Design recommendations

FOR INSTALLATION OF FLYGT JET AERATORS, 50 HZ

FLYGT

a xylem brand

Content

Introduction

Oxygen must be provided in wastewater treatment plants to satisfy several different demands. These include the biological degradation of organic materials and oxidation of ammonia and other inorganic materials. Aeration is the process by which oxygen is transferred to the liquid. The main purposes are to supply the oxygen required and provide enough mixing to keep solids in suspension.

The jet aerator is a simple device, consisting of a Flygt submersible pump coupled to one or more ejectors to achieve various oxygen transfer rates. The ejector system consists of air suction pipes which protrude above the water surface, of a venturi-like nozzle and of a diffusing pipe – the so-called ejector.

The main uses for jet aerators are oxygen transfer, mixing and odor control. Jet aerators are suitable for aeration at 3-7 meters water depths and for small to medium size treatment plants.

This design recommendation is for applications with a total solid concentration less than 2%. Please note that the Flygt jet aerator can even be used in sludge applications but these applications will not be considered in this document.

This design recommendation is only valid for Flygt jet aerators. Xylem assumes no liability for non Flygt products. For recommendations outside the scope of this document, please refer to your local Xylem representative.

Application areas

Typical applications where the Flygt jet aerator is used:

- Retention basins/equalization tanks
- Aeration basins in secondary treatment:
  - Sequential Batch Reactor (SBR)
  - Oxidation Ditch
  - Conventional Activated Sludge Process
- Aeration ponds/aerated lagoons
- Supernatant basins
- Lake rehabilitation
- Leachate treatment at landfills

Additional application areas for the Flygt jet aerator not covered in this design recommendation:

- Aerobic digesters
- Sludge storage basins
- Sludge aeration after anaerobic digester (methane gas removal)

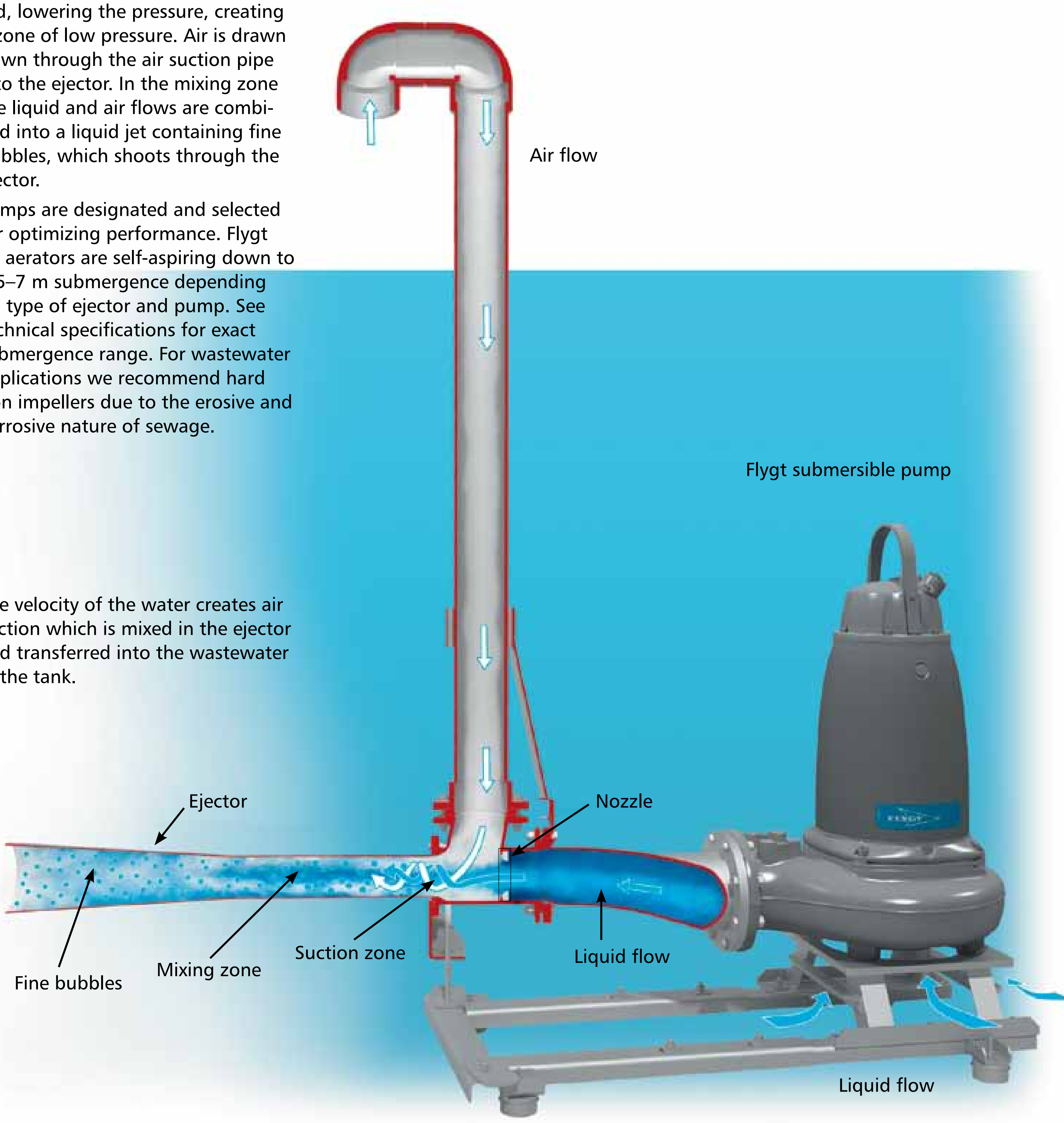
Product description

Working principle

A standard Flygt N-pump generates the primary liquid flow (see figure). As the flow passes through a nozzle the velocity of the liquid is accelerated, lowering the pressure, creating a zone of low pressure. Air is drawn down through the air suction pipe into the ejector. In the mixing zone the liquid and air flows are combined into a liquid jet containing fine bubbles, which shoots through the ejector.

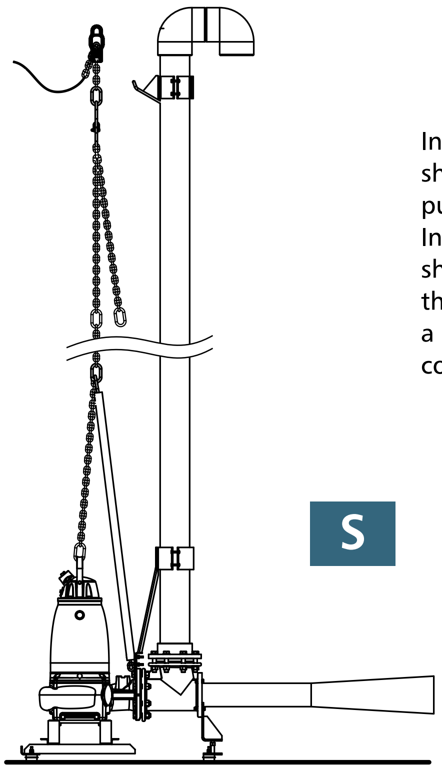
Pumps are designated and selected for optimizing performance. Flygt jet aerators are self-aspiring down to 3.5–7 m submergence depending on type of ejector and pump. See technical specifications for exact submergence range. For wastewater applications we recommend hard iron impellers due to the erosive and corrosive nature of sewage.

The velocity of the water creates air suction which is mixed in the ejector and transferred into the wastewater in the tank.

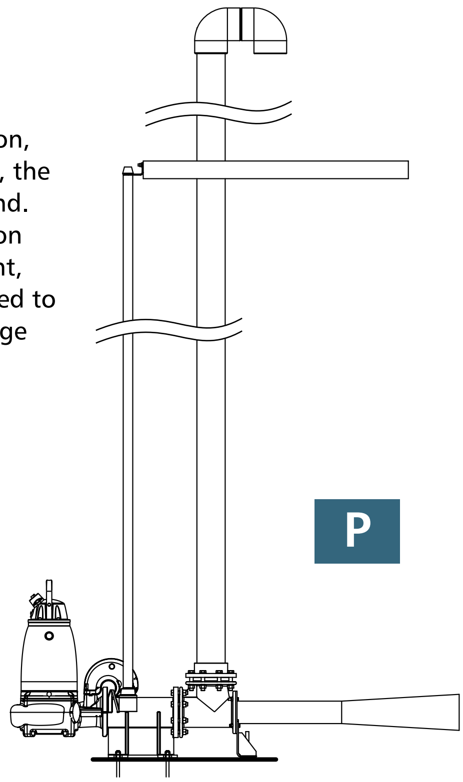


Installation types and recommendations

Two installation types are available, S (stand-alone) and P (fixed installation using guide bars).



In the S-installation, shown to the left, the pump is on a stand. In the P-installation shown to the right, the pump is guided to a straight discharge connection.



The air intake bend prevents unwanted objects from entering suction pipe.

S-installation implies easy installation, easy ejector maintenance and possibility to alter location and direction in the tank.

P-installation is recommended when the equipment is installed in high flow velocity applications and there are concerns that the jet aerator might move.

The small ejector 112, with a throughlet of 55 mm is not recommended when there are larger solids present – for example in primary sludge – as the risk for clogging increases.

Submerged installation is most common for the Flygt jet aerator.

Dry installation is not possible for the following models, due to the lack of internal cooling for the pump:

- Flygt JA 112-3085
- Flygt JA 112-3102
- Flygt JA 117-3127

Dry installation is adapted when the tank is very small or the bottom layout does not allow a standard installation. Furthermore dry installation is suited for a pump in an existing pump room or for instance when there is no possibility to access the tank from above. When the installation is in a covered tank or inside a building, the air suction pipe can require a special design. Installation of an anti-vibration joint before and after the pump is recommended in order to avoid vibrations being transmitted between the pump part and the ejector. In order to make pump maintenance easier, a shutoff valve should be installed before and after the pump. The water inlet pipe should have a straight length of 10 diameters before the inlet bend to the pump. The air suction pipe can be installed outside the tank, but it must extend above the water level.

To avoid wastewater splashing out of the air inlet pipe when the ejector is started or stopped, the air suction pipe end should be at least two meters above the tank's water level.

Product selection

The following tables can be used for selecting jet aerators, and to determine if an extra mixer is required to fulfil the mixing criteria. When more data and information is available than just application, inflow and tank sizes, other selection tools such as technical specifications or Flygt software can be used. Please contact Xylem for more assistance.

Start the selection process by choosing the jet aerator that fulfils the aeration requirements according to the tables below. Use the selection graph for mixing to determine if mixing provided by the selected aerator is sufficient. If not, select a mixer so that the thrust from both units fulfils the mixing requirement. For larger tanks, a combination of a mixer and a jet aerator is often the optimal solution.

Selection tables for oxygen requirement

The following tables are designed to satisfy the oxygen requirement only. This means that the jet aerator selection depends on the incoming flow and its BOD concentration but not on the tank dimensions. Please note that if your input data deviates significantly from the predefined applications below, other product selections might be required.

The assumed parameters in all of the listed applications are:

α 0.75, β 0.95, θ 1.024, DO 2 mg/l
Water temperature 20°C,

Site elevation 0 masl, Depth 3–5 m.

For water temperatures below 20°C and/or water depth below 5 m the following jet aerator selections are conservative.

Application inflow [l/s]	Aeration in municipal wastewater applications
1	JA 112-3102
2	JA 117-3127
4	JA 117-3153
6	JA 217-3202
10	JA 317-3202
20	2 units JA 317-3202

The assumed BOD is 300 mg/l. Nitrification is assumed at TK-N 40 mg/l.

Application inflow [l/s]	Aeration in dairy wastewater applications in milk production
1	JA 117-3127
2	JA 117-3153
4	JA 217-3202
6	JA 317-3202
8	2 units JA 217-3202

The assumed parameters BOD is 700 mg/l.
No nitrification assumed.

Application inflow [l/s]	Aeration in manure wastewater applications
1	JA 217-3202
2	JA 317-3202
3	2 units JA 317-3202

The assumed BOD is 2700 mg/l.
No nitrification assumed.

Application inflow [l/s]	Aeration in city dump wastewater applications
4	JA 117-3127
8	JA 117-3153
12	JA 217-3171
16	JA 217-3202
32	JA 317-3202

The assumed BOD is 150 mg/l.
No nitrification assumed.

Selection graph for mixing

The amount of supplied air is adapted to the demand of oxygen in the process, and if excess air is required to keep the suspended solids in suspension, it is more energy efficient to do so with a mechanical mixer. The mechanical mixer:

- Provides good and direct contact between wastewater and returned sludge
- Keeps suspended solids in suspension
- Maintains the desired flow direction through the tank

An efficient process requires complete mixing where the whole tank volume is utilized. The following graph can be used for mixer selection, the aim being to keep solids in suspension.

Selection example

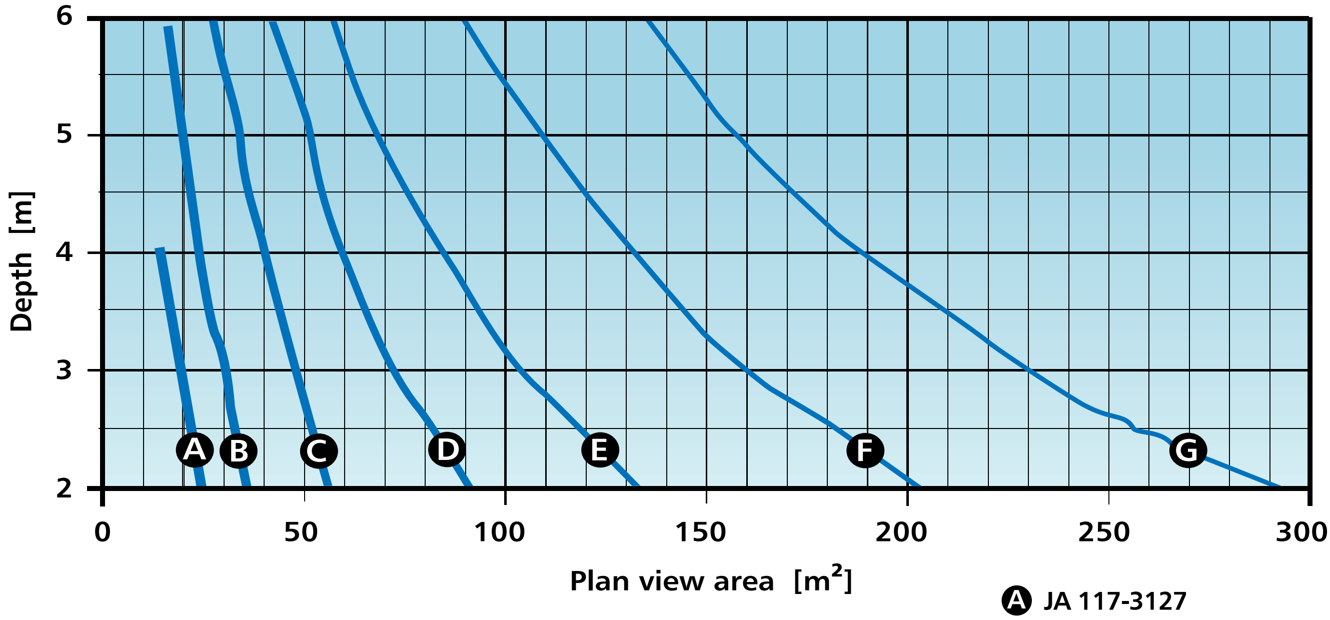
An aeration tank in a wastewater treatment plant needs to be equipped with a Flygt jet aerator. The tank dimensions are 10m x 7m x 4m. The water temperature is 10°C–20°C. The inflow to the tank is 5 l/s.

There is no other information on the biological load.

From the oxygen table "Aeration in municipal WWTP applications", at 6 l/s, one JA 217-3202 is selected.

The tank surface area is 10m x 7m = 70m². From the mixer selection table above, for 70m² at 4m liquid depth one JA 217-3202 does not fulfil the mixing requirement (ok at 60m² at 4m depth), i.e. a (small) mixer must be added. The mixer 4620 is selected to complement the jet aerator to reach the mixing requirement.

Jet aerator mixing selection chart in rectangular tanks, 50 Hz



A JA 117-3127

B JA 117-3153 or 4620

C JA 117-3171 or 4630

D JA 217-3202

E 4640

F JA 117-3153 AND 4640

G JA 317-3202

The graph describes the maximum tank volume that a mixer and/or a Flygt jet aerator can maintain to keep the solids in suspension.

For average retention times (tank volume/inflow) less than one hour, please contact Xylem for an optimal jet aerator selection and positioning.

For tank dimensions where the ratio length/width > 2.5 or the ratio length/depth > 2.5 multiple jet aerators are needed.

Positioning jet aerators and mixers in circular and rectangular tanks

The jet aerators should be placed according to positioning principles applied for mixers.

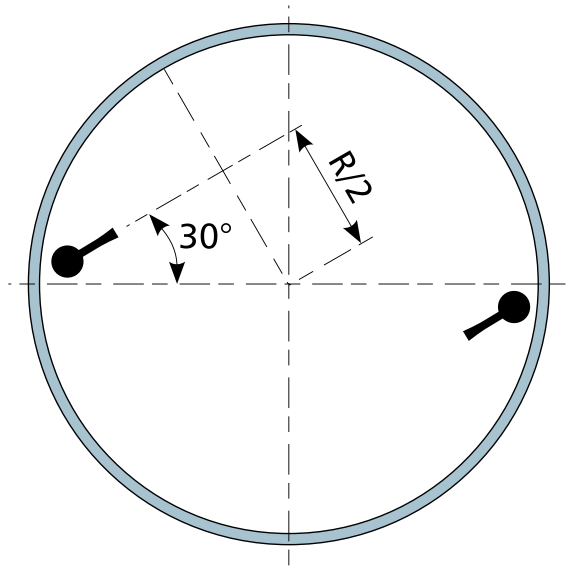
To utilize the jet source optimally and achieve maximum bulk flow in the whole volume, the jet should be directed towards the longest possible free path. The bulk flow follows the shape of the tank, and the flow pattern forms an unbroken loop. A free jet expands at an angle of approximately 20 degrees. Before the jet reaches the wall, it has to turn back to ensure the return flow.

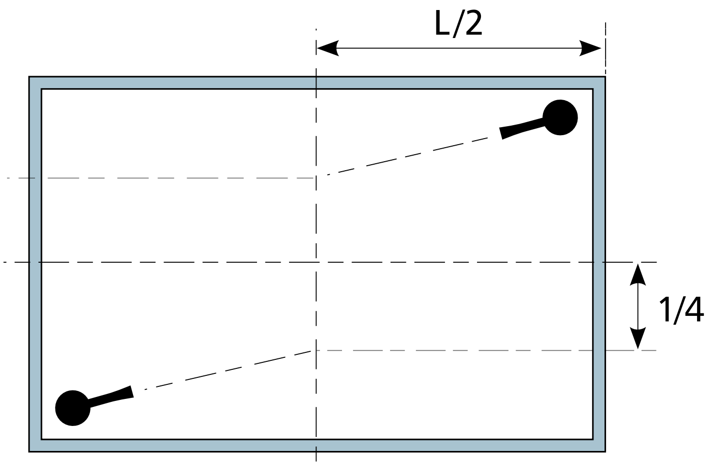
Creating a sufficiently strong bulk flow in the tank is paramount to achieve good mixing. Based on the jet expansion, it is possible to define a few general rules for an optimised positioning. Using the steps below, jet aerators and submersible mixers can be positioned in any tank.

1. Identify the bulk flow loop. The bulk flow loop is in most cases determined by the tank shape and geometrical dimensions
2. Locate the jet aerator in the loop
3. Allow a long jet path for large bulk flow. This often means location in a corner
4. Smooth deflection for low losses
5. Do not aim the jet aerator at obstacles

Long jet path and smooth deflection is in general a contradiction, and a compromise is necessary. In a circular tank the optimal velocity is obtained when the jet is directed at 1/2 radius (30° from the centerline). The same principle can be used in rectangular tanks. Direct the jet aerator towards 1/4 of the width at the centerline (L/2) as in figure 4.

Principles of positioning of one or two jet aerators for maximizing bulk flow. The jet aerators should be placed at an angle of 30° off the tank center in a circular tank. In a rectangular tank the jet aerator should be directed towards a point that is at 1/4 of the tank's width at the centreline (L/2)

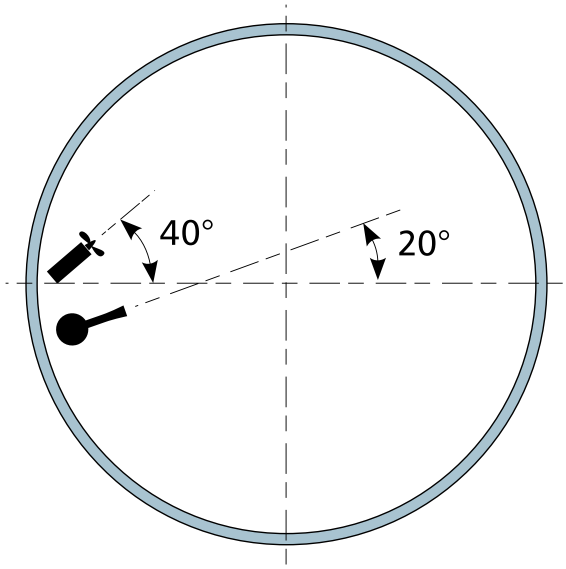




The following positioning recommendation is applicable in larger tanks when a mixer is used to complement the aerator to fulfil the mixing requirement.

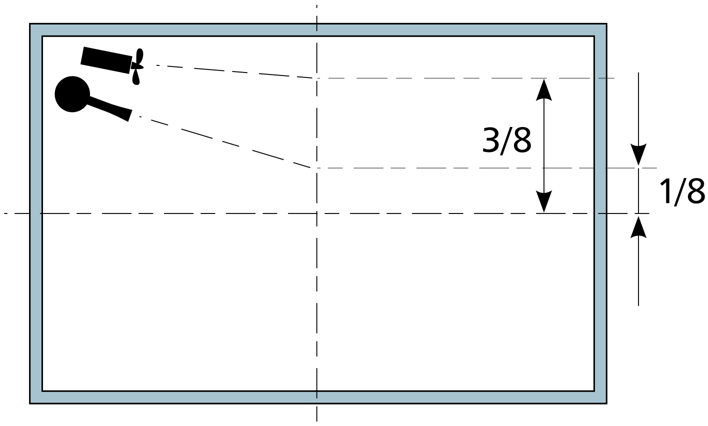
The jet aerators can be used in any tank shape. The only minimum clearance that needs to be considered is the distance to the side wall. The distance from the ejector outlet to the side wall should be a minimum 0.6 m. For oxidation ditches, the same clearance as for mixers applies. Please note that no equipment should be installed in the air jet from the jet aerator.

In a circular tank the mixer should be placed at an angle of 40° off the tank center and the jet aerator 20° to maximize bulk flow.



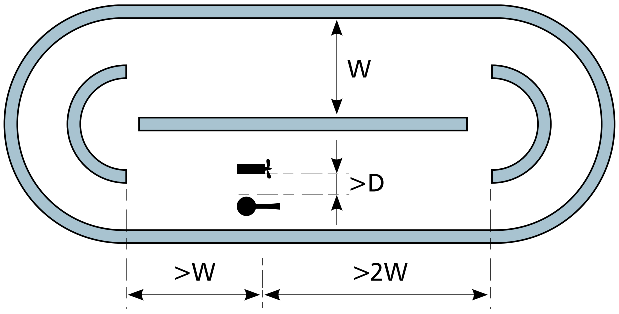
Positioning of a jet aerator and mixer in a circular tank.

To maximize bulkflow in a rectangular tank the mixer should be directed towards 3/8 of the width and the jet aerator towards 1/8 of the width from the center at the perpendicular centerline.



Positioning of a jet aerator and mixer in a rectangular tank.

In an oxidation ditch the clearance between a jet aerator and a mixer placed side by side must be larger than the diameter of mixer propeller.



Positioning of a jet aerator and a mixer in an oxidation ditch.

Jet aerators and/or mixers in series

To prevent poor hydraulic conditions which could cause vibrations in the case of an installation in series, the distance between the units should be at least one air jet length or 10 mixer propeller diameters, to prevent poor hydraulic conditions which could cause vibrations.

The approximate distance from jet aerators to where the air plume strikes the surface are presented in this table.

50 Hz Flygt jet aerators jet lengths at 3–7 m depth

Depth	3 m	4 m	5 m	6 m	7 m
JA 112-3085	2.3	–	–	–	–
JA 112-3102	2.6	2.9	–	–	–
JA 117-3127	6.2	6.9	7.6	–	–
JA 117-3153	7.0	7.7	8.4	9.0	9.6
JA 117-3171	7.8	8.6	9.4	10.0	10.6
JA 217-3202	7.0	7.8	8.4	9.0	9.6
JA 317-3202	7.6	8.4	9.1	9.8	10.4

VFD control

The Standard oxygen transfer rate, SOTR, capacity can be controlled using a Variable Frequency Drive on the pump. Maximum turn down capacity depends on the depth and this is exemplified for JA 117-3153 in the table below. At a lower frequency the pump will not generate enough flow (velocity) to create the under pressure required at the given depth.

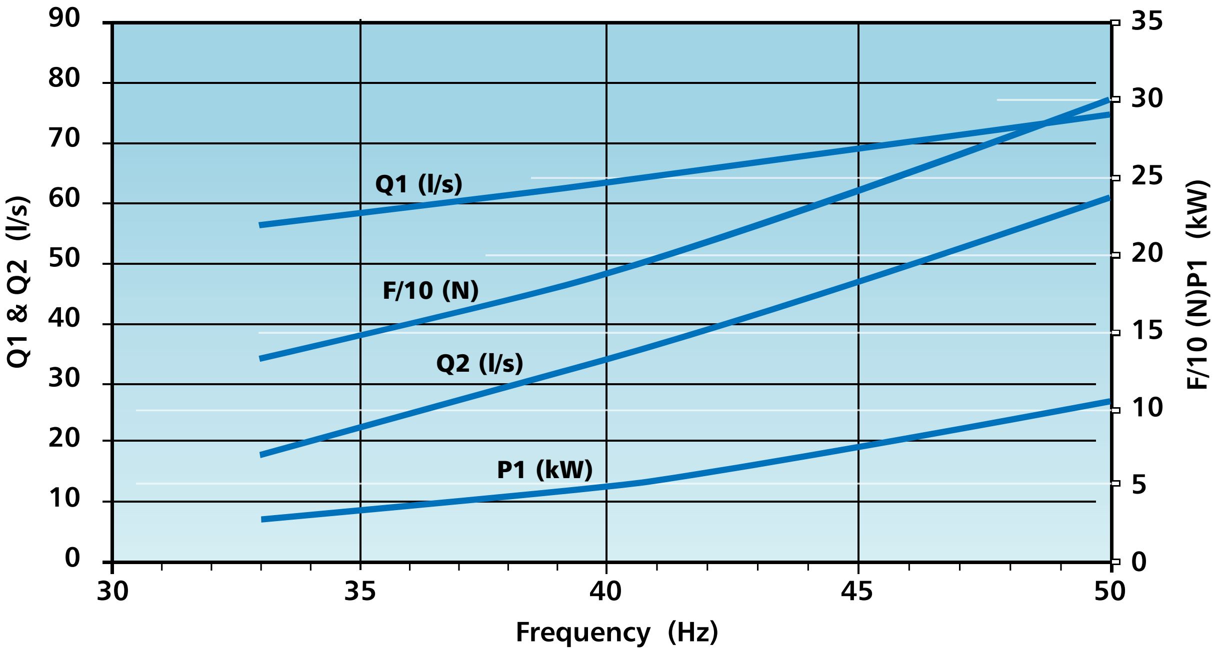
An example of performance change due to changed frequency can be seen in the chart below. This is for a JA 117-3153 at 4 meters depth. At this depth, the minimum frequency required is 33 Hz, meaning that data below this value is meaningless.

Minimum frequency at a given depth

Depth	3 m	4 m	5 m	6 m	7 m
Min. frequency [Hz]	29	33	37	40	45

Q1 (l/s)	Primary flow = water
Q2 (l/s)	Secondary flow = air
P1 (kW)	Total wire power uptake
F (N)	Thrust force

JA 117-3153



Abbreviations

SOTE	Standard oxygen transfer efficiency
SOTR (kg O_2/h)	Standard oxygen transfer rate
SOR (kg O_2/h)	Standard oxygen requirement
AOR (kg O_2/h)	Actual oxygen requirement
SAE (kg O_2/kWh)	Standard aeration efficiency (= SOTR/P1)
Nm^3	Normal cubic meter (0° C, 1 atm)
F (N)	Thrust force
BOD (mg/l)	Biochemical oxygen demand
TK-N (mg/l)	Total Kjeldahl nitrogen
F/M (kg O_2/kg MLSS day)	Food/Mass ratio
SRT (days)	Sludge retention time
MLSS (mg/l)	Mixed liqour suspended solids
Q_1 (l/s)	Primary flow = water
Q_2 (l/s)	Secondary flow = air
P1 (kW) (electrical)	Total wire power uptake

Systems Engineering

Xylem can offer in-depth expertise in the design and execution of comprehensive solutions for water and wastewater transport and treatment.

Our know-how and experience are combined with a broad range of suitable products for delivering customized solutions that ensure trouble-free operations for customers. To do this our engineers utilize our own specially developed computer programs, as well as commercial, for design and development projects.

Scope of assistance includes a thoroughgoing analysis of the situation and proposed solutions – together with selection of products and accessories.

We also provide hydraulic guidance and assistance for flow-related or rheological issues. Customers turn to us, as well, for analysis of complex systems for network pumping, including calculations for hydraulic transients, pump starts and flow variations.

Additional services:

- Optimization of pump sump design for our products and specific sites
- Assistance with mixing and aeration specifications and design of appropriate systems
- System simulation utilizing computational fluid dynamics (CFD)
- Guidance for model testing – and organizing it
- Guidance for achieving the lowest costs in operations, service and installation
- Specially developed engineering software to facilitate designing

The range of services is comprehensive, but our philosophy is very simple: There is no substitute for excellence.

Xylem [ˈzīləm]

1) The tissue in plants that brings water upward from the roots
2) A leading global water technology company

We're 12,000 people unified in a common purpose: creating innovative solutions to meet our world's water needs. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. We move, treat, analyze, and return water to the environment, and we help people use water efficiently, in their homes, buildings, factories and farms. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise, backed by a legacy of innovation.

For more information on how Xylem can help you, go to xyleminc.com

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