THE LINDE GROUP

Linde

Innovative solutions for drinking water treatment.

Preserving the quality of life.

Drinking water. A high-quality beverage.

Clean water is one of the fundamental building blocks of a high quality of life. But utilities are facing increasing demands to provide it because the world's water resources are under growing pressure, both in terms of quality and quantity. While quantity demands are due to the globally increasing need for fresh water, higher quality demands are mainly driven by the escalating pollution load on ground and surface waters and by increasingly strict legal regulations concerning drinking water quality.

Filling and transport of liquid gas

Gas metering unit

Linde delivers drinking water quality

Drinking water is vital for life and serves as the major component for products of the food and beverage industry. It has to meet the highest quality requirements, which are regulated by law and strictly controlled. For many years, gases from Linde have been successfully contributing to the optimisation of the quality of water. Among the most commonly used applications are the removal of water contaminants with oxygen and the tuning of the pH value for the improvement of corrosion-chemical properties with carbon dioxide.

One-stop complete solutions

As one of the leading companies of the industrial gases industry, Linde commands a global network for the provision and distribution of the required gases. Our experts develop the complete engineering solutions for the storage, metering and addition of the gases. To efficiently introduce the gases, well-proven Linde processes areavailable:

SOLVOX®:	Process for dissolving of oxygen
SOLVOCARB®:	Process for dissolving of carbon dioxide

Clear water through oxygen. Removal of water contaminants with SOLVOX®.

In water, a multitude of natural purification processes take place that consume dissolved oxygen. Therefore, especially in ground water and in deep water from dams, the oxygen concentration can be very low to zero.

Oxidative drinking water treatment
Raw waters often contain high concentrations of dissolved iron and manganese, as well as ammonium ions and other reduced chemical species. Iron and manganese ions are undesirable, as they precipitate within the drinking water supply network, where they lead to corrosion. That is why, after the enrichment of raw water with oxygen, heavy metal ions are already removed, with the aid of microorganisms, in the filter systems of the waterworks. As the specific oxygen demand for this is low, it can usually be met with atmospheric oxygen. If further oxidisable substances such as ammonium or methane are contained in the water, a higher oxygen concentration is required which can be adjusted reliably and economically with Linde's SOLVOX process.

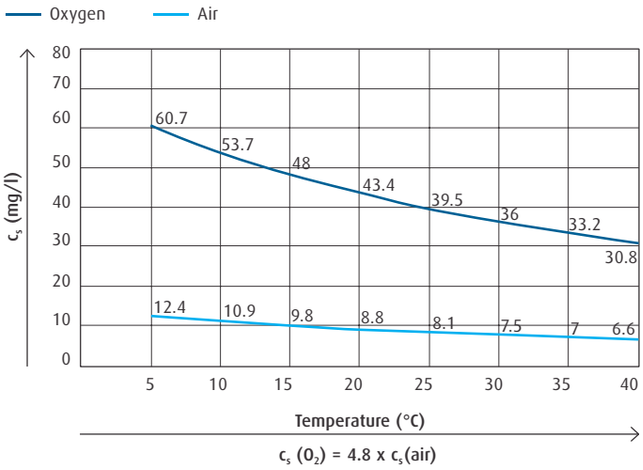
Specific oxygen demand for the oxidation of:

1 g iron (II)	0.149 g
1 g manganese (II)	0.299 g
1 g ammonium	3.569 g
1 g methane	4.000 g

High efficiency at low operating costs

In comparison to air, pure oxygen has a 4.8 times higher theoretical oxygen saturation concentration in water. Thus the increase of the oxygen content is easily possible without high energy input. Compared to air, the gas volume that has to be fed into the raw water is dramatically decreased, reducing the amount of carbon dioxide that is lost through stripping to atmosphere. Since there is no disruption of the filter operation through nitrogen emission, the filter life is extended and there are less operating costs for backwashing.

O_2 saturation concentration c ρf air and of oxygen in pure water at 1 bar



Oxygen assures drinking water quality

Apart from the removal of water contaminants, oxygen is also needed for the build-up and maintenance of a corrosion-inhibiting protective layer in metallic drinking water pipes. A pure water oxygenation to 6 mg/l helps to assure perfect drinking water quality in the supply network and improves the taste of the water.

Advantages of oxygen application:
- Improvement of the pure water quality
- Better taste of the water
- Improvement of the filter system performance
- Reduction of operating costs
- Avoidance of carbon dioxide strip loss
- Protection against corrosion

Clearly clearer. Ozone reduces organic contaminations.

The removal of organic water contaminants is carried out after a pre-treatment of the raw water involving ozone. Resistant substances, for example humic material complexes, are broken down with ozone to a point where they are ready for further biological treatment. The influence of ozonisation is reflected in the noticeable improvement of the water's organoleptic properties such as smell, taste, clearness and colour.

Ozone is produced on site from dehumidified air or oxygen and quickly reacts with water contaminants. During the reaction of ozone, oxygen is formed, which means that there is no additional water contamination.

Advantages of ozone production with oxygen:

- Higher ozone yield with less energy consumption
- Smaller system dimensions
- No pre-drying required

Further application areas for ozone:

- Oxidation of anthropogenic substances such as drug residues and pesticides
- De-ironing, de-manganisation
- Disinfection and inactivation of viruses

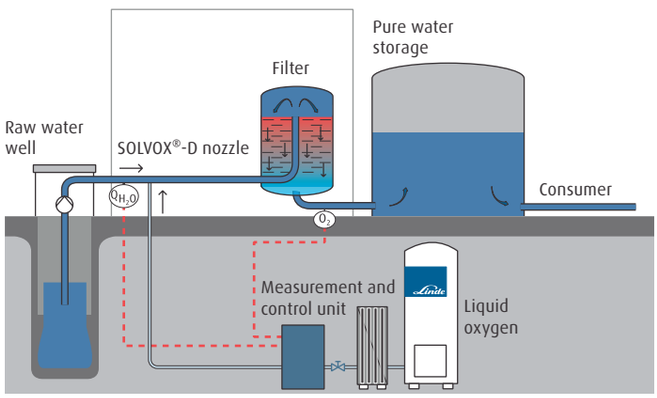
Optimal conditions. SOLVOX processes for targeted dissolving of oxygen.

The SOLVOX processes have been developed for the economical introduction of oxygen into water. They assure optimal oxygen utilisation under the given operating conditions.

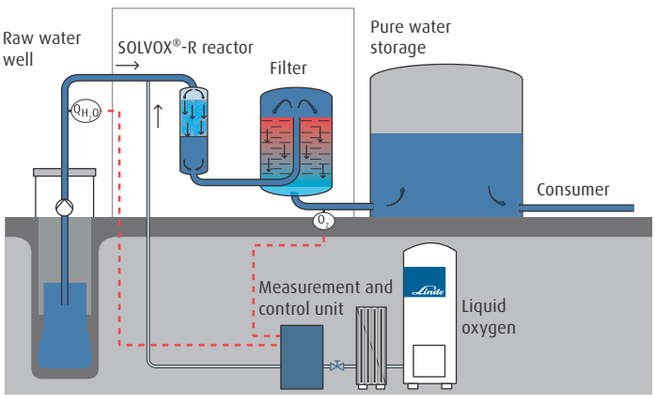
Depending on the case of application, the oxygen is fed directly into the raw water feed of the filter system or fed into the supply system separately before the introduction of the drinking water, using either nozzles (SOLVOX-D) or reactors (SOLVOX-R).

The metering of the oxygen is carried out in an automatic control unit, depending on the flow rate and the oxygen concentration of the raw water.

SOLVOX-D process, inline operation



SOLVOX-R process, inline operation



SOLVOX-D

The SOLVOX-D process is specially designed for the injection of oxygen into pressure pipe lines, where the oxygen is fed directly into the raw water stream through a stainless steel nozzle. The process efficiency can be further enhanced by the downstream installation of a static mixer.

For maintenance work, the nozzle can be easily dismantled and cleaned without having to interrupt the operation.

Additional benefits of the SOLVOX-D process:
- No extra energy required
- Low investment costs
- Fast and easy installation
- Low maintenance

SOLVOX-D injection device

SOLVOX-R

In the SOLVOX-R process, the oxygen is dissolved in a stainless steel pressure vessel. The oxygenation can be carried out in an inline or bypass operation.

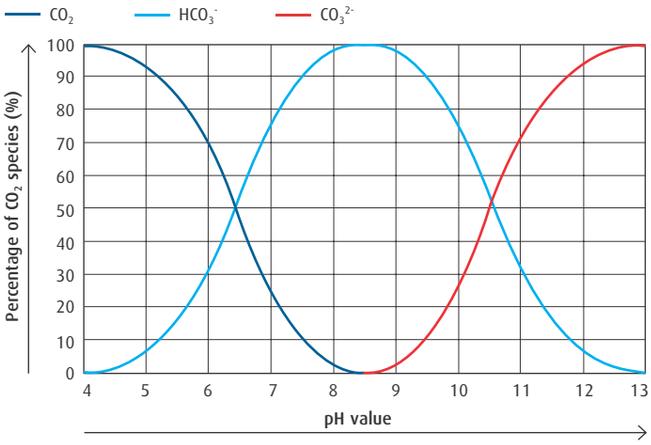
Essential benefits of the SOLVOX-R process:
- Maximum oxygen utilisation
- High oxygen concentration achievable
- Low pressure loss in the input system
- Low maintenance

SOLVOX-R reactor

Effective against corrosion.
SOLVOCARB® and carbon dioxide.

Carbon dioxide is a component of natural waters, where it exists predominantly as a physically dissolved gas. A small part of it reacts with water to form carbonic acid (H_2CO_3) which, depending on the temperature and pH value, splits up into its anions hydrocarbonate (HCO_3^-) and carbonate (CO_3^{2-}).

Distribution of CO_2 species in water as a function of the pH value at 10 °C



Buffering capacity and corrosiveness of a water are based upon the reaction of CO_2 species with the calcium ion, which precipitates from the water in the form of sparingly soluble calcium carbonate (calcite, $CaCO_3$). If the acid content and the concentration of calcium ions of a water is in equilibrium (lime-carbonic acid equilibrium), calcite is neither dissolved nor precipitated. The state of calcite saturation is characterised by the equilibrium pH value.

In terms of distribution, drinking water is ideally within the range of its calcite saturation. But if more carbon dioxide is dissolved in the water than equals the equilibrium amount, the excess carbon dioxide attacks the existing protective layer in the piping network and causes corrosion damages on concrete and metal pipes. If, on the other hand, a water contains too little dissolved carbon dioxide, the pH value of its calcite saturation is exceeded and lime precipitation in pipelines and taps is the result.

Lime-carbonic acid equilibrium, summary presentation:

$$CaCO_3 + CO_2 + H_2O \rightleftarrows Ca^{2+} + 2\ HCO_3^-$$

→ CO_2 addition: Calcite dissolution (hardness increase)
→ CO_2 removal: Calcite precipitation (de-carbonisation)

SOLVOCARB® – brings water back in balance.
During drinking water treatment, a water can acquire a calcite-precipitating property, e.g. by open aeration or after a rapid de-carbonisation with lime milk. As a result, downstream plant components such as pipes and valves show heavy scaling and the service life of filters is significantly shortened.

In such cases, the addition of carbon dioxide with a simultaneous lowering of the pH value prevents or reverses the precipitation of calcite. The lime-carbonic acid equilibrium can also be precisely readjusted in lime precipitation of raw waters by regulating the pH value with carbon dioxide.

Optimal hardness increase through carbon dioxide

The content of dissolved calcium and magnesium ions defines the hardness of a water. Hardness agents are necessary for the build-up of a lime-rust protection layer within the drinking water network, but for this, they have to exist in sufficient concentration in the water.

Raw waters from lime-poor regions as well as dam waters contain only small amounts of hardness ions, and without treatment, these have a corrosive effect and cannot form a protective layer. After desalination, drinking water from sea water also produces waters with low buffer capacities which have to be hardened before distribution. Through the addition of carbon dioxide and an equivalent amount of lime milk, the ideal water hardness can be precisely adjusted to a given pH target value.

With the SOLVOCARB processes, Linde not only offers the gases supply, but also the know-how and the required hardware for the efficient injection of carbon dioxide into water.

Advantages of carbon dioxide application:
- Exact adjustment of the ideal water hardness
- Higher buffer capacity
- Better taste of the water
- Prevention of scaling
- Minimisation of corrosion

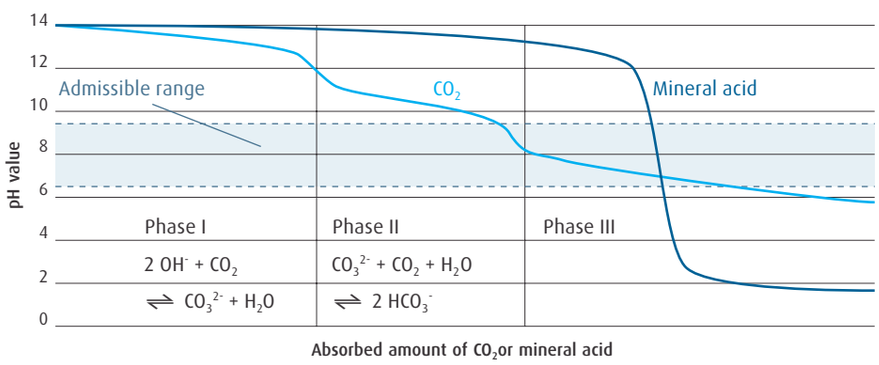
Smooth pH value adjustment with carbon dioxide – efficient and safe.
The addition of carbon dioxide into water creates carbonic acid:

$$CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows HCO_3^- + H^+ \rightleftarrows CO_3^{2-} + 2H^+$$

The application of carbon dioxide or carbonic acid is the ideal alternative to mineral acid metering for adjusting the pH value of poorly buffered waters such as drinking water. A fundamental advantage of carbonic acid is based on the flat course of its neutralisation curve, especially within the admissible pH range of drinking water. Due to this advantage, the desired pH value can be adjusted easily and precisely even at variable raw water parameters, without the danger of acidification.

Further advantages compared to mineral acid:
- No salinity increase
- No adverse effect on the taste
- No corrosion damages on plant components
- Easy metering
- Safe handling
- Safe and easy storage
- Excellent value for money

Neutralisation of sodium hydroxide solution with CO_2 and with mineral acid

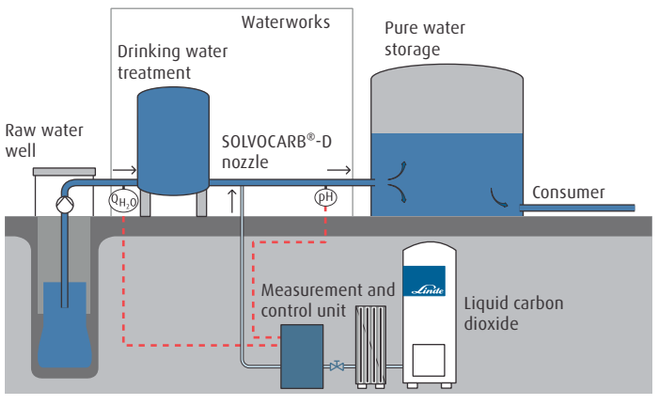


Economical solutions for individual requirements. Precise addition of carbon dioxide with SOLVOCARB.

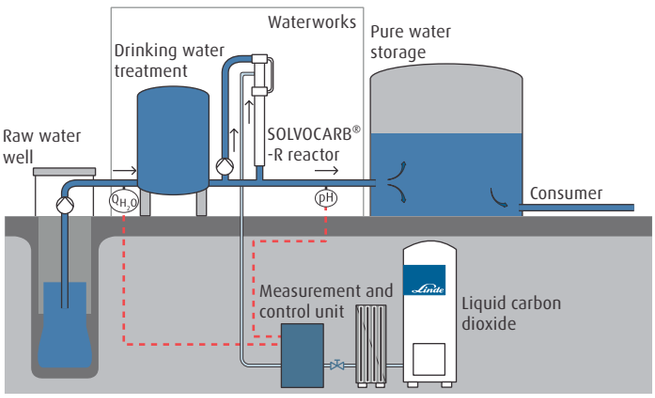
With the SOLVOCARB process, Linde provides tried and tested, reasonably priced metering and dissolving systems for carbon dioxide.

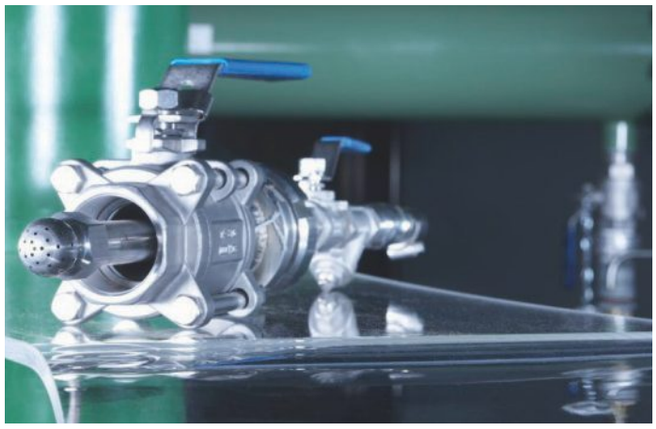
The nozzles and reactors of the SOLVOCARB family can be applied flexibly in an inline or bypass operation, thus offering a broad range of solutions for specific customer requirements.

SOLVOCARB-D process, inline operation



SOLVOCARB-R process, bypass operation





SOLVOCARB-D injection device

SOLVOCARB-R reactor with CO_2 metering unit

SOLVOCARB-D

The SOLVOCARB-D process has been specially developed for the injection of carbon dioxide into pressure pipe lines, where the carbon dioxide is fed directly into a raw water stream through a stainless steel nozzle. Downstream of the injection point, a reaction section is required where the carbon dioxide dissolves. The reaction section can be significantly shortened by the installation of a static mixer.

Advantages of the SOLVOCARB-D process:

- No extra energy required
- Low investment costs
- Fast and easy installation
- Maintenance without service interruption
- Low maintenance

SOLVOCARB-R

In the SOLVOCARB-R process, the carbon dioxide is dissolved in a reactor.
Reactors of various designs and material configurations are available for different types of application conditions.

Essential advantages of the SOLVOCARB-R process:

- High gas utilisation
- Low maintenance

Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages, and greater profitability. Each concept is tailored specifically to meet our customers' requirements – offering standardised as well as customised solutions. This applies to all industries and all companies regardless of their size.

If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimisation, and enhanced productivity are part of daily business. However, we define partnership not merely as being there for you but being with you. After all, joint activities form the core of commercial success.

Linde – ideas become solutions.

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