorbent is then fully charged, and can absorb no more adsorbate. The adsorbent in most widespread use is activated carbon. Activated carbon has a very distinct pore system. One gram of activated carbon has a pore surface area of approximately 1000 m^2.



Concentration profiles in an adsorber:

1 raw water,
2 fixed bed of activated carbon
3 treated water,
4 concentration profiles;
H fixed bed height, **t** time,
c adsorbate concentration
c_0 adsorbate concentration in inlet
c* adsorbate concentration in outlet

Adsorption is mainly implemented with continuous-flow adsorbers. In this case, the concentration profile marked in red on the illustration is established after the time **t**. It corresponds to the trend of the adsorbate concentration in the water along the fixed bed.

This concentration profile is divided into three zones:

- Zone A

The adsorbent is fully charged and can absorb no more adsorbate. So the adsorption equilibrium has been reached. The adsorbate concentration corresponds to the inlet concentration (**c_0**).

- Zone B

The adsorption equilibrium has not yet been reached, so adsorbate is still being adsorbed. This zone is known as the **mass transfer zone**.

- Zone C

Since the adsorbate has been fully removed in zone B, the adsorbent is still non-charged here, so the adsorbate concentration is zero.

Over time, the concentration profile moves through the fixed bed in the direction of the flow. At the time **t + Δt** it corresponds to the blue curve. There is no longer any non-charged adsorbent remaining in the fixed bed. The adsorbate concentration in the outlet (**c***) is greater than zero. This state is termed the breakthrough, and the trend over time of the adsorbate concentration in the outlet is termed the breakthrough curve. The shape of the concentration profile indicates how well the capacity of an adsorbent is utilised before the breakthrough is reached. The narrower the mass transfer zone, the more effectively the capacity is utilised.