Enhanced Waste Water Treatment with Pure Oxygen

Using Pure Oxygen to Solve Waste Water Problems

Lack of oxygen causes many problems in waste water treatment. It can result in inadequate purification or even in anaerobic decomposition, subjecting the vicinity to highly offensive odours.

Problems that can arise in waste water treatment plants:

1. Lack of oxygen in existing activated sludge plants, as a result of:

- Increased waste water inflow
- Increased concentration of pollutants
- Greatly fluctuating pollutant load
- More thorough purification dictated by stricter legal requirements

Solution:
Meet peaks in demand by injecting pure oxygen.

2. Failure of aeration systems, caused by:

- Defective compressors for diffused aeration
- Damage to mechanical surface aerators

Solution:
Save the day by injecting pure oxygen as an emergency procedure.

3. Inadequate elimination of nitrogen.

Solution:
Inject pure oxygen in a focused manner, switching to use of upstream, intermittent or simultaneous denitrification.

Oxygen supply plant

Problems Where Waste Water is Generated:

1. Fees charged for discharging highly contaminated (but bio-degradable) industrial waste water, e.g. from the food-processing industry.

Solution:
Prepurify the waste water with pure oxygen.

2. Odours from waste water holding ponds and lagoons

Solution:
„Aerobic sealing“ with pure oxygen.

Oxygen measurement and control unit

Problems in Conveying Waste Water:

Corrosion damage and odour problems may occur when waste water is conveyed through pressure pipes.

Solution:
Enrich with pure oxygen at the start.

Advantages of Using Pure Oxygen

- Low investment costs
- Quick and economic solutions to problems
- Focused injection of oxygen
- Increased efficiency without enlarging facilities
- Low maintenance requirement
- Optimum oxygen utilisation
- Flexible oxygen injection
- High oxygen concentrations attainable

Using Pure Oxygen to Cope with Peak Loads in Waste Water Treatment Plants

Lack of Oxygen in Activated Sludge Plants

Many activated sludge plants built years ago are no longer able to handle today's increased requirements concerning waste water purification.

Because of greater pollutant loads, the installed aeration systems are unable to supply the micro-organisms with enough oxygen.

Should the existing aeration system be enlarged?

To increase the aeration capacity in overloaded activated sludge tanks, there is usually no choice but to enlarge the aeration equipment – a costly undertaking.

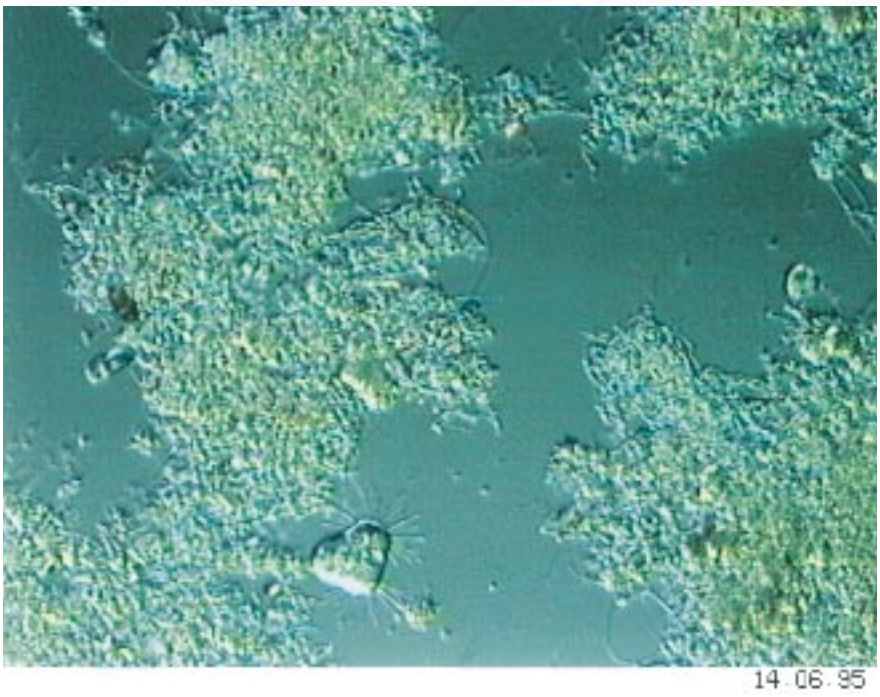
It may be necessary, for example, to install larger surface aerators, additional compressors, as well as air diffusers.

But such measures quickly run up against the following constraints:

- The space requirement is too great; the activated sludge tank is too small to accommodate any more equipment.
- Uneconomical and inefficient oxygen transfer, due to injection of too much air at points crowded too closely together.

And because the aeration facility must be designed from the outset to cope with the maximum load, high investment costs are involved.

Weakly structured flocs caused by an inadequate supply of oxygen in a brewery's waste water treatment plant



Well-developed sludge flocs after being treated with oxygen for 2 weeks

Supporting Aeration with Additional Pure Oxygen

Overloaded aeration systems are simple to enhance or extend by injecting additional oxygen using Linde's SOLVOX® processes.

These processes involve supplying the activated sludge with pure oxygen, either through perforated hoses (SOLVOX®-B), by oxygen reactors (SOLVOX®-R), or by injector systems (SOLVOX®-I).

- The SOLVOX®-B process does not require any additional energy for injecting the oxygen.
- The SOLVOX®-R and SOLVOX®-I processes inject oxygen with virtually no losses.
- The investment costs for all three injection systems are gratifyingly low.
- All three processes allow oxygen to be supplied to specific areas of the tank.

Pure oxygen supports surface aeration

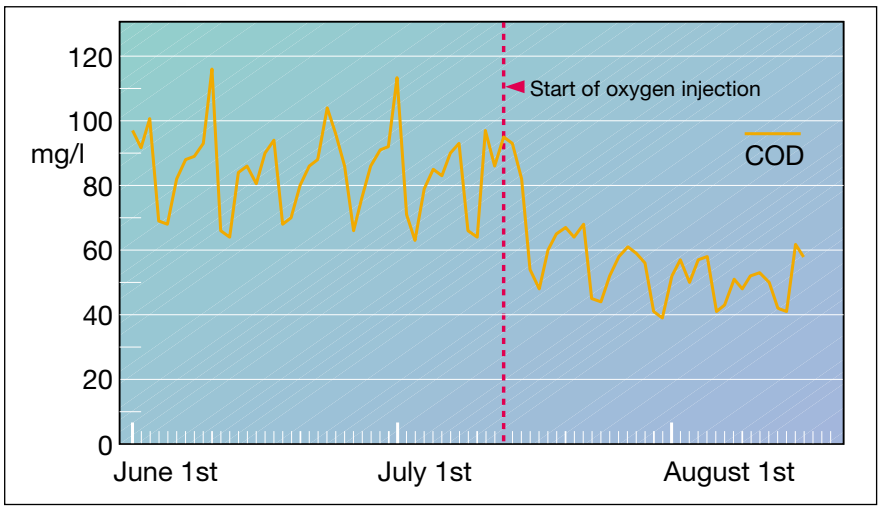
Greater Efficiency by Using Pure Oxygen

By injecting pure oxygen into overloaded activated sludge plants, you can expect the following improvements:

- Improved sludge settling
- Higher sludge content in the activated sludge tank
- Lower sludge load
- Increased purification capacity
- Lower, constant BOD_5 and COD concentrations in the effluent from the sewage works

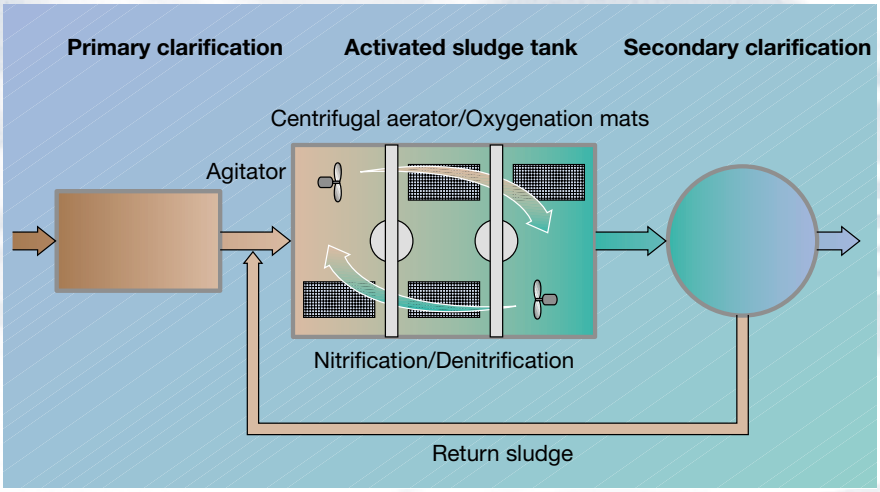
Finally, these improvements result in lower waste water levies and odourless purification.

Injection of pure oxygen results in low, constant COD effluent concentrations



Eliminating Nitrogen with Pure Oxygen

Particularly where elimination of nitrogen is concerned, before enlarging a treatment plant at great expense it is advisable to devote some thought to alternative approaches. The most cost-effective solution is usually to simply switch to a procedure involving focused injection of pure oxygen.



Schematic of intermittent denitrification

Alternative 1:

Intermittent Denitrification

When using this approach, it is important to achieve the optimum oxygen concentration within a few minutes after starting the nitrification phase. Supplementary pure oxygen is therefore injected right at the start of this phase; the existing aeration system continues to supply most of the oxygen. The additional oxygen is injected using Linde's SOLVOX® processes.

Denitrification in the same tank

Following the denitrification phase, aeration as well as oxygen feed are shut off. Consumption of oxygen by the activated sludge quickly causes the entire activated sludge tank to become anoxic, whereupon the denitrification process commences. Energy-saving agitators prevent settlement of the activated sludge.

Rapid cycling, low effluent concentrations

Injection of pure oxygen permits up to 24 cycles per day, yielding extremely low concentrations of N_{total} and COD in the effluent and complying with legal requirements.

Benefits of all 3 approaches

- **Nitrogen is eliminated much more effectively**
- **The legal requirements are met. Waste water levies are considerably reduced**
- **No need to build new facilities or remodel existing ones**
- **All three solutions can be quickly implemented**
- **Minimal expenditures for measurement and control equipment**
- **Improved sludge settling: no spontaneous denitrification further downstream**

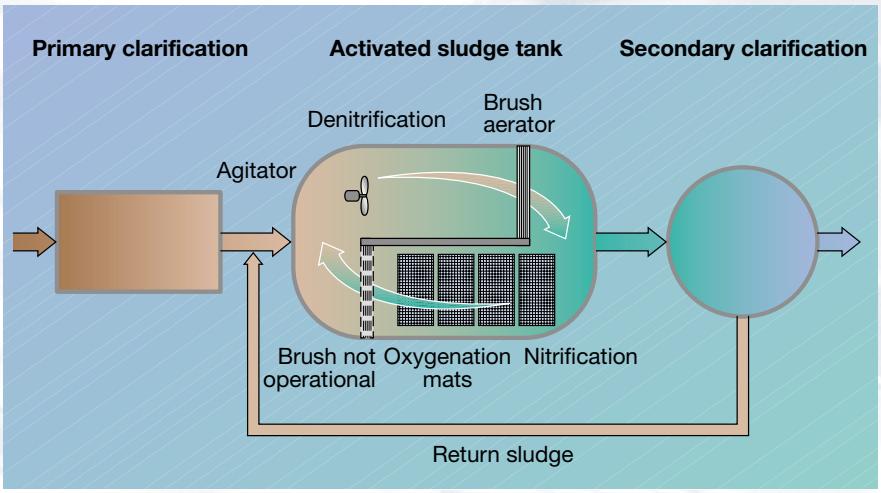
Alternative 2:

Simultaneous Denitrification

When taking this approach, it is important to achieve the optimum oxygen concentration within the first few metres of the nitrification zone. Pure oxygen is therefore added at the start of this zone using one of Linde's SOLVOX® processes; here too, the existing aeration system in the nitrification zone continues to supply most of the oxygen.

Denitrification in special zones

To trigger the denitrification process, anoxic areas are created in the activated sludge tank – simply by shutting off the supply of oxygen to them.



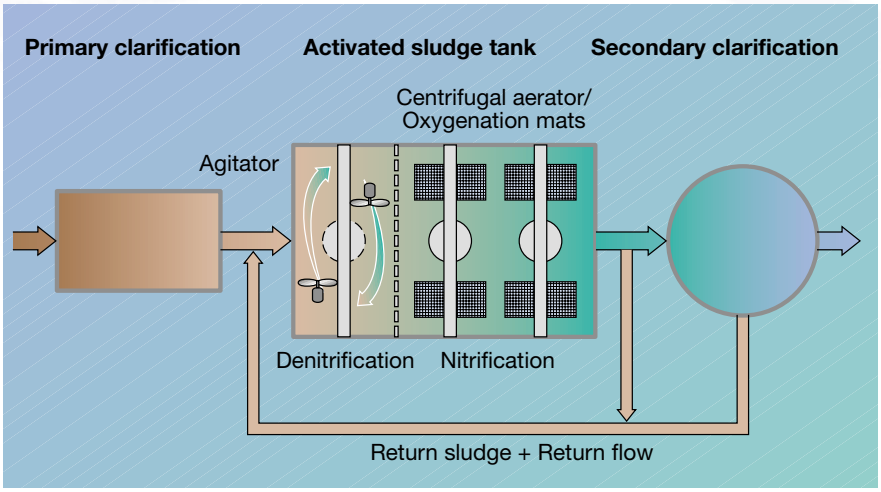
Schematic of simultaneous denitrification

Alternative 3:

Upstream Denitrification

This procedure is especially suitable for activated sludge plants consisting of multiple tanks, and for long tanks that can be partitioned.

Separating off an area for denitrification involves sacrificing part of the aeration system. Yet there is usually not enough surface area in the nitrification section to extend the conventional aeration system. And simply increasing the air injection rate through the rest of the air diffusers causes efficiency to decrease significantly. The solution is to inject pure oxygen, which meets the additional oxygen requirement more economically and, especially, more reliably.



Schematic of upstream denitrification

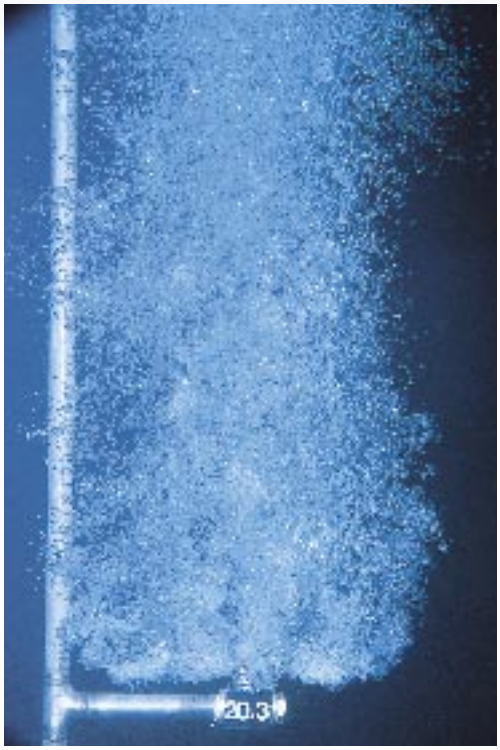
Pure Oxygen for Emergency Use in Activated Sludge Plants

Quick, Immediate Supply in Emergencies

It is essential to continually inject an adequate amount of oxygen into the waste water/activated sludge mixture in a biological treatment plant. If this supply fails – as a result of a malfunction or while rebuilding work is going on – "temporary" oxygen can be immediately injected by another method to maintain the plant's efficiency and prevent the worst-case scenario from happening: collapse of the aerobic processes, with anaerobic processes taking over.

Emergency oxygen can be supplied using either the Linde SOLVOX®-B or SOLVOX®-N oxygenation system, depending on the application at hand.

Installing an oxygenation mat in an activated sludge tank



Oxygen in all its beauty: a cloud of bubbles rising from a SOLVOX®-N conical-head nozzle

The SOLVOX®-N process is designed to permit injection of oxygen into caustic waste waters with a high calcium content, like those produced during production of paper from secondary fibres. This system injects the oxygen through robust stainless steel nozzles.

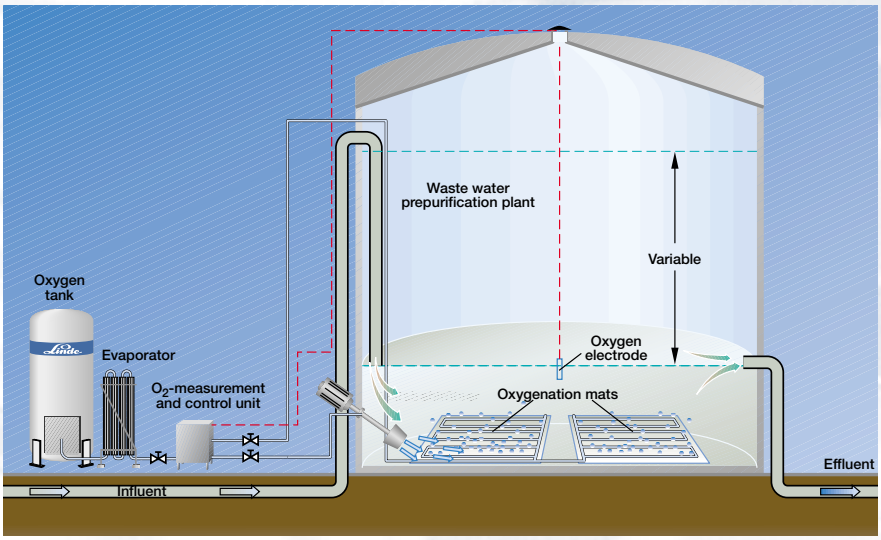
The SOLVOX®-N emergency oxygenation system is intended for immediate, temporary use when emergency situations arise, or as a stop-gap measure for maintaining plant operation until a SOLVOX®-B or SOLVOX®-I system is installed.

Pure Oxygen for Prepurification of Waste Water

Prepurification of Waste Water in Holding Tanks

In addition to increasing the efficiency of overloaded activated sludge plants, pure oxygen can also be of benefit in other parts of the waste water purification process, for example:

- Prepurification in buffer tanks for highly concentrated, irregularly produced industrial waste waters
- Prevention of odours from mixing and equalising tanks



Schematic of a wastewater prepurification plant

SOLVOX®-B in a prepurification tank

Prepurification Facilities

Many companies associated with the food industry like, for example, dairies, breweries, fruit and vegetable processing plants, yeast producers and drug companies generate waste water with high concentration of pollutant matter that lends itself to biological treatment. To avoid high waste water charges, many of these companies operate on-site biological prepurification facilities.

The SOLVOX®-B and SOLVOX®-R processes involve injecting pure oxygen into the waste water to decompose the pollutants until it is sufficiently clean to be passed on to the municipal sewage treatment plant.

Waste Water Prepurification in Overloaded Trickling Filters

Even in small prepurification tanks, pure oxygen can be added to achieve a significant amount of preliminary degradation. This greatly boosts the performance of the entire trickling filter facility.

Offensive odours from fouling waste water can be reliably prevented by irrigating prepurified oxygen-enriched waste water onto the trickling filter.

Prepurification of waste water before transfer to a trickling filter plant

Pure Oxygen for Conveying Waste Water in Pressure Pipes

Lack of Oxygen during Waste Water Transport

When conveyed in pressure pipes, waste water has no contact with the atmosphere. And if it remains in a pipe for prolonged periods of time, bacterial degradation processes rapidly consume the available oxygen.

The consequences are:

Corrosion damage and odour emissions in gravity channels and the inlet structures of treatment plants.

Corrosion damage on a pressure pipe

Injecting pure oxygen into pressure pipes guarantees aerobic conditions throughout their length; no hydrogen sulphide or organic polysulphides are generated. Instead, purification processes similar to those in the biological stage of the treatment plant begin there.

Injection of Oxygen into Pressure Pipes

At the start of the pressure pipe, pure oxygen is injected into the waste water using the Linde SOLVOX®-D process. Timers automatically control the amount of O_2 injected during the day and at night. If heavy rainfall occurs, auxiliary time-delay relays halt the O_2 supply.

The investment costs for the injection equipment and the O_2 measuring and control unit are low.

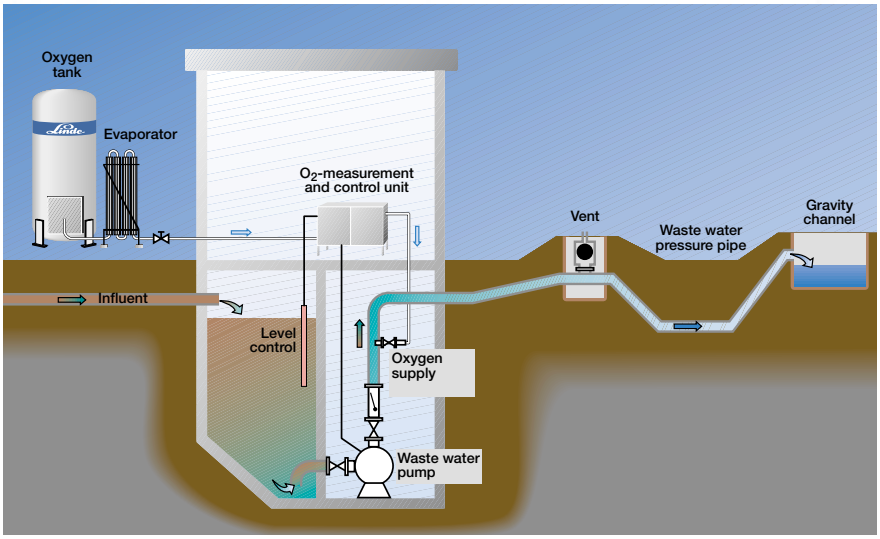
The following results can be expected:

- No odours caused by hydrogen sulphide and volatile organic sulphides
- No concrete or metal corrosion caused by hydrogen sulphide or sulphuric acid
- Improved sedimentation during primary clarification
- Reduced load on the biological stage as a result of preliminary decomposition in the pressure pipe

Oxygen measuring and control unit with electrical switch box

Other advantages of this approach:

- No outside power source required
- No chemical additives required (e.g., iron salts to precipitate H_2S)
- No problematic deposits (e.g., iron sulphide sludge in primary clarification)
- Low investment costs
- Inexpensive operation



SOLVOX®-D: oxygen injection into waste water pressure pipes

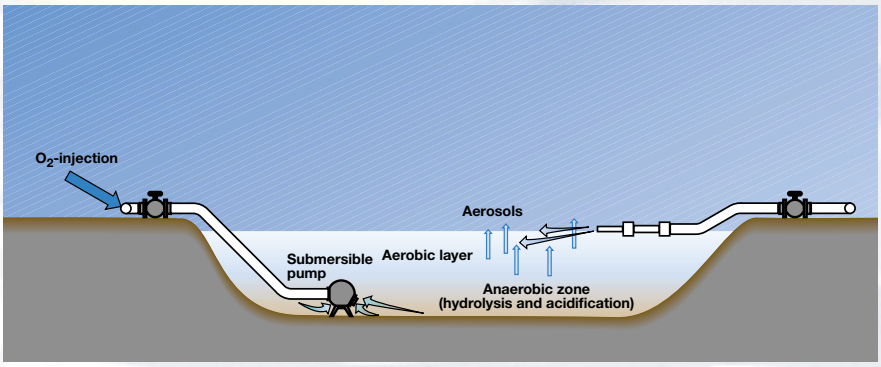
“Aerobic Sealing” of Lagoons

Prevention of Odours

Parts of the food processing industry (sugar refineries, potato processors, etc.) operate at high capacity for several weeks after harvests, generating waste waters that carry a heavy load of readily decomposable pollutant matter.

Most of this waste water is stored temporarily in lagoons before undergoing secondary purification.

Owing to lack of aeration, the oxygen dissolved in the waste water is exhausted relatively quickly. It does not take long for anaerobic acidification to begin, associated with intense, malodorous emissions.



SOLVOX®-D for “aerobic sealing”

“Aerobic Sealing”

Linde’s patented “aerobic sealing” process involves pumping waste water out of the lagoon, enriching it with pure oxygen using the SOLVOX®-D process, and then distributing it over the surface of the lagoon.

The lagoon’s contents are not vertically mixed. Instead, an oxygen-rich layer of water forms on its surface, where foul-smelling, highly volatile decomposition products – like sulphides and volatile fatty acids – are oxidised.

“Aerobic sealing” of waste water lagoons

Industrial Gases from LINDE for Solving a Wide Range of Environmental Problems

Not only oxygen, but also carbon dioxide and hydrogen are increasingly being used to solve environmental problems. Linde AG’s Industrial Gases Division is active in many important areas of water purification, including waste water treatment, treatment of drinking water and industrial process waters, and rehabilitation of natural water bodies.

We’ll be happy to provide you with more information on these topics:

Brochures:
- Neutralisation of alkaline water
- Storage tanks for supplying liquefied gases

Data sheets:
- SOLVOX®-R: with oxygen reactors
- SOLVOX®-B: with gas-supply hoses
- SOLVOX®-D: for pressure pipes
- SOLVOX®-I: injector-based
- Solvogen®: for removing oxygen from water
- Oxygen
- Carbon dioxide
- Hydrogen

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