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Oxygen Transfer Tests for Supratec Plate-Diffuser, Type OXYFLEX MF1100 "Efficient"

Report

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Determination of the Oxygen Transfer Efficiency and the Pressure Loss for Membrane Plate-Diffusers

1. Purpose of the Tests

In the context of a tendering procedure Emscher Wassertechnik was commissioned with oxygen transfer tests for aerators. The tests were carried out in the experimental station of Emschergenossenschaft at the wastewater treatment plant Emschermündung.

2. Test Set-up

The test tank comprises a steel structure fitted with portholes on one side, which allow the visual evaluation of bubble development and flow conditions. With an area of 6 x 6 m and a water depth of roughly 3.90 m, the tank has a volume of approximately 140 m³. Consequently, the results can be applied to full-scale plants.

The compressed air was generated by means of rotary piston blowers, manufacturer: Spelleken. A blow-off valve made it possible to infinitely variable adjust the quantity of air in each case.

For accurate registration of air volume an adapted measurement instrument is installed in the middle of the downpipe, manufacturer of measurement instrument: Krohne OPTISWIRL 4070 - DN 40. The measurement instrument has a firmware version for density compensation of gases via integrated pressure and temperature sensor. The air volume is recorded using data logger, the average air volume of the evaluation period is used as calculated value of the air volume. A pressure gauge, installed approx. 1 m downstream of the orifice plate, allows determination of the pressure losses in the system. The measured value is also continuously recorded using data logger.

Air was supplied via a stainless steel pipe (DN 100), to which a transverse distribution pipe (DN 100), equipped with seven slide valves (2"), was connected. Three of these valves were connected with tubes (2") to the distribution pipe for the diffusers.

The arrangement of the diffusers in the tank was chosen by the customer respectively by the operating tenderer. 33 plate-diffusers with EPDM-membrane, manufactured by Supratec, Type OXYFLEX MF1100 "Efficient" with a gassing surface of approx. 0.2 m² per plate-diffuser were installed. Relating to the base area of the tank it results from this a rate of coverage of (33 x 0.2 m²) / 36 m² = 18 %. The construction height of the diffusers above the tank floor was roughly 13 cm (up to the middle point of the diffusers).

The arrangement of diffusers in the tank is shown in the following image.

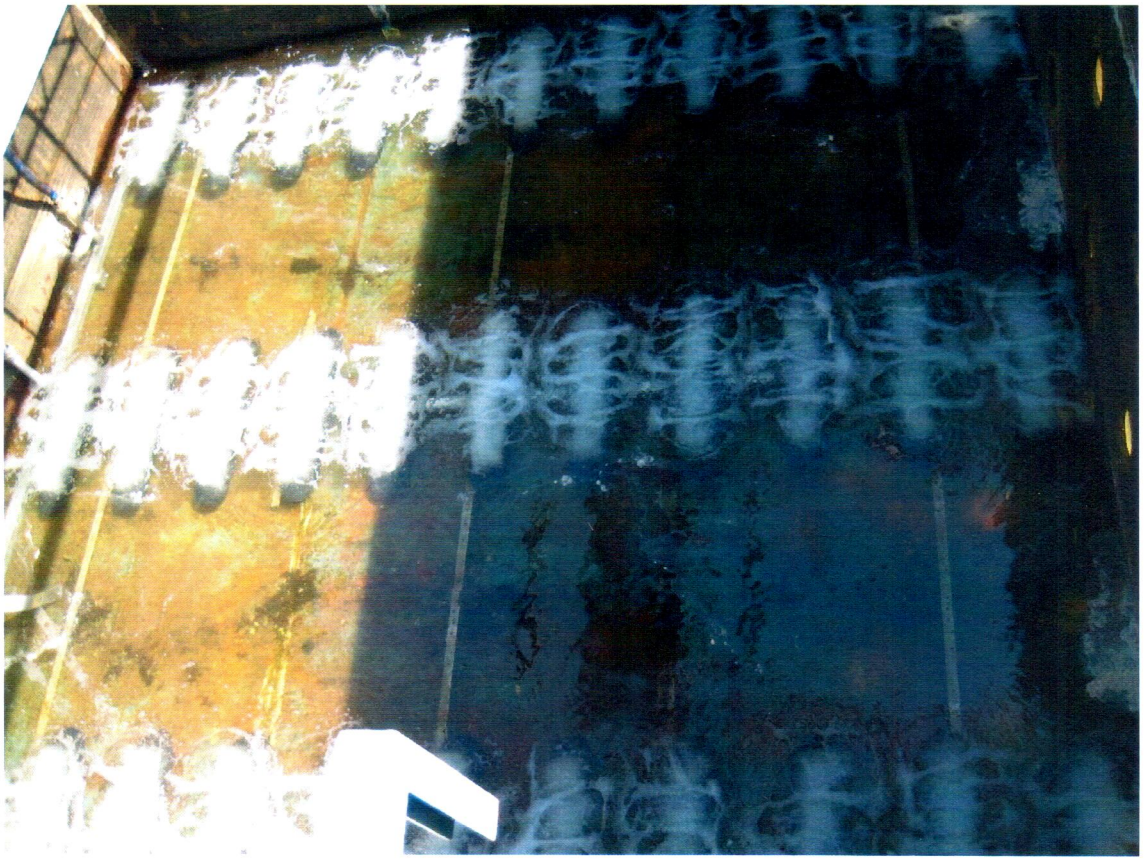

Figure 1: Arrangement of diffusers in the test tank

Oxygen measurement devices were placed at 2/3 length of a central bar at different levels. The level of the lowest measurement device was roughly 1.0 m, the level of the middle measurement device was roughly 2.0 m and the level of the upper measurement device was 3.0 m above the tank floor.

3. Testing Method

Diffusers were tested with four different quantities of air. The quantity of air was specified by customer.

The tests were performed in accordance with DIN EN 12255-15[1] and the DWA recommendations M 209[2]. The oxygen transfer tests were carried out in clean (tap) water, with a depth of 3.90 m. The depth of immersion was, thus, 3.77 m.

[1] DIN EN 12255-15: „Messung der Sauerstoffzufuhr in Reinwasser in Belüftungsbecken von Belebungsanlagen", April 2004
[2] ATV-DVWK-Merkblatt M 209: „Messung der Sauerstoffzufuhr von Belüftungseinrichtungen in Belebungsanlagen in Reinwasser und in belebtem Schlamm", GFA, St. Augustin, April 2007

Cobalt (II) sulphate was used as catalyst to deoxygenate the tank contents. This was added in dissolved form prior to the beginning of the test in such quantity that the C_o-concentration was 0.5 mg/l. To ensure uniform distribution, the sodium sulphite was slowly strewn in along both sides of the existing walkway during operation.

The oxygen content was measured by means of three factory-calibrated LDO measurement devices, manufactured by Hach-Lange. The measurement devices use an optical, drift-free method for measurement of dissolved oxygen. The oxygen concentration was continuously measured and recorded with a data logger. The data was then transferred to a computer and analysed. When the increase in the oxygen concentration was less than 0.1 mg/(l*hr) measurements were ended.

The water was replaced, if a critical concentration of salt of 2,000 mg TDS/l (conductivity roughly 3,000 µS/cm) was reached during a test.

4. Test Evaluation

The evaluation of oxygen uptake with non-linear regression was done with software OCAW, a special software for absorption and desorption measurements. The theoretical final saturation value ($C_{S,md,20}$) at the half depth of entry was the basis for the evaluation purposes. To adjust the influence of salt concentration in the tank the aeration coefficient k_La_{20} is corrected with the measured conductivity with the following equation for a salt concentration of 1.000 mg/l:

Aeration coefficient $k_La_{20,1000}$ [1/hr] = k_La_{20} * 1.1 / (1 + 0.1 * 2/3 LF / 1000).

The listed power input and the calculated gross oxygen yield are based on calculated values, they are used for a comparison of the tested diffusers. The power input was determined in each case based on the air quantity measured, using the equation:

$$N_B = \frac{Q_L * \gamma_W * p}{\eta * 75 * 1.36} \text{ [kW]}$$

The efficiency η was taken as being 0.6 in all cases. As the yield at a waste water treatment plant depends on the whole system (efficiency blowers, installation of pipes, control system, control valves etc.), the results of the pilot plant are not usable in practise directly.

Figure 2 shows the specific oxygen uptake [g/(Nm³*m)] as a function of the quantity of air supplied per diffuser and time.

The pressure loss [hPa] of aeration system including supply pipe as a function of the quantity of air supplied per diffuser and time are shown in figure 3. Additional test series with dry diffusers was carried out in a small separate test tank with installed single diffusers.

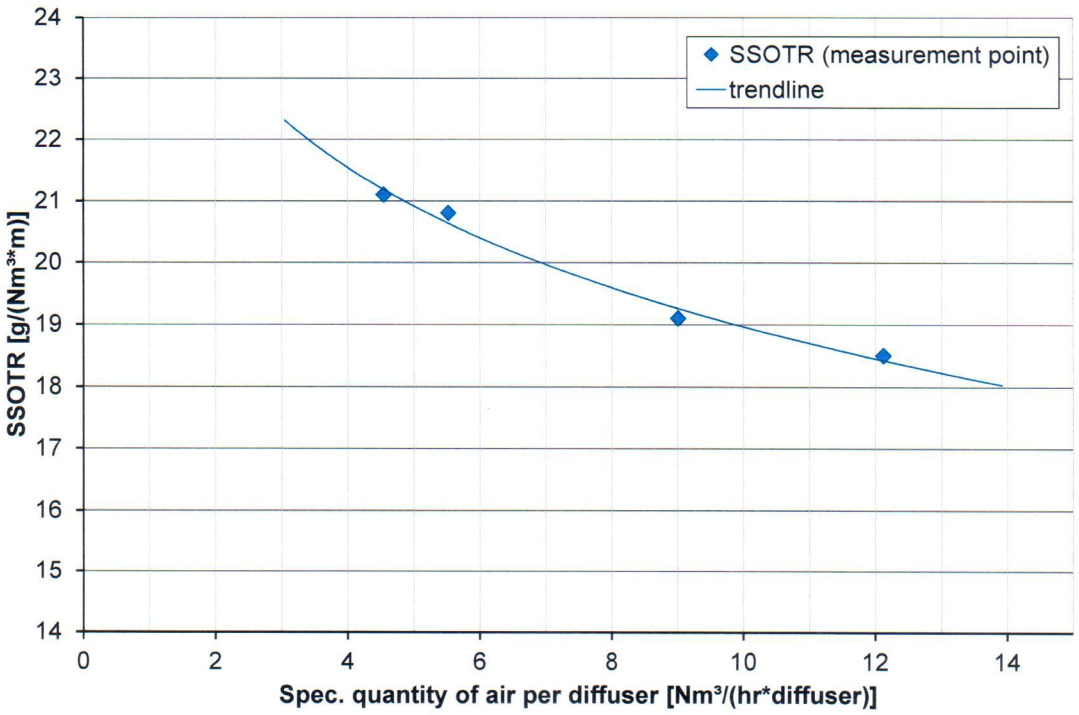

Figure 2: Oxygen uptake as a function of the quantity of air supplied

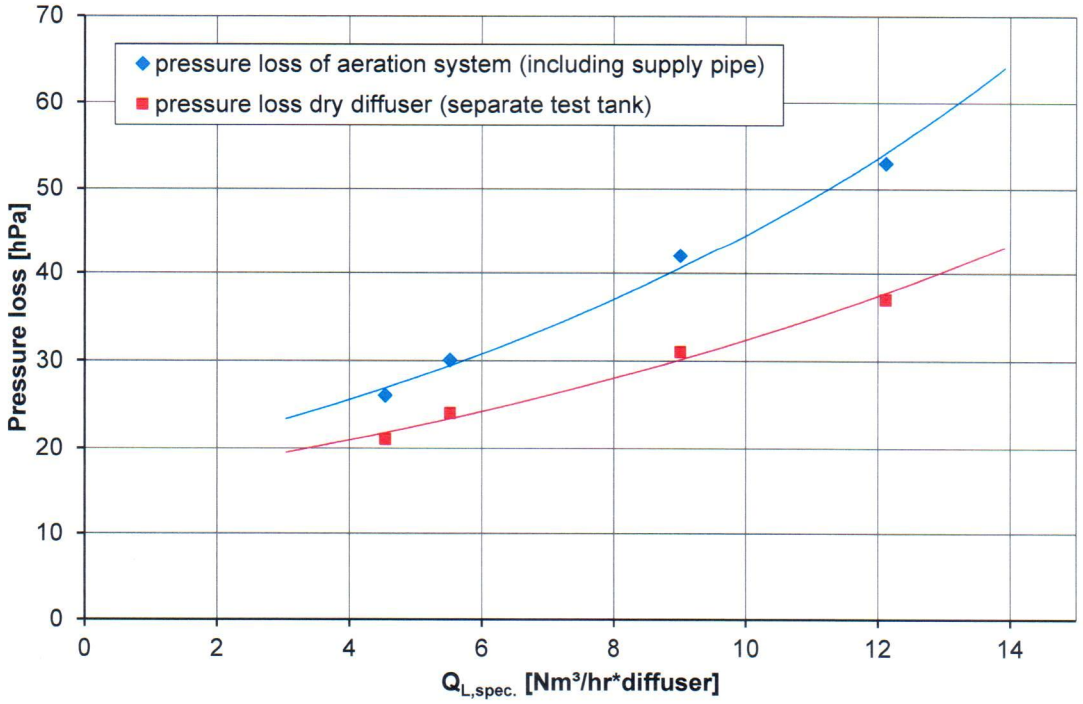

Figure 3: Pressure loss of aeration system including supply pipe and additional test with dry diffusers as a function of the specific quantity of air supplied

5. Summary

At the 28th Mai 2015, tests in clean/tap water were performed in a test tank at the experimental station of the Emschergenossenschaft to determine the oxygen input capacity, oxygen yield and specific oxygen uptake achieved with the EPDM-membrane plate-diffusers manufactured by Supratec, Type OXYFLEX MF1100 "Efficient". The tests, as well as their evaluation, were carried out in accordance with DIN EN 12255-15 and the DWA-Recommendations M 209. Four oxygen input tests were performed in total in a tank with a volume of roughly 140 cubic metres. The air quantities were varied without modifying the configuration, so that the results can be shown as a function of the air quantity.

Evaluation of the test results produced the following values:

Spec. quantity of air		Pressure loss		SSOTR
Per diffuser	Per m³ tank volume	Incl. supply pipe	Dry diffuser (separate test tank)	
[Nm³/(hr*diffuser)]	[Nm³/(hr*m³)]	[hPa]	[hPa]	[g/(Nm³*m)]
4.54	1.07	26	21	21.1
5.52	1.30	30	24	20.8
9.01	2.12	42	31	19.1
12.12	2.85	53	37	18.5

Essen, 27 July 2015

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Supratec
Gesellschaft für Umwelt- und Verfahrenstechnik mbH

Project: waste water treatment plant Gabal el Asfar

Realisation with OXYFLEX® membrane diffuser

Technical data

	per tank	total	
design of the diffuser	plate	plate	
diffuser type	OXYFLEX® MF1100	OXYFLEX® MF1100	
version	Efficient	Efficient	
material of the membrane	EPDM	EPDM	
water depth	6,25	6,25	m
diffuser working depth	6,05	6,05	m
α - alpha-factor (supposed)	**0,65**	**0,65**	
β- beta-factor (supposed)	1,00	1,00	
Diffuser feed			
max. short-time feed (maintenance purpose)	14,0	14,0	Nm³/h per diffuser[1]
max. permanent feed	12,0	12,0	Nm³/h per diffuser[1]
chosen feed	**4,5**	**4,5**	Nm³/h per diffuser[1]
min. feed	2,0	2,0	Nm³/h per diffuser[1]
Layout			
number of drop pipes	15	120	piece
number of distribution pipes per drop pipe	3	3	piece
number of diffuser per distribution pipe	35	35	piece
recommended quantity of diffusers	**1575**	**12600**	piece
Operating Diffuser Airflow: average AOR			
resulted air feed per diffusers	4,5	4,5	Nm³/h per diffuser[1]
resulted air feed per m² of diffuser surface	22,6	22,6	Nm³/h per m² active diffuser area[1]
specific standard oxygen transfer rate (SSOTR)	21,5	21,5	g O_2/Nm³/m $_{\text{installation depth}^1}$
specific standard oxygen transfer efficiency (SSOTE)	7,2	7,2	% per m installation depth
standard oxygen transfer rate (SOTR/SOR)	**925**	**7397**	kg O_2/h
standard oxygen transfer rate - in waste water (αSOTR/AOR)	601	4808	kg O_2/h
therefor required air amount	**7108**	**56867**	Nm³/h
Operating Diffuser Airflow : maximal AOR			
resulted air feed per diffusers	5,5	5,5	Nm³/h per diffuser[1]
resulted air feed per m² of diffuser surface	27,7	27,7	Nm³/h per m² active diffuser area[1]
specific standard oxygen transfer rate (SSOTR)	20,5	20,5	g O_2/Nm³/m $_{\text{installation depth}^1}$
specific standard oxygen transfer efficiency (SSOTE)	6,8	6,8	% per m installation depth
standard oxygen transfer rate (SOTR/SOR)	**1082**	**8654**	kg O_2/h
standard oxygen transfer rate - in waste water (αSOTR/AOR)	703	5625	kg O_2/h
therefor required air amount	**8722**	**69780**	Nm³/h
Operating Diffuser Airflow : total 113.000 Nm³/h			
resulted air feed per diffusers	9,0	9,0	Nm³/h per diffuser[1]
resulted air feed per m² of diffuser surface	44,8	44,8	Nm³/h per m² active diffuser area[1]
specific standard oxygen transfer rate (SSOTR)	18,2	18,2	g O_2/Nm³/m $_{\text{installation depth}^1}$
specific standard oxygen transfer efficiency (SSOTE)	6,1	6,1	% per m installation depth
standard oxygen transfer rate (SOTR/SOR)	**1555**	**12442**	kg O_2/h
standard oxygen transfer rate - in waste water (αSOTR/AOR)	1011	8088	kg O_2/h
therefor required air amount	**14125**	**113000**	Nm³/h
Operating Diffuser Airflow : total 171.000 Nm³/h			
resulted air feed per diffusers	13,6	13,6	Nm³/h per diffuser[1]
resulted air feed per m² of diffuser surface	67,9	67,9	Nm³/h per m² active diffuser area[1]
specific standard oxygen transfer rate (SSOTR)	16,0	16,0	g O_2/Nm³/m $_{\text{installation depth}^1}$
specific standard oxygen transfer efficiency (SSOTE)	5,3	5,3	% per m installation depth
standard oxygen transfer rate (SOTR/SOR)	**2069**	**16553**	kg O_2/h
standard oxygen transfer rate - in waste water (αSOTR/AOR)	1345	10759	kg O_2/h
therefor required air amount	**21375**	**171000**	Nm³/h
tank			
length of tank	119,2	119,2	m
width of tank	14,0	14,0	m
floor area of the tank	**1669**	**13350**	m²
No.of tanks	1	8	piece
diffuser coverage density	18,9	18,9	%
active area for each diffuser	0,2	0,2	m²
total active diffuser area	315,0	2520,0	m²
Data under consideration of an arrangement with mixer	no	no	
Data under consideration of a full extensively arangement!	yes	yes	
pressure loss (considering condition as delivered)	**≤ 30**	**≤ 30**	**mbar**

The a.m techncial data should be considered for the layout of the agitator acc. to VDMA 24656.

[1] Nm³ acc. to DIN EN ISO 1343 at t=0°C, p=1,01325bar, relative humidity = 0%

Supratec
Gesellschaft für Umwelt- und Verfahrenstechnik mbH

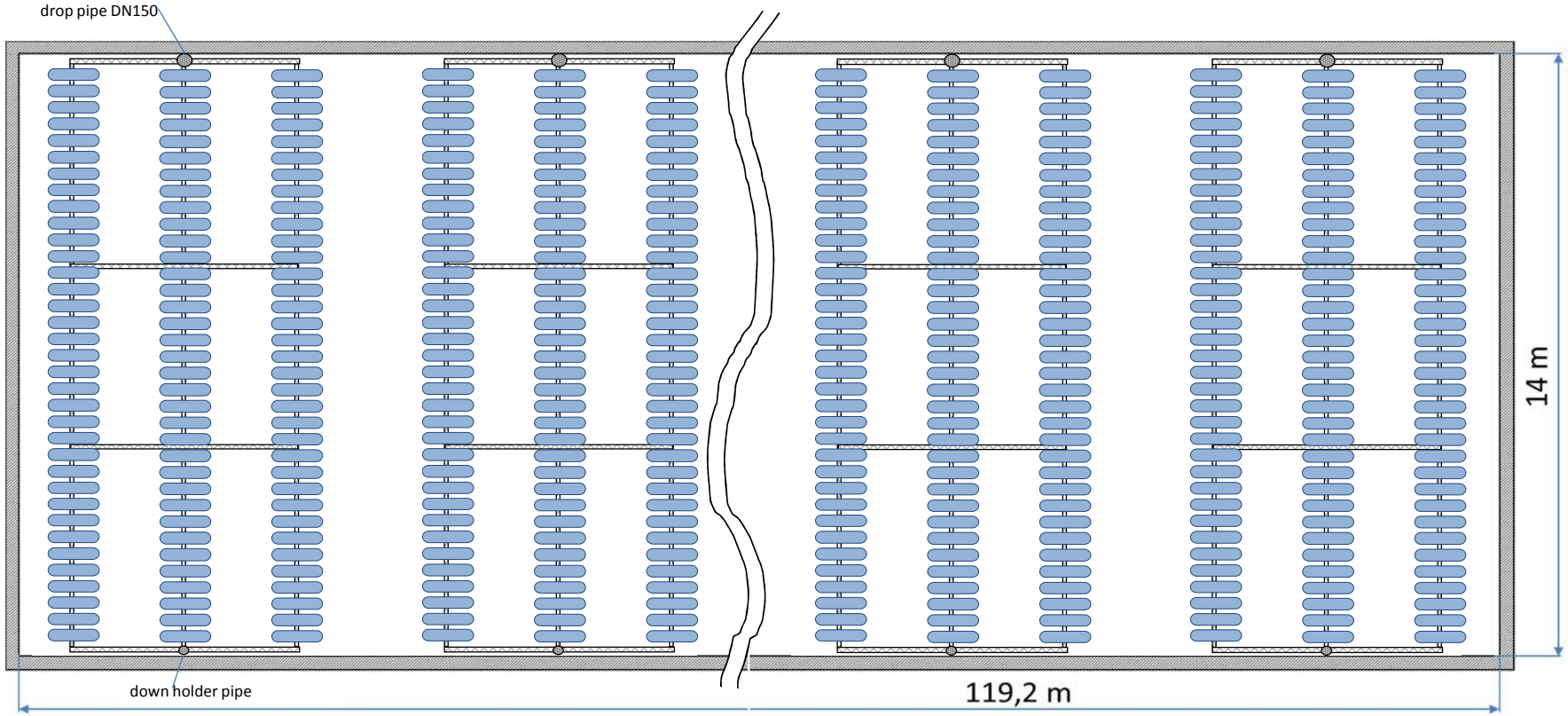
Project: waste water treatment plant Gabal el Asfar

sketch with a proposal of a possible arrangement

15 liftable grids each with 3 distribution pipes and 35 x OXYFLEX® MF1100 per distribution pipe
105 diffuser per grid

∑ 1575 OXYFLEX® MF1100 per tank

required air amount	:	7108 Nm³/h [1]	resulted air feed per diffusers	:	4,5	Nm³/h per diffuser[1]
standard oxygen transfer rate (SOTR/SOR)	:	925 kg O_2 / h	resulted air feed per m² of diffuser surface	:	22,6	Nm³/h per m² active diffuser area[1]
specific standard oxygen transfer rate (SSOTR)	:	21,5 g O_2/Nm³/m [1] installation depth[1]	floor area of the tank	:	1669	m²
diffuser working depth	:	6,05 m	total active diffuser area	:	315	m²
			diffuser coverage density	:	18,9	%



[1] Nm³ acc. to DIN EN ISO 1343 at t=0°C, p=1,01325bar, relative humidity = 0%