

Aquaculture solutions
for healthy fish.
Equipment portfolio.



Introduction.

In the past 50 years, the global demand for fish products has doubled. Today, more than 45 % of the world's seafood comes not from wild catch but from either land-based or off-shore fish farms. Aquaculture is cultivating fresh-water or salt-water marine species in controlled environments. These farms face the challenges of maintaining optimal fish growing conditions: appropriate nutrition, prevention of diseases and maintaining a healthy water environment. The most important factor for achieving healthy fish is to have healthy water. Thus, controlling the concentration of oxygen dissolved in water is crucial in aquaculture. Generally, the following conclusion can be made: the closer the oxygen concentration is to air saturation, the better the growth and health conditions are.

Maintaining the right level of oxygen in the water will improve utilisation of feed, reduce the growth period, reduce fish mortality and reduce the need for vaccination and antibiotics. As a consequence, the appropriate use of oxygen improves the economic situation of a fish farm significantly and provides additional production reliability. With the SOLVOX® product line, Linde has the right solution to meet these specific needs. SOLVOX® comprises a variety of oxygen dissolution and distribution systems. Linde offers the full range of oxygen supply modes: from cylinder and bulk storage to on-site generation, Linde has the experience to deliver the total engineered solution.

Get the latest aquaculture technology from Linde. Your experienced and reliable partner for fish farming.



Fish farmers need a company to count on, from reliable delivery of oxygen to the experience to provide practical solutions. At Linde, we are on the forefront of aquaculture technology. We have worked with aquaculture topics since the early days of this industry. Our broad experience, our dedicated research scientists, and our ongoing research and development work carried out in our test centre help us deliver the latest technology and know-how to you.

Guidelines for oxygen levels

Oxygen saturation

 85 %

 75 %

 60 %

 40 %

 30 %

Effect on salmonids (e. g. salmon, trout) and other species (e. g. sea bass, sea bream)

 No indication of negative effect

 Reduction in appetite

 Increased effect on appetite, possible mortality

 No appetite and high mortality

 Massive mortality

SOLVOX®.

Product line.

Linde's SOLVOX® product line offers a wide range of oxygenation systems for the aquaculture industry. The SOLVOX® family comprises equipment for optimised dissolution of oxygen in water, perfect distribution of oxygenated water to the fish and a regulation concept for smooth and reliable operation. With the SOLVOX® equipment, we can serve all types of aquaculture installations.



SOLVOX®A installation



SOLVOX®A 54

SOLVOX®A: Low-pressure oxygen dissolver for salt water and brackish water

Patented by Linde, SOLVOX®A is a flexible dissolving unit which can be applied to any fish tank. Usually, the unit is integrated into the pipe work to oxygenate the entire water flow entering the tank. For larger tanks, more than one SOLVOX®A unit can be installed to achieve optimum distribution of dissolved oxygen within the tank. SOLVOX®A is easy to install and combines high oxygenation efficiency with low energy demand.

The unique function of SOLVOX®A has an additional advantage as it also removes nitrogen from the water at the same time as it adds oxygen. This is important as fish is sensitive to nitrogen supersaturation. It is recommended to complete a SOLVOX®A installation with a SOLVOX®Stream device (see next page). A SOLVOX®Stream device (see next page) completes each SOLVOX®A installation.

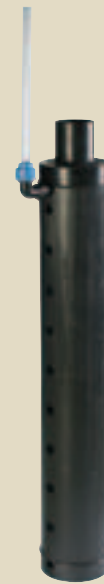
Available sizes (SOLVOX®A)

Product	Average flow rate [l/min]	Oxygenation capacity* [kg/h]	Length [mm]	Pipe diameter [mm]
SOLVOX®A 6	100	0.23	300	50
SOLVOX®A 9	150	0.36	350	63
SOLVOX®A 15	250	0.55	300	63
SOLVOX®A 24	400	0.94	400	90
SOLVOX®A 33	550	1.30	350	90
SOLVOX®A 45	750	1.72	450	110
SOLVOX®A 54	900	2.09	400	110
SOLVOX®A 150	2,500	6.62	500	160
SOLVOX®A 210	3,000	8.33	700	200
SOLVOX®A 300	5,000	11.74	800	250
SOLVOX®A 400	7,000	16.2	850	280

* At pressure drop 2mWC (2 meter water column), nominal water flow rate and 15°C water temperature



SOLVOX®Stream application in a fish tank



SOLVOX®Stream D 160

SOLVOX®Stream: Slot tube with water flow indicator for improved oxygen distribution and tank hydraulics

SOLVOX®Stream ensures that oxygenated water is homogeneously distributed in the fish tank over the complete depth of the tank. It is designed to achieve an optimal circulation speed in the fish tank depending on the fish species, fish size and the customer's demand.

SOLVOX®Stream is used in combination with oxygenation equipment such as SOLVOX®A. This combination of equipment guarantees that the required environmental conditions in terms of hydraulics and oxygen concentration can be set individually for each fish tank. The SOLVOX®Stream device is a tailor-made product that can be customised for required flow rates ranging from 50 l/min to 20,000 l/min.

An important feature is the water flow indicator which helps the fish farmer to control the water flow into each tank. Thus, available water resources can be optimally utilised.

Standard sizes (SOLVOX®Stream)

Product	Average flow rate [l/min]	Pipe diameter [mm]
SOLVOX®Stream 6	100	110 x 50
SOLVOX®Stream 9	150	110 x 63
SOLVOX®Stream 15	250	125 x 75
SOLVOX®Stream 24	400	140 x 90
SOLVOX®Stream 33	550	160 x 90
SOLVOX®Stream 45	750	200 x 110
SOLVOX®Stream 54	900	250 x 125
SOLVOX®Stream 150	2500	280 x 160

Please note: The specifications given in this table represent some standard sizes available from Linde. However, SOLVOX®Stream slot tubes are tailor-made products that can be customised to meet your specific needs.

SOLVOX®C: Pressure dissolver for sea water and fresh water

SOLVOX®C cones are designed to increase the concentration of gases in water to a rather high level. In standard operation, the gas transfer efficiency is close to 100%. The operation of the cone is simple: as water and gas enter from the top, the water jet forces the water to mix intensively with the oxygen bubbles, thus creating a high specific interface and high turbulence at the top of the dissolver.

As the cone widens, the velocity is reduced. Here, even smaller gas bubbles that haven't fully dissolved yet can rise against the downwards oriented water flow, so only water free of bubbles leaves the cone at

the bottom. Since the SOLVOX®C cones can be operated at elevated pressure, the dissolved oxygen concentration can be increased significantly above saturation. Thanks to their high reliability, efficiency and simple installation, oxygenation cones are utilised widely in aquaculture. These cones are made of glass-fibre-reinforced plastic (GRP) and are CE marked.

Technical data

	SOLVOX®C 60	SOLVOX®C 110
Water flow	60 m ³ /h	110 m ³ /h
Connection inlet and outlet	DN 100	DN 150
Maximum working pressure	3.8 bar (g)	3.0 bar (g)
Maximum oxygen dosing capacity at T=10°C	6.3 kg/h	9.4 kg/h



SOLVOX®C installation



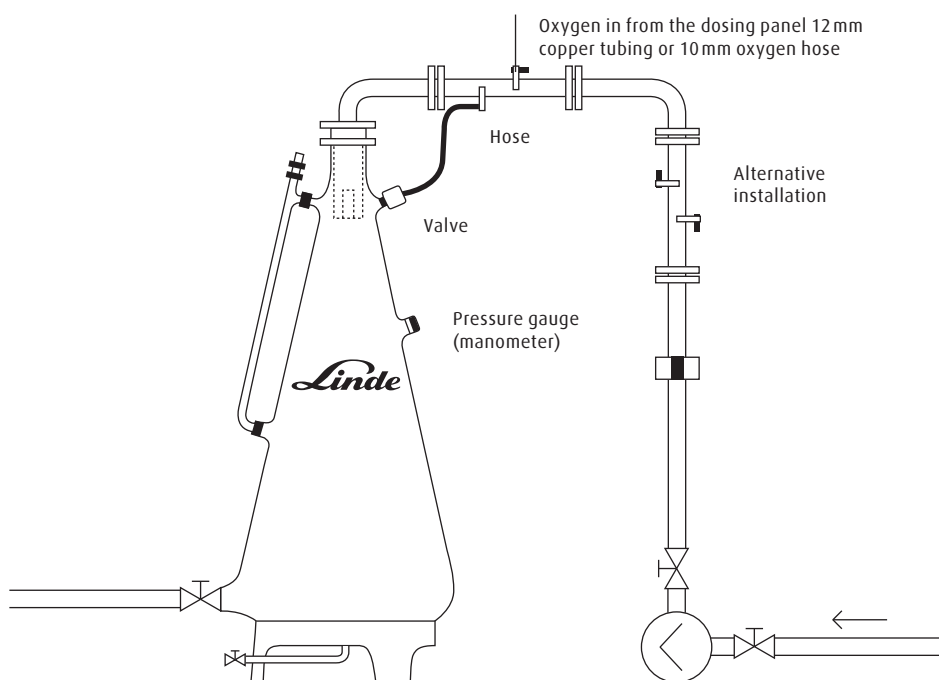
SOLVOX®C

SOLVOX®CV: Boosting oxygenation – venturi nozzle for capacity increase of pressure dissolvers

SOLVOX®CV is an additional system to boost the oxygenation capacity of SOLVOX®C cones, allowing up to 50 % higher oxygen dosing without increasing the water flow rate or energy consumption. SOLVOX®CV uses a venturi nozzle to re-inject oxygen which is gathered at the top of the cone into the water feed pipe. The installation can be done without any time-consuming shutdown. The SOLVOX®CV is flanged directly onto the water feed pipe of the cone. By doing so, the water flow rate into the cone can be increased by up to 25 % above nominal value, which then gives you an additional 25-% increase in oxygen capacity.



SOLVOX®CV



The complete SOLVOX®CV consists of:

- SOLVOX®CV to be installed on the inlet pipe.
- Valve and hose to be mounted on the cone.
- Inlet piece
- Level tube with ventilation

SOLVOX®B: Perforated hose for dissolving of oxygen without auxiliary energy

The SOLVOX®B oxygenation hose is fixed on a support or a rack which is placed at the bottom of a tank. The energy to operate SOLVOX®B is exclusively provided by the oxygen tank pressure – no auxiliary energy is required. This qualifies SOLVOX®B as an emergency oxygenation system. When no oxygen is needed, the pores close tightly, so the hose remains ready for operation at any time.

Optimum oxygen utilisation is achieved by creating small bubbles. Unlike vinyl tubing, the SOLVOX®B hose is to a high extent persistent against UV and ozone and will therefore not become brittle due to sunlight exposure. SOLVOX®B hose is flexible and therefore easy to work with. Being a low-cost, easy-to-install solution to dissolve oxygen into water, SOLVOX®B is widely used as an emergency oxygenation system.



SOLVOX®CD: Ceramic diffusers

Linde's SOLVOX®CD ceramic diffuser is a high-performance, aluminium-housed oxygen dissolving equipment. Its high efficiency is a result of creating microscopic bubbles. Moreover, the flat plate design ensures uniform bubbles across the entire surface and minimises bubble coalescence. SOLVOX®CD is therefore also suitable to dissolve oxygen into shallow tanks down to water depths of less than 1 metre. The main field of application for the SOLVOX®CD is to provide additional oxygen to individual tanks and raceways and for emergency oxygen supply.

Specifications

Stone size [mm]		610 x 63
Weight [kg]		2.0
Flow rate [l/min] at different pressures	1.5 bar	3.5
	2.0 bar	7.0
	2.5 bar	10.0



SOLVOX®F oxygen control cabinet

Fish grow best at a constant oxygen level in the water, but the oxygen consumption of fish varies with stocking density, feeding regime, activity status, temperature etc. In order to keep the oxygen level as constant as possible, different amounts of oxygen have to be provided at different times.

The dosing cabinet is designed to do just that. Emphasis is placed on its simple and flexible construction, with the option to modularly expand the cabinet. For a reliable and safe operation, an emergency oxygenation function can be integrated as an additional feature: in case of a power breakdown, solenoid valves will open automatically. The oxygen flow rates for each condition are pre-set via dosing valves.

Increased safety with a back-up cabinet

Aquaculture is one of the most vulnerable business areas if problems occur with the gas supply. Production is becoming more intensive and comprehensive, so there is also more risk. The emphasis, therefore, has to be on safety.

Should any problems occur with the operation of the tank system, the reaction time is short! In any case, gas supply from a liquid oxygen tank is the safest way of gas supply available, but it's always advisable to have a backup to cover the worst case. This usually is accomplished by storing some compressed oxygen in cylinders or cylinder bundles.

Features of a back-up cabinet:

- Connected to the monitoring and control system, which sets off the alarm in the event of high or low tank pressure
- Fast connection to an alternative supply (e.g. oxygen in cylinders or cylinder bundles)
- Adequate regulator capacity



Control cabinet installation on a fish farm site.



The photo above shows a cabinet for three tanks with operating oxygen and emergency oxygen. This cabinet is shown with a separate pressure regulator for emergency oxygenation.



Back-up cabinet: this dosing cabinet ensures that oxygen is supplied from cylinders or cylinder bundles in case of interruption of liquid oxygen supply.

Research and development in aquaculture. Optimising the best.

Linde aquaculture research centre in Ålesund, Norway

Linde runs a test and research centre for aquaculture in Ålesund, Norway. At the centre, Linde specialists are developing and testing a wide range of gas-related equipment for aquaculture applications. It includes fresh water and sea water facilities, a water recirculation system as well as water heating. In the research centre, Linde provides a variety of

equipment to perform environmental analyses as well as field measurements. We are therefore well equipped to work with aquaculture customers and are conducting experiments in order to optimise solutions by replicating typical conditions existing on a fish farm.



Transparent pipework to visualise optimum gas dissolution



Technical hall with fish tanks and gas-dissolving equipment

Our development.

The direct link to our customers.

Our research is always in line with the needs of our customers. Whether the market drives you to new species or to new types of production tanks and facilities, we are your partner to satisfy your needs and develop new solutions around oxygen, hydraulics and dissolved gas management in fish production.

Our portfolio includes:

- Cost-effective substitution of air by oxygen
- Oxygenation equipment to improve and increase production in fish and seafood farms
- Liquid and compressed gases and related supply and control systems
- Tailor-made solutions for individual customers
- A thorough understanding of the interaction of all the elements in fish farming through our international network of fish farming experts

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.

Linde AG

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