CoMeTas AquaSolution AQS-144-800-(2*2) 3 micron

Test report

Physical removal of microbiological and particulate contaminants

WATER • ENVIRONMENT • HEALTH

CoMeTas
July 2010

CoMeTas AquaSolution
AQS-144-800-(2*2) 3 micron
Test report

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APPENDICES

2 INTRODUCTION

This test report reports the verification of the performance of an environmental technology following the DANETV Centre Quality Manual – Water Technology.

2.1 Verification protocol reference

This test report was prepared in response to the test design established in the CoMeTas AquaSolution verification protocol, AQS-144-800-(2*2) 3 micron filter /1/.

2.2 Name and contact of vendor

CoMeTas A/S, Lerhøj 10, 2880 Bagsværd, Denmark, Phone +45 4498 6060
Contact: Kenneth H. Johansen, e-mail khj@cometas.dk
Homepage: www.cometas.dk

The laboratory responsible for the analysis of samples:
Particulates (size distribution): DHI
Total bacteria count: DHI
Chemical analysis TOC (DHI), total hardness, THM (Eurofins)

2.3 Name of centre/test responsible

Danish Centre for verification and Climate and Environmental Technologies, (DANETV), DHI DANETV Water Centre, Agern Allé 5, DK-2970 Hørsholm, Denmark

Verification responsible: Mette Tjener Andersson, e-mail: mta@dhigroup.com Phone +45 4516 9148

Test responsible: Bodil Mose Pedersen, e-mail: bop@dhigroup.com Phone +45 4516 9433

2.4 Technical experts

The technical experts assigned to this test and responsible for review of test plan and test report include:

Internal technical expert: Gerald Heinicke (GHE) e-mail ghe@dhigroup.com, DHI, Agern Allé 5, 2970 Hørsholm, Phone +45 4516 9268

External technical expert: Professor Erik Arvin, Technical University of Denmark (DTU), DTU Environment, Phone +45 4525 1472 era@env.dtu.dk

3 TEST DESIGN

The test plan is applicable to any pressure driven membrane process. The total verification testing was performed over 17 days (not including time for system set-up and initial test run). The verification testing was conducted to provide equipment testing information. Task description is provided in Table 3-1.

Table 3-1 Task description within the verification testing.

Task	Issue	Test
1. Characterization of membrane flux and recovery	Rate of flux decline	Development of flux during specified operational conditions
2. Evaluation of back wash efficiency	Frequency, water consumption	Flux recovery of back wash
3. Evaluation of finished water quality	Produced water quality	Measurements of feed water quality and produced water quality
4. Membrane integrity testing	Removal of particles and total microbial count	Rejection capability of particles and evaluation of total microbial count in feed water and produced water

3.1 Test site

The test was conducted as a field test at Gladsaxe Svømmehal, Vandtårnsvej 55, DK-2860 Søborg, and the test plant was provided by Provital A/S and equipped with CoMeTas ceramic filters. Provital A/S is a joint venture between CoMeTas A/S and Løkken Spa og Pool A/S. Gladsaxe Svømmehal has two pool areas – one area equipped with one 50 m basin and a pool area equipped with a warm water pool and a paddling pool. The warm water pool, the paddling pool and the pipelines all together contain 50 m^3. The pool water from the warm water pools is re-circulated and passes sand filters designed for removal of suspended particles (see Figure 3-1). The pool water used for the test was a side stream of re-circulated pool water from the warm water pool.

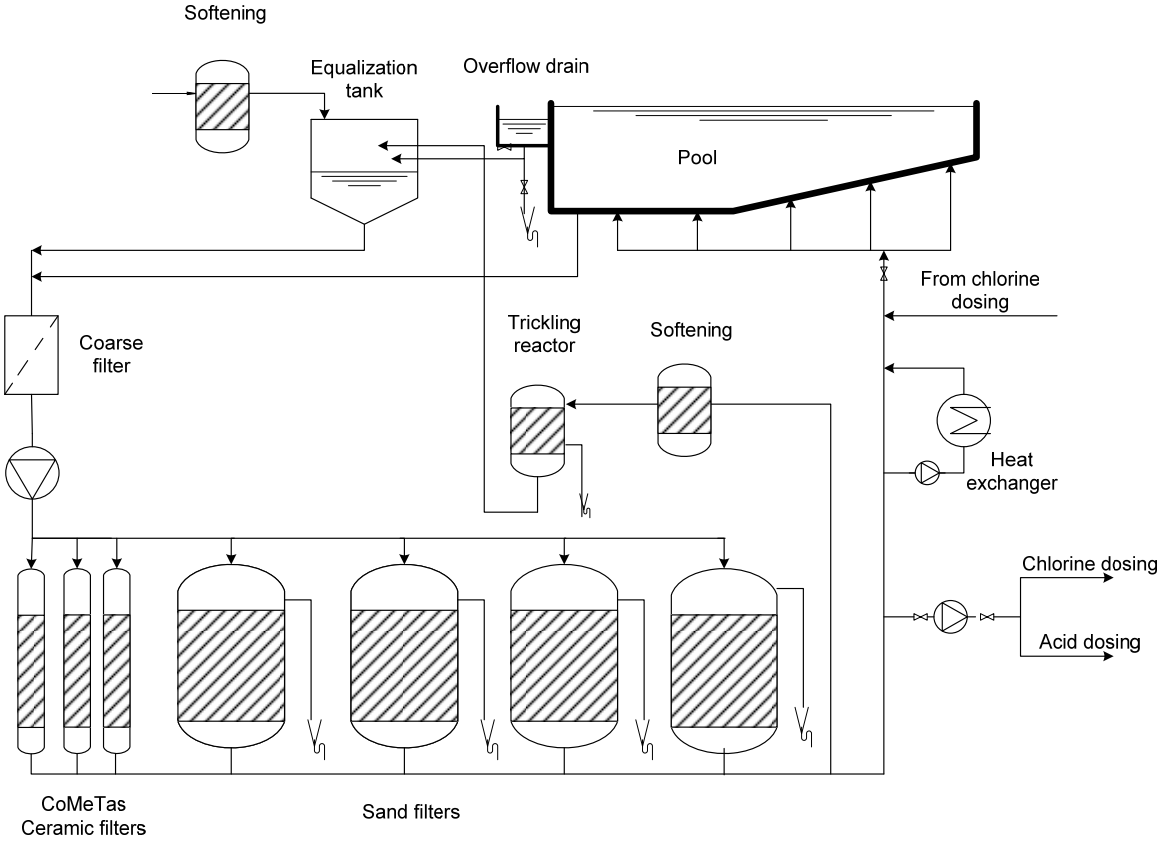


Figure 3-1 Flow diagram showing the re-circulation and treatment of pool water in sand filters.

The temperature of the pool water was 33°C. One of the sand filters, which usually treat nearly one half of the re-circulated pool water, was replaced during the test period by the AquaSolution filtration plant. The exact ratio of sand filter treated water and AquaSolution treated water was measured during the preliminary characterization of the test site and through the test period. Table 2 in Appendix 6 shows data from measurements of flow and the relative flow ratio treated by the filtration plant.

3.2 Tests

Sand filtration is currently in use for a broad number of water treatment applications. Filtration through ceramic membranes is an alternative to sand filtration, where the objective is removal of natural organic matter contributing to formation of disinfection by-products.

During the test, records have been collected from the operation and the belonging sampling and analyses. Reported data are found in Appendix 6.

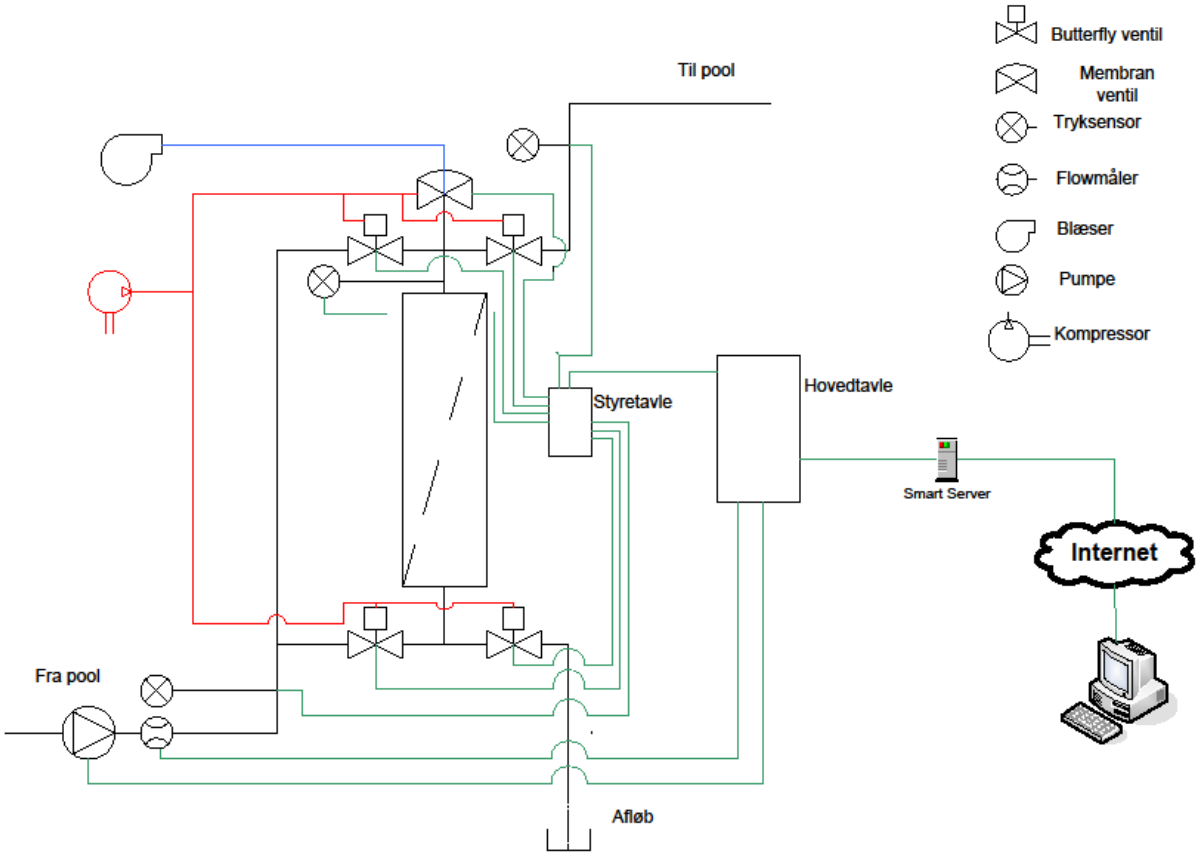


Figure 3-2 Overview of components and characteristics of membrane test unit (Pressure – Impulse diagram). Drawing delivered by Provital A/S.

3.2.1 Characterization of the test site

The test site selected for the verification was characterized by four tasks: sampling and analyses, measurements and description of the test site.

Sampling and analyses

The numbers of samples taken during the initial runs are presented in Table 3-2. Sampling took place during normal operation and just before and after a back wash cycle. When sampling took place on-line measuring and date and hour of the measurements were recorded. The on-line parameters collected are presented in Table 3-3.

Table 3-2 Number of samples analysed during the initial runs. TOC = Total organic carbon, THM = trihalomathanes, °dH = degrees of hardness.

Parameter	Unit	Laboratory	Feed water	Treated water	Back wash water
Particle counting	Number/mL	DHI	3	3	2
Total microbial counting	Number/mL	DHI	2	2	
TOC	µg/l	DHI	5	6	3
Total Hardness	°dH	Eurofins	2	2	
THM	µg/l	Eurofins	1	1	

Measurements and data logging carried out at test site

During 48 hours of normal operation on-line logging of data took place. The data collected during the operation were evaluated and a graph was plotted showing the mem-

brane pressure at the inlet and outlet over time (see Appendix 7). Back wash cycles were included in the logging period. The flux/flow was equally plotted against time and logging of back wash frequency took place (the time when the back wash took place was recorded).

Table 3-3 Measurements carried out at the test site and by the filtration plant. (ORP = Ocidation reduction potential)

Parameter	Unit	Gladsaxe Svømmehal	Provital plant
pH		On-line	
Free chlorine	mg/l	On-line	
Bound chlorine	mg/l	On-site	
Temperature	°C	On-line	
Redox (ORP)	mV	On-line	
THM	µg/l	2 samples per year	
Feed flow	m^3/h		On-line
Feed water pressure	bar		On-line
Produced water pressure	bar		On-line
Back wash cycle start	ss:mm:hh:dd:mm		On-line
Back wash cycle stop	ss:mm:hh:dd:mm		On-line

Description of test site
Information was collected concerning the test site address; contact and number of visitors per year in the swimming pools (see Section 7.1.1).

The physical characteristics of Gladsaxe Svømmehal were reported. The characteristics include: Types of basins, temperature, volume of warm water pool, volume of tap water used for back washing of sand filters and frequency of back washing.

Furthermore, specifications of sand filters were given. Specifications include: Sand filter area and height, sand material and back wash velocity (air and water).

3.2.2 Initial operational runs
The initial test run comprised evaluation of the equipment operation and determination of the treatment conditions that cause efficient treatment of the feed water. The initial runs were shakedown testing and included the tasks described in Table 3-1, which consist of preliminary characterisation of feed water, produced water and back wash water, logging of on-line data from membrane filtration plant and description of test site. The operational conditions during the initial operational runs are presented in Table 3-4.

Table 3-4 Test conditions for the initial operational runs.

Parameter	Unit	Interval or typical value
Feed flux	$m^3/(m^2*h)$	1.0-2.9
Specific feed flux (typical)	$m^3/(m^2*h)/bar$	10
Feed flow	m^3/h	20-60
Feed pressure	bar	0.6-0.75
Permeate pressure (produced water)	bar	0.5-0.6
Number of back washes	Number/day	1
Back wash cycle length	Minutes	10
Consumed water for back wash	L/back wash	75

3.2.3 Verification testing

The test equipment was operated 24 hours a day, during 17 days. Duration of interruptions was recorded and did not exceed more than 30% of time. The tasks performed are listed below:

Task 1: Characterisation of membrane flux and recovery
Task 2: Evaluation of back wash efficiency
Task 3: Evaluation of water quality
Task 4: Membrane integrity testing (particle counting and total microbial counting)
Task 5: Data management

Task 1: Characterisation of membrane flux and recovery
The objective of this task was to evaluate the membrane operational performance. Measurements of flow and pressure (in and out) were logged. Logging of pressure took place every minute. The membrane pressure and flow were logged during operation. Membrane pressure-time curve has been developed.

Task 2: Evaluation of back wash efficiency
An important aspect of membrane operation is the restoration of membrane productivity after (specific) flux decline has occurred. The objective of this task was to evaluate the effectiveness of the back wash. The recovery of (specific) flux was determined after a back wash cycle.

The criterion for starting the back wash cycle is usually a transmembrane pressure higher than 0.25 bar. The back wash cycle was expected to perform automatically and the criterion was set by the vendor to be once every 24 hours. Actually it was necessary to force the back wash to start.

The flow in the whole re-circulating pool water system varied depending on the development of clogging of the sand filters, and therefore it was not possible to obtain a constant water flow to the test plant. This meant that the back wash of the filter could not be trigged by transmembrane pressure and therefore the back wash was planned to start automatically once every 24 hours.

The immediate recovery of membrane productivity can be expressed by the ratio between the final (specific) flux value of the current filtration run (J_{Sf}) [$L/(h*m^2)/bar$] and the initial (specific) flux (J_{Si}) measured for the subsequent filtration run.

Recovery of (specific) flux = 100 * [1- (J_{Sf}/ J_{Si})]

The loss of (specific) flux capabilities can be expressed by the ratio between the initial specific flux for any given filtration run (J_{Si}) and the specific flux at time zero (J_{Sio}) as measured at the initiation of the first filtration run in a series.

Loss of original (specific) flux = 100* [1-(J_{Si}/J_{Sio})]

Task 3: Evaluation of finished water quality
The objective of this task was to evaluate the water quality produced by the AquaSolution membrane. Some of the water quality parameters (pH, temperature, free chlorine) were measured on-line by Gladsaxe Svømmehal and the belonging instruments were read and data written down by the technician who took care of the monitoring of the test plant. Analyses of the water quality were performed by a laboratory under accreditation (Eurofins: hardness, THM). The analytical parameters determined are presented in Table 3-5. Methods of measurements used for documentation of the operational conditions are found in Table 3-6.

Table 3-5 Analytical parameters and analytical methods used for verification testing. THM = trihalo methane, TOC = Total organic carbon, GC-ECD = Gas Chromatography with Electron Capture Detector.

Parameter	Facility	Method
pH	On-site	pH-meter, Gladsaxe Svømmehal
Temperature	On-site	Grundfos RPS Temperature sensor
Hardness	Laboratory	DS 250:1973
Particle count	On-site	AccuSizer AD
Total microbial count	Laboratory	Reasoner and Geldrich /2/
THM	Laboratory	GC-ECD
Free chlorine	On-site	Chlorine sensor
Bound chlorine (Chloro amines)	On-site	Gladsaxe Svømmehal (method)
TOC	On-site/laboratory	Sievers 800 TOC

Table 3-6 Operational parameters – methods of measurements.

Parameter	Facility	Method	Precision %	Range of application
Flow	On-line	Krohne Optiflux 2000	± 0.5%[1)]	0-150 m^3/h
Flux		Calculated		
Pressure	On-line	Jumo MIDAS	≤0.5 of scale max.	0-1.6 bar
Pressure	On-line	Grundfos RPS	± 1.5% of scale max.	0-2.5 bar
Total microbial count	Laboratory	Reasoner and Geldrich /2/		>5 counts/mL
Particle count	On-site	AccuSizer AD	<5%	1.5-400 µm
Temperature	On-line	Grundfos RTS	± 1°C [2)]	0-100°C

[1)] Velocity ≥ 0.4 m/s.
[2)] ± 1°C at temperatures between 25 and 80°C.

Analyses of water quality parameter (hardness, THM, total microbial count) were performed by an analytical laboratory maintaining ISO 17025 accreditation.

Task 4: Membrane integrity testing (particle counting)
The particle removal efficiency of the membrane filtration process was established by particle counting on grab samples taken from the feed water and the produced water. The removal efficiency value was demonstrated and monitored during 17 days of operation and focused on the removal efficiency of particles within defined particle size intervals 1.5-4.99 µm, 5.00-10.32 µm and 10.33-20.39 µm. The AccuSizer 780/SIS instrument for particle size distribution operated with size intervals which not exactly corresponds the intervals chosen when planning the test: 1.5-5 µm, 5-10 µm and 10-20 µm.

The methods used for determination of the particle size distribution should preferably be accredited, however, this was not practically possible and therefore the size distribution was performed by using the AccuSizer 780/SIS equipment which is based on the method of single-particle optical sensing (SPOS) also called optical particle counting. The particle sensor was calibrated by the supplier in October 2009.

It was expected that the membrane also provided a constant barrier to microbial contaminants, but the microbial contaminants in the pool water was affected by the chlorination and therefore it was not possible in an on-site test to verify if the membrane provided a barrier to the microorganisms. However, present microorganisms were quantified in grab samples taken from the feed water and the produced water in order to get an indication if the membrane works as a microbial barrier. The method (DHI SF 30/816:02) used for enumeration of the total microbial count was adjusted to chlorinated pool water. The method included incubation for 14 days at 22°C and counting of colonies after 7 and 14 days. A long cultivation period promotes the detection of surviving bacteria. /2/.

The test staff conducted the water quality sampling during the testing.

Task 5 Data management.
Data management including manually recording and handling of logged data is described in Chapter 5 and the test results are described in Chapter 7.

3.2.4 Test methods
No standard method exists for testing filters intended for treatment of pool water. The test methods have accordingly been prepared for the purpose with reference to the EPA/NSF ETV Equipment Verification Testing Plan for Removal of Microbiological and Particulate Contaminants by Membrane Filtration /3/.

3.2.5 Test staff
The test staff, which were test responsible: B.Sc. Eng. Bodil Mose Pedersen (BOP) and test technician Susanne Klem (SEK).

3.2.6 Test schedule
The verification test took place from 28 November to 16 December 2009. The initial runs took place from 12 November 2009 to the start of the verification test.

3.2.7 Test equipment
The high flux AquaSolution asymmetric silicon carbide (SiC) membrane (AQS-144-300-(2*2) 3 micron) is designed for dead-end-operation and for removal of particulate natural organic matter from a water matrix. The membrane also rejects bacteria – de-

pending on the pore size in the filter of interest. However, in the present test particle removal was the primary objective.

The AquaSolution filter elements (three units) were placed in a housing delivered by Provital A/S. For the verification testing 3 filters in parallel were tested corresponding to a water flow of 20-60 m^3/h.

The current filtration unit tested was equipped with an automatic operation system. The flow and pressure at inlet and outlet were measured continuously and the back wash cycle was automatically forced to start every 24 hours.

Description of the test equipment delivered by Provital A/S is given in Appendix 9 and includes construction, operation, data logging and monitoring equipment.

3.2.8 Type and number of samples

The types and numbers of samples taken are summarized in Table 3-7 and Table 3-8. During 17 days of operation sampling took place based on a plan set in advance (Appendix 8). Taps for sampling were mounted on the pipe leading to the filter and on the pipe returning the flow to the pools.

The water quality depends on the number of visitors in the pool area and in order to represent different load situations the week days where sampling took place were not the same during the test period. Immediately after spot samples were taken the on-line instruments, which measured pH, temperature, free chlorine and bound chlorine in the recirculated pool water, were read. The spot samples, which were taken from the feed water and the produced water, were sent to a laboratory under accreditation and analyzed. The laboratory delivered appropriate bottles for storage of samples until analysis.

Table 3-7 Sampling performed during 17 days of operation. Spot samples were taken from the feed water and the produced water.

Parameter	Sampling/Reading
pH	Reading on-line instrument
Temperature	Reading on-line instrument
ORP	Reading on-line instrument
Free chlorine	Reading on-line instrument
Bound chlorine (Chloro amines)	Analysed by Gladsaxe Svømmehal
Hardness	10 (equally divided over the test period)
THM	4 (equally divided over the test period)

Particle concentrations were measured in samples taken from the feed water and the produced water. Sampling took place 6 times (6 events) with equal time intervals during the test period. The intervals between the spot samples representing one event appear from Table 3-8. Total microbial count was included in the program, but microbial counting was only performed to characterize the pool water before and after treatment. Samples from 3 events are included.

Table 3-8 Sampling, particle counting (p) and total microbial counting (m) within the following ranges: 1.5-4.99 µm, 5.00-10.32 µm and 10.32-20.39 µm.

Water	Hours after back wash					
	0.5	1	2	4	22	23.5
Feed water	pm	p	p	p	p	pm
Produced water	pm	p	p	p	p	pm

Particle size analyses were carried out on 36 duplicate samples from the feed water and on 36 duplicate samples from the produced water. Replicates were carried out. The time was recorded when the sampling took place.

Total microbial count was analyzed in 6 samples from the feed water and 6 samples from the produced water.

3.2.9 Operation conditions

The operational conditions planned for the verification of the product appear from Table 3-9.

Table 3-9 Planned and actual operational conditions during the test period.

Parameter	Unit	Planned test interval	Actual test interval
Feed flow	m^3/h	20-60	22-36
Specific flux	$m^3/(m^2*h*bar)$	1.0-2.9	1.0-1.8
Transmembrane pressure	Bar	0.2-0.3	0-0.25
Time between back washes	Hours	23.5-24.5	3-28
Back wash cycle length	Minutes	9-11	7-9
Consumed water for back wash	L/back wash	70-80	170-390
Temperature	°C	32-34	32-34
Water volume (pools and pipes)	m^3	50	50
Re-circulation flow	m^3/h	60-80	81-91

3.2.10 Operation measurements

During operation, the logging of operational conditions took place on the FTP-server connected to the filtration plant. Logging of pressure (in and out) took place every minute. Parameters and units are summarized in Table 3-10.

Table 3-10 Operational data recorded.

Parameter	Unit
Feed flux	$m^3/(m^2*h*bar)$
Feed flow	m^3/h
Feed flow pressure	bar
Produced water pressure	bar
Transmembrane pressure	bar
Time between back washes	hours
Back wash cycle length	minutes
Consumed water for back wash	L/back wash

3.2.11 Product maintenance

Product maintenance described by Provital A/S is given in Appendix 9.

3.2.12 Health, safety and wastes

Work at the test site was done according to DHI rules for safe field work included in the DHI safety rules.

Back wash water was discharged to the sewer system in the same way as the back wash water from the existing sand filters in Gladsaxe Svømmehal is.

4 ANALYSIS

Reference analyses were not submitted to an analytical laboratory because it was difficult to find a laboratory with a sufficient low detection limit for TOC analyses. Therefore the TOC analyses were performed at DHI's own laboratory facilities.

The date was recorded concerning the latest calibration of the flow meters and the pressure meters.

The particle counter was calibrated by the supplier and a calibration certificate is shown in Appendix 3.

4.1 Analytical laboratory

Water quality of feed water (THM and hardness) was carried out by Eurofins Danmark, Smedeskovvej 38, DK-8464 Galten. The total microbial count of feed water, produced water and back wash water was performed by DHI, Department of Environmental Risk Assessment. The TOC analyses were performed by DHI, Department of Urban and Industry. The analyses carried out appear from Table 4-1.

4.2 Analytical parameters

The analytical parameters appear from Table 4-1.

4.3 Analytical methods

The analytical methods are given in Table 4-1.

Table 4-1 Parameters and total number of samples analysed (feed water and produced water).

Parameter	Method	Samples	Limit of detection
TOC	Sievers 800 TOC analyzer	12*)	0.5 µg/l
Particle analysis	AccuSizer 780/SIS	36 (in and out)	1.5 µm
THM	GC-ECD	4	1 µg/l
Hardness	SM3120	10	0.5 °dH
Total microbial count	SF 30/810:02:DS/ISO 6222 /4/ and SF 30/816:02 /2/	16	5 and 0.5 count/mL

*) 12 samples = 3 days (one sample of feed water and produced water immediately after back wash and immediately before back wash).

4.4 Analytical performance requirements

The limits of detection are given in Table 4-1.

4.5 Preservation and storage of samples

All water samples were sampled in glass bottles and the secondary samples were put into bottles delivered by the laboratories. The samples were preserved by the laboratories if needed and at least stored cold (1-5ºC) and dark until delivered to the laboratories within maximum 3 days.

5 DATA MANAGEMENT

In general the data filing and archiving procedures of DHI Quality System Manual were followed.

The data management involved manually recording of operational data and handling of operational data which was logged on a FTP-server located at the test site. Data from the FTP-server was transferred to DHI. Add to this, transfer of analytical results was from the qualified laboratories mentioned in Section 4.1.

5.1 Data storage, transfer and control

Data handling consisted of collection and writing into custom designed Excel spread sheets prepared in advance. The spread sheets were used for calculation and storage of data concerning water quality. Operational parameters were transferred from the FTP-server. Operational data were collected from Gladsaxe Svømmehal's monitoring of the pool water quality together with data on sampling (time and location). The Excel spread sheets were available on a lab-top PC provided by the test centre and located at the test site. Actions and events with relevance to the test plan were written into a log book including date and time. Samples sent for analyses by an external laboratory were labelled with the pre-defined label in order to ensure correct transfer of analytical data. Data received from the FTP-server was reviewed by the test-site test responsible.

Data compiled and stored are summarized in Table 5-1.

Table 5-1 Data compilation and storage summary.

Data type	Data media	Data recorder	Data record timing	Data storage
Test plan and report	Protected pdf files	Test responsible	When approved	Files and archives at DHI
Test details at test site	Log book and pre-prepared forms	Technician, DHI	During collection	Files and archives at DHI
Operational data	FTP-server	CoMeTas	During operation	Transferred data - files and archives at DHI
Calculations	Excel files	Test responsible, DHI	During calculation	Files and archives at DHI
Analytical reports	Paper	Test responsible, DHI	When received	Files and archives at DHI

6 QUALITY ASSURANCE

The tests were performed under the Centre Quality Manual – Water Technology which is ISO 9001 compliant, but not certified /5/. The DHI laboratories have ISO 17025 accreditations and OECD GLP approvals /6/ for a range of tests and ISO 17025 for sampling of drinking water. As part of the ISO 17025 and GLP inspections, the procedures for general laboratory processes, quality assurance and documentation/archiving are assessed.

6.1 Test report review

This test report has been subject to internal review by the verification responsible from DHI DANETV Water Centre (Water Technology Centre) Verifications: Mette Tjener Andersson and technical expert Gerald Heinicke.

External review of the test report was done by the technical expert assigned to this verification.

6.2 Performance control – Sensor calibration

The sensor in the AccuSizer is calibrated by using a set of particle standards of narrow size distribution having well defined diameters (typically polystyrene latex).

The sensor calibration is performed with a single point standard reference material. The standard should be in the centre range of system (10 µm). The population-weighted distribution of the standard is compared with the reported size. The values should be within 5% of each other. If the values deviate by more than 5% the procedure for recalibrating the system should be followed for the entire range of standards.

The calibration was performed by the manufacture in October 2009 less than two months before the verification test. The calibration is stated in a certificate which is included in this test report (Appendix 3).

6.3 Test system control

The stability of the test equipment was controlled continuously by supervision and recording of data in the log book and by logging of operational data on the FTP-server. The data recorded was the feed flow, inlet/outlet pressure, transmembrane pressure, temperature, the frequency of back washing, disposal of back wash water, particle analysis.

The control of the particle analysis was done by using analysis of field blank (milipore water) samples.

6.4 Data integrity check procedures

All transfer of data from printed media to digital form and between digital media has been checked by spot check of not less than 5% of the data (test responsible). If errors were found in a spot check, all data from the transfer were checked.

6.5 Test system audits

Because the internal auditor started unexpected leave when the verification test started it was not possible to get another trained auditor for the test audit. As a result the audit was not performed. Subsequently the test data and the test data quality have been evaluated by the internal and the external expert.

6.6 Test report review

The test report was reviewed by the verification responsible from DHI WTC Verifications: Mette Tjener Andersson and by the internal expert Gerald Heinicke.

External review of the test report was done by the external expert as part of the review of the verification report.

7 TEST RESULTS

The ceramic filter from CoMeTas A/S called AquaSolution AQS-144-800-(2*2) 3 micron was tested for removal of particles in pool water re-circulated in a swimming pool at 33°C. The verification testing described in section 3.2.3 was followed. This chapter summarizes the test results, the obtained data, other recorded actions or events and any deviations from the test plan.

The test included:
Task 1: Characterisation of membrane flux and recovery
Task 2: Evaluation of back wash
Task 3: Evaluation of water quality
Task 4: Membrane integrity testing (particle counting and total microbial counting)

In addition to the sub-tasks the verification test included characterization of the test site. Below the implementation of the tasks is given.

7.1 Test data summary

In this section recorded data from those 4 tasks included in the test plan and calculated data quality indicators according to section 8.2 of the verification protocol for the test plant are summarized. Data collected during the test including calculated data are presented in Appendix 6. Data from data logging are presented in figures placed in Appendix 7. The verification testing took place over a 17-days period 28 November to 16 December 2009 and DHI supervised the filtration plant on days marked in Appendix 6, Table 5.

7.1.1 Characterisation of test site

During the run-in testing AQS 144-800 (5*5) 3 micron filters were used. The filters were on the 26 November 2009 substituted by AQS 144-800 (2*2) 3 micron filter. The test plant stopped 5 times during the test. These stops made up less than 1.7% of the test time.

Table 7-1 summarizes data about the test site relevant to the test plant and the treated pool water from the warm water pool and the paddling pool in Gladsaxe Svømmehal.

Table 7-1 Characterization of the test site given by Gladsaxe Svømmehal /8/.

Parameter	Information
Place	Gladsaxe Svømmehal, Gladsaxevej 200, DK-2860 Søborg, Denmark
Number of visitors	265,000 visitors per year (50-meter basin, warm water pool and paddling pool)
Contact	Work manager Jørgen Vienberg
Types of basins	50-meter basin, paddling pool, warm water pool
Temperature	33°C in the warm water and the paddling pool
Volume of warm water pools including pipes	50 m^3
Re-circulating volume for the warm water pools	About 100 m^3/h
Volume of make-up water for back wash	20 m^3/week
Re-circulation ratio	About 0.5 hours
Frequency of sand filter back wash	Once per week

The operation conditions during the test period appear from Table 7-2. The flow ratio through the filtration plant was on average 38% of the flow that passed through the warm water pool and the paddling pool all together. The back wash was originally set to 24 hours, but the back wash did not start automatically and therefore the back wash was started manually. That is why the intervals between the back washes varied during the test period.

Table 7-2: Operating parameters during test period. The column "Observations" includes the number of logged data, data extracted from data files and number of observations on-site. Flow and pressure data were measured on-line and data was logged on the FTP-server. Temperature and flow meter data measured by permanent installed equipment in Gladsaxe Svømmehal were read and noted in the log book. Data used for calculation of the flow ratio relative to the filtration plant and the total re-circulated flow consisted of 38 readings during the test period. Duration of back wash and water volume for back wash was measured during 5 back wash events.

Operating Parameter	Unit	Observations	Range	Average	Standard deviation
Start date and time		28-11-2009 19:30			
End date and time		16-12-2009 11:30			
Run length	day:hours	17:16			
Flow online	m^3/h	24,875	10.7-39.5	27	3.3
Pressure in	bar	24,017	0-0.78	0.52	0.06
Pressure out	bar	24,017	0-1.6	0.40	0.05
Transmembrane pressure	bar	24,017	0-0.25	0.12	0.03
Flow and pressure logging interval	minutes	1			
Temperature	°C	18	32.1-33.9	32.9	0.3
Flow meter reading (before bw)	m^3/h	18	21.5-32.5	26	3.4
Flow meter reading (after bw)	m^3/h	18	28.5-36.2	30.5	2.0
Flux (before bw)	$m^3/h \cdot m^2$	18	1.04-1.57	1.25	0.16
Flux (after bw)	$m^3/h \cdot m^2$	18	1.38-1.75	1.48	0.09
Specific flux (before bw)	$m^3/h \cdot m^2 \cdot bar$	18	4.9-15.7	10.1	3.0
Specific flux (after bw)	$m^3/h \cdot m^2 \cdot bar$	18	11.3-24.6	16.0	3.2
Recovery flux	%	18	-8.3-74.4	34.6	22.6
Flow ratio Provital/GS	%	38	26.4-40.6	34.2	4.3
Back washes	number	18			
Back wash duration	minutes	5	7-9	7	
Back wash volume	l	5	170-390	241	85.7

bw = back wash.

Details about flux, transmembrane pressure, back washes and recovery of flux are described in section 7.1.2 and 7.1.5.

7.1.2 Characterisation of membrane flux and recovery

The operating test conditions for the test plant were established based on the initial runs.

The logged on-line data have been used to set up Table 7-3, which contains data on the flow, pressure, calculated flux, specific flux, recovery and loss of flux between two back washes.

The back wash was set to take place every 24 hours and the membrane flow and feed/filtrate pressure were followed by logging on the FTP-server in 1-minutes intervals. Data that were logged 3 minutes before and after back wash were used for calculation of the specific flux.

Table 7-3 On-line data used for calculation of recovery after back wash and loss of specific flux between 2 back washes. Membrane area 20.7 m^2.

Week day	**Date**	**Flow [m^3/h]** 3 minutes before back wash	**Flow [m^3/h]** 3 minutes after back wash	**Flux** [m^3/m^2*h] before back wash	**Flux** [m^3/m^2*h] after back wash	**Trans-membrane pressure** [bar] before back wash	**Trans-membrane pressure** [bar] after back wash	**Specific flux** [$m^3/m^2*h*bar$] before back wash	**Specific flux** [$m^3/m^2*h*bar$] after back wash	**Recovery** %	**Loss of flux** %
Sunday	29.11.2009	25.5	30.5	1.23	1.47	0.11	0.13	11.2	11.3	1.2	
Monday	30.11.2009	28.0	28.7	1.35	1.39	0.09	0.09	15.0	15.4	2.4	-32.6
Tuesday	01.12.2009	25.2	30.5	1.22	1.47	0.12	0.06	10.1	24.6	58.7	34.1
Wednesday	02.12.2009	25.7	29.5	1.24	1.43	0.13	0.09	9.6	15.8	39.7	61.1
Thursday	03.12.2009	25.7	31.5	1.24	1.52	0.13	0.10	9.6	15.2	37.2	39.7
Friday	04.12.2009	23.7	28.5	1.14	1.38	0.14	0.08	8.2	17.2	52.5	46.3
Saturday	05.12.2009	22.2	29.0	1.07	1.40	0.15	0.12	7.1	11.7	38.8	58.5
Sunday	06.12.2009	25.5	30.0	1.23	1.45	0.16	0.12	7.7	12.1	36.3	34.1
Monday	07.12.2009	23.7	28.7	1.14	1.39	0.13	0.09	8.8	15.4	42.8	27.1
Tuesday	08.12.2009	21.7	29.0	1.05	1.40	0.16	0.10	6.6	14.0	53.2	57.5
Wednesday	09.12.2009	23.0	28.5	1.11	1.38	0.13	0.08	8.5	17.2	50.3	39.0
Thursday	10.12.2009	25.5	30.0	1.23	1.45	0.13	0.08	9.5	18.1	47.7	44.9
Friday	11.12.2009	25.0	30.5	1.21	1.47	0.13	0.09	9.3	16.4	43.3	48.7
Saturday	12.12.2009	21.5	32.0	1.04	1.55	0.21	0.08	4.9	19.3	74.4	69.8
Sunday	13.12.2009	32.0	36.2	1.55	1.75	0.12	0.11	12.9	15.9	19.0	33.3
Monday	14.12.2009	30.2	32.0	1.46	1.55	0.11	0.08	13.3	19.3	31.4	16.6
Monday	14.12.2009	32.5	33.0	1.57	1.59	0.1	0.11	15.7	14.5	-8.3	18.8
Tuesday	15.12.2009	30.5	31.5	1.47	1.52	0.11	0.11	13.4	13.8	3.2	7.6
Number		18	18	18	18	18	18	18	18	18	17
Minimum		21.5	28.5	1.04	1.38	0.09	0.06	4.9	11.3	-8.3	-32.6
Maximum		32.5	36.2	1.57	1.75	0.21	0.13	15.7	24.6	74.4	69.8
Average		26.0	30.5	1.25	1.48	0.13	0.096	10.1	16.0	34.6	35.5
Std.dev.		3.4	2.0	0.16	0.09	0.03	0.02	3.0	3.2	22.6	24.2

A typical example of progress in the pressure (in, out and transmembrane pressure) can be seen at Figure 7-1 showing a time series plot on 8 December 2009. Just after the back wash had taken place the transmembrane pressure increases and the flow increases as well. But slowly the flow decreases and after about 3 hours the flow stabilizes at about 23 m^3/h and the transmembrane pressure increases to 0.15 bar equal to a specific flux at 7.4 $m^3/(m^2*h*bar)$. Just before the back wash the flux was 6.6 $m^3/(m^2*h*bar)$. The flux varies and just before back wash on 9 December 2009 the flux is 8.5 $m^3/(m^2*h*bar)$. The flux is influenced by the operation of the permanent installed sand filter running in parallel to the CoMeTas filter. The factors that influence the flux are: The blocking of the sand filters (influenced by the number of visitors) and the back wash frequency of the sand filters.

The verification test cannot document the progress in flux caused by blocking of the membrane filter because it is influenced by the operation of the permanent installed sand filters.

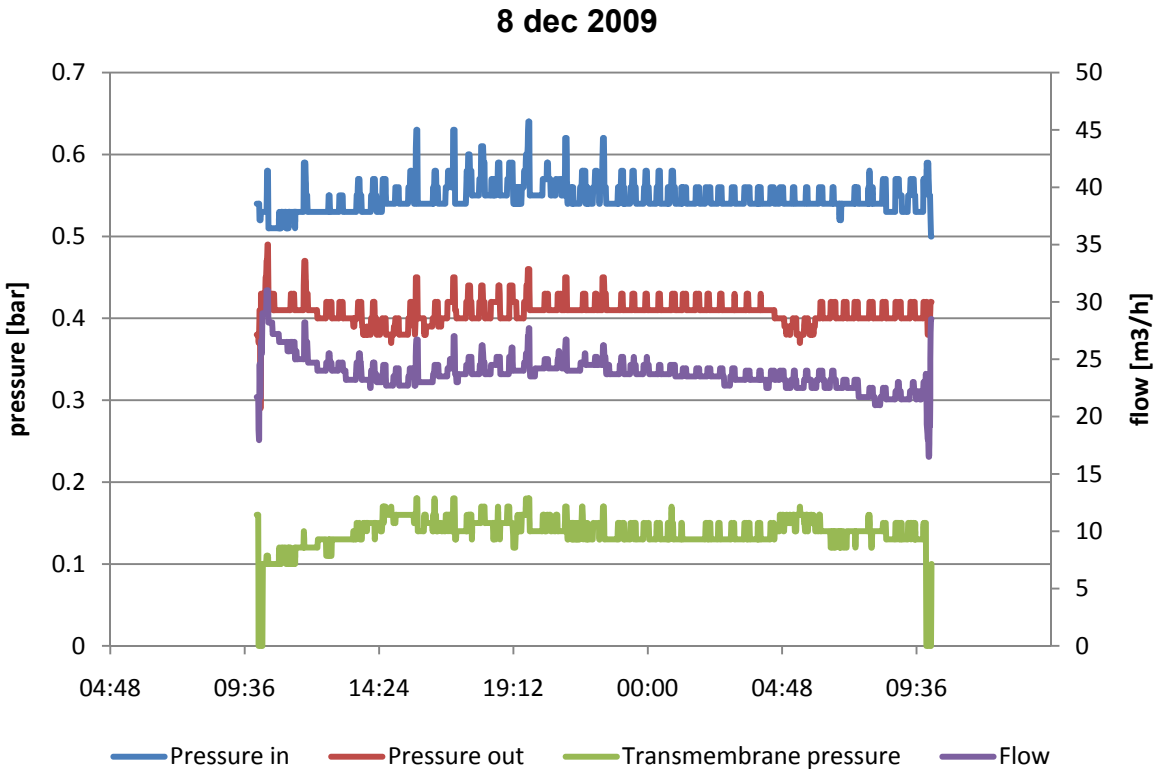


Figure 7-1 Example of data logging of flow, pressure at inlet and outlet and the transmembrane pressure on 8 to 9 December 2009.

The loss in flux (see Table 7-3) is not only due to the blocking of the test filter but also stems from the fact that more or less particles escape from the sand filters and influences the test filter. Other examples of time series plot can be seen in Appendix 7.

7.1.3 Evaluation of back wash

The back wash interval was set to 24 hours. When the back wash starts the water flow to the filter and out of the first filter is stopped. Then the blower starts and the valve for air cleaning opens. After this the water in the filter is discharged to the sewer. The filter is then filled with water and the second filter goes through the same procedure. The whole procedure takes about 10 minutes for all 3 filters.

The duration and the used volume of water for the back wash were measured by manually start of the back wash. On 1 and 10 December 2009 the back wash was started twice and 3 times respectively for the purpose of measuring the volume of the back wash water.

The actually measured time for the back wash – 5 to 13 minutes – appears from Table 2 in Appendix 6. Four times during the test period it was observed that the back wash of the second and the third filter did not start automatically and this meant that the whole back wash cycle was delayed and had to be re-started manually.

When measuring the water volume used for back wash, a back wash cycle was started and the water was collected in a container. Then the volume was estimated by measuring the water depth and the surface area. The average water volume used for back wash was 241 L which appear from Table 7-4 and the duration of the current back washes were 7-9 minutes.

Table 7-4 Volume of back washes.

Day	Date	Time	Volume [L]	Comment
Tuesday	01.12.2009	10:50	170	Manually started back wash
		11:01	390	
Thursday	10.12.2009	10:01	223	Duration of back wash: 9 minutes
		10:37	207	Duration of back wash: 7 minutes
		11:08	215	Duration of back wash: 8 minutes
Average			241	
Minimum			170	
Maximum			390	
Std.dev.			85.7	

7.1.4 Evaluation of water quality

The characterization of the feed water included reading of data from the permanent installed on-line instruments measuring the pH, temperature, ORP, free chlorine and bound chlorine in Gladsaxe Svømmehal. When supervision of the test plant took place the on-line instruments were read and data noted (see Appendix 6, Table 5).

The total microbial counts measured in samples from the feed water showed less counts/mL (on average 4.6 counts/mL) compared to the produced water (on average 12.4 counts/mL) which indicates that microorganisms were accumulated in the filter (see Table 7-5). The relative high counts of microorganisms (460 counts/mL) in the back wash water support the assumption that the microorganisms were accumulated in the filter and partly flushed during back wash.

Table 7-5 Total microbial counts measured in samples taken from the feed water and the produced water. One single sample from the back wash water was analysed.

Date	Method	Sampling before/after back wash	In feed water counts/mL	Out produced water counts/mL	Back wash water counts/mL
12.11.2009	SF 30/810:02	before	<0.5	<0.5	460
12.11.2009	SF 30/810:02	after		<0.5	
30.11.2009	SF 30/816:02	1 hour after	5	20	
01.12.2009	SF 30/816:02	23.5 hours after	<5	15	
09.12.2009	SF 30/816:02	0.5 hours after	10	14	
10.12.2009	SF 30/816:02	23.5 hours after	<5	18	
14.12.2009	SF 30/816:02	0.5 hours after	<5	<5	
15.12.2009	SF 30/816:02	23.5 hours after	5	5	
Minimum			<5	<5	
Maximum			10	18	
Average*			4.6	12.4	

*When the counts were <5, then half the detection limit is used.

Some of the organic particles present in the pool water might be removed by the test plant. This is an advantage since particulate organic carbon might be precursors of unwanted disinfection by-products formed during chlorination. For that reason the TOC concentrations were analysed in the feed water and the produced water.

Table 7-6 shows TOC-concentrations in the feed water and in the produced water. The data show an average based on two analyses per sample. Two data sets differ from the others: The TOC-concentration in the feed water on 14 December 2009 is higher than the mean concentration plus 2 times the standard deviation, and the data set from 8 December 2009 shows a higher TOC-concentration in produced water than in the feed water. When those two data set are excluded the data basis become very small and that is why a statistic test has not been made showing whether the mean values of the TOC in feed water differ from the concentration in the produced water.

Table 7-6 TOC-concentrations measured in samples taken from the feed water and the produced water. The TOC-data are an average value of two measurements on one sample.

Date	Hours after back wash	In TOC µg/l	Out TOC µg/l	In - Out µg/l
30-11-2009	1	3,060	2,960	100
01-12-2009	23.5	3,070	3,010	60
08-12-2009	2	2,945	3,125	-180
09-12-2009	23.5	3,300	3,160	140
14-12-2009	0.5	4,400	3,015	1,385
15-12-2009	23.5	3,025	2,975	50
Average		3,300	3,041	
Minimum		2,870	2,960	
Maximum		4,410	3,170	
Std.dev.		529	79	

Furthermore the pool water was analyzed regarding THM and hardness. Data are found in Table 4 in Appendix 6. In order to prevent fouling of the membranes the feed water

must have a low hardness degree. The pool water was softened by ion exchange and the hardness varied between 0.6 and 4.5 °dH.

7.1.5 Membrane integrity – Rejection of particles

Table 7-7 shows among other data the percentage of particles within three particle size intervals that have been removed by filtration. The test showed that 64% of particles within 1.5-4.99 µm were removed, 79% of particles within 5.00-10.32 µm and 89% of particles within 10.32-20.39 µm were removed. All data on particle counting within the mentioned particle size intervals are found in Appendix 6.

Table 7-7 Summarized particle count data within different particle size intervals (1.5-4.99 µm, 5.00-10.32 µm and 10.33-20.39 µm).

	Feed water			Produced water		
	1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm
Number of counts	66	66	66	65	65	65
Average Number/mL	116	17	26	42	3.6	2.8
Std.dev.	80	12	18	27	3.2	3.3
Min. Number/mL	43	4	4	17	0	0
Max. Number/mL	540	81	103	206	24	25
95% Confidence interval	96-136	14-20	22-31	35-48	2.9-4.4	2.0-3.6
Percentage removed				64	79	89

The data basis includes 6 events and each event consisted of 2 samples taken respectively at 0.5, 1, 2, 4, 22 and 23.5 hours after back wash. The numbers of performed particle counting were 66 for the feed water and 65 for the produced water. Each sample was counted 3 times. The first counting was discharged and a mean value of the particle numbers within the particle size intervals: 1.5-4.99 µm, 5.00-10.32 µm and 10.33-20.39 was calculated.

7.2 Test performance observation

The test plant operated continuously during the verification test; only five smaller interruptions were observed which covered less than 1.7% of the testing time. In this section special observations during test are described.

7.2.1 Characterization of the test site

When the planning of the verification test started it was not possible to find a test site (indoor water complex) where the test could be performed on the whole re-circulated water flow, because swimming pools have to fulfil hygienic and chemical requirement laid down in the Danish legislation. The implication was that the filtration plant was tested on a side stream so that there always was a back-up treatment of the pool water. Testing on a side stream meant that it was not possible to evaluate the long term effect of the filtration on the pool water quality – for instance the changes in the concentration of disinfection by-products (DBP).

During the test run it was not possible to operate the inlet flow or the pressure at the inlet of the filtration plant because these parameters were influenced by operation of the sand filters operated in parallel to the testing plant.

The number of visitors in the pool area varies during the day and during the week which furthermore influences the load of the filters and the number of particles in the feed water. When many visitors are in the pool area then they cause high concentrations of particles in the water and a high particle load of the filter. The lowest measured particle concentration in the feed water was 51 particles per mL and the highest concentration was 740 particles per mL. More than 95% of the particles were less than 20 µm in diameter.

7.2.2 Evaluation of back wash

One of the test conditions was an automatic started back wash procedure every 24 hours. However, the back wash procedure did not start automatically and once a day it was necessary to start the back wash manually. Furthermore the back wash procedure stopped after back wash of the first filter and then again the procedure was started manually. Taking into consideration the difficulties with the back wash procedure it has not been possible to make a real evaluation of the natural advancing clogging of the filter and the effect of automatic back wash on the recovery of flux.

7.2.3 Evaluation water quality

Characterization of the water was not performed with reference to the treatment efficiency based on the fact that the test plant was operated in parallel to the permanent installed sand filters in Gladsaxe Svømmehal and changes in the pool water quality during the test run could not be ascribed to the treatment effect of the test plant. Therefore the analyses of hardness (10 samples), trichlormethan, bromdichlormethan, dibromchlormethan and bromoform (4 samples) and the reading of the on-line instruments (pH, ORP, temperature and free chlorine) only gave information of the composition of the pool water treated in the test plant.

The Danish swimming pool announcement /7/ says that total microbial count at 37°C must be less than 1000 counts/100 mL. The reason for testing the total microbial count was a part of the characterization of the pool water and if bacteria were present then it would be important information concerning the test plants ability to remove bacteria.

When disinfection is included in the water treatment it is not possible to evaluate the removal of microorganisms expected by the filtration. Nearly all microorganisms will be dead and plate counting for numbering the microorganisms is not workable. This was realized when samples from the feed water showed a very low concentration of total microbial count. Test of microorganism removal is not relevant as long as legislative requirements exist on disinfection of pool water.

7.2.4 Membrane integrity – Rejection of particles

The objective of this task was to test the detention of particles in the size intervals: 1.5-4.99, 5.00-10.32 and 10.33-20.39 µm by sampling at the feed water and the produced water. The sampling took place 0.5, 1, 2, 4, 22 and 23.5 hours after back wash. No systematic development in the detention of particles was observed in the interval between two back washes. Add to this samples from the feed water cannot be correlated with specific samples of the produced water and apparently there were no differences between the numbers of particles in samples taken just before and just after back wash. Therefore all the feed water data have been handled together and when it comes to the data concerning produced water it is all the same.

7.3 Amendments to and deviations from test plan

There were no amendments to the test plan. During the testing, deviations were noticed and a list of the deviations is included in Appendix 10.

A P P E N D I C E S

A P P E N D I X 1

Terms and definitions used in the test plan

Word	Explanation
Analytical laboratory	Independent analytical laboratory used to analyze reference samples
Application	The use of a product specified with respect to matrix, target, effect and limitations
AQS	Trademark - AquaSolution
Back washing	Periodic mode which the filter is cleaned by sending pressurized water/air in the reverse direction of filtration
BEK	Bekendtgørelse = Announcement
Cross flow filtration	Filtration mode where membrane flow is re-circulated. The feed passes through a membrane and the solids are trapped in the filter
Dead end filtration	Filtration mode where there is no circulation and the only flow inside the membrane is the feed flow
DBP	Desinfection by-products
DIN	Deutches Institut für Normung
DS	Danish Standard
Feed water	Water introduced to the membrane module
Feed water recovery	Filtrate flow rate divided by the feed water flow rate
Filtrate	Water produced by the membrane filtration process
Flux (water flux)	Rate of product water (flow) through a pressure-driven membrane divided by the total filtration surface area
Fouling	Deposition of organic matter on the membrane surface, which cause inefficiency
Effect	The way the target is affected, in this verification the way the target compounds are measured
EN	European standard
EPA	U.S. Environmental Protection Agency
ETV	Environmental technology verification (ETV) is an independent (third party) assessment of the performance of a technology or a product for a specified application, under defined conditions and adequate quality assurance
EU	European Union
Evaluation	Evaluation of test data for a technology product for performance and data quality
Experts	Independent persons qualified on a technology in verification or on verification as a process
HAA	Halogen Acetic Acid
HAN	Halo Aceto Nitriles
Hardness (water) ºdH	One degree German (ºdH) is defined as 10 milligrams of calcium oxide per liter of water. This is equivalent to 17.848 milligrams of calcium carbonate per litre of water, or 17.848 ppm
ISO	International Standardization Organization
Matrix	The type of material that the product is intended for
Membrane fouling	A reduction of filtrate flux that can be restored by mechanical or chemical means is teemed “reversible” fouling. In contrast “irreversible” fouling is defined as a permanent loss in filtrate flux capacity that cannot be restored. The fouling of membranes designed for particle or microbial removal is primarily attributed to deposition of material on the membrane surface and/or in the membrane pores
Method	Generic document that provides rules, guidelines or characteristics for tests or analysis
MF	Membrane filtration
NSF	NSF International (Public Health and Safety Company)

Word	Explanation
NVOC	Non Volatile Organic Carbon
Performance claim	The effects foreseen by the vendor on the target (s) in the matrix of intended use
Performance parameters	Parameters that can be documented quantitatively in tests and that provide the relevant information on the performance of an environmental technology product
Pool water control	Control of pool water quality against pool water maximum concentrations
Precision	The standard deviation obtained from replicate measurements, here measured under repeatability or reproducibility conditions
(Environmental) product	Ready to market or prototype stage product, process, system or service based upon an environmental technology
QA	Quality assurance
Range of application	The range from the LoD to the highest concentration with linear response
Reference analyses	Analysis by a specified reference method in a laboratory under accreditation (ISO 17025)
Repeatability	The precision obtained under repeatability conditions, that is with the same measurement procedure, same operators, same measuring system, same operating conditions and same location, and replicate measurements on the same or similar objects over a short period of time
Reproducibility	The precision obtained under reproducibility conditions, that is with measurements that includes different locations, operators, measuring systems, and replicate measurements on the same or similar objects
Robustness	% variation in measurements resulting from defined changes in matrix properties
RSD	Relative standard deviation in %
Scaling	The precipitate that forms on surfaces in contact with water as the result of a physical or chemical change
SM	Standard Methods for the Examination of Water and Wastewater, latest edition
SiC	Siliceous carbide
Specific flux (permeability)	Flux divided by transmembrane pressure
Standard	Generic document established by consensus and approved by a recognized standardization body that provides rules, guidelines or characteristics for tests or analysis
Target	The property that is affected by the product, in this verification the target compounds measured
(Environmental) technology	The practical application of knowledge in the environmental area
Test/testing	Determination of the performance of a product by parameters defined for the application
THM	Tri Halo Methan
Transmembrane pressure	Feed stream (average feed/concentrate) pressure (cross flow operating mode) or feed pressure (dead-end operating mode) minus the permeate (product)
UF	Ultrafiltration
Vendor	The party delivering the product or service to the customer
Verification	Evaluation of product performance parameters for a specified application under defined conditions and adequate quality assurance
TOC	Total organic carbon

A P P E N D I X 2

References

/1/ DANETV: CoMeTas AquaSolution AQS-144-800-(2*2) 3 micron. Verification Protocol May 2010 www.etv-denmark.com

/2/ Meike Kramer; Iris Hübner; Klaus Hagen and Lothar Erdinger "Particle Analysis in Swimming Pool Water". Poster Presentation; 2nd International Conference Swimming Pool and Spa Munich 2007

/3/ EPA/NFS ETV Equipment Verification Testing Plan for Removal of Microbiological and Particulate Contaminants by Membrane Filtration, Chapter 2, February 2005

/4/ DS/EN ISO 6222: 2000 Water Quality - Enumeration of cultureable micro-organisms – Colony count by inoculation in a nutrient agar culture medium

/5/ DanETV Centre Quality Manual – Water Technology; version 2 October 2009 www.etv-denmark.com

/6/ DHI Quality System Manual October 2009

/7/ Announcement on swimming pools etc. and these quality. (in Danish) Bekendtgørelse nr. 288 af 14/04/2005: Bekendtgørelse om svømmebassiner m.v. og disses kvalitet

/8/ Gladsaxe Svømmehal; Information about the swimming bath and the re-circulation system given by work manager Jørgen Vienberg

A P P E N D I X 3

Certificate – AccuSizer 780/SIS

Particle Sizing Systems, Inc.
Santa Barbara, Calif., USA

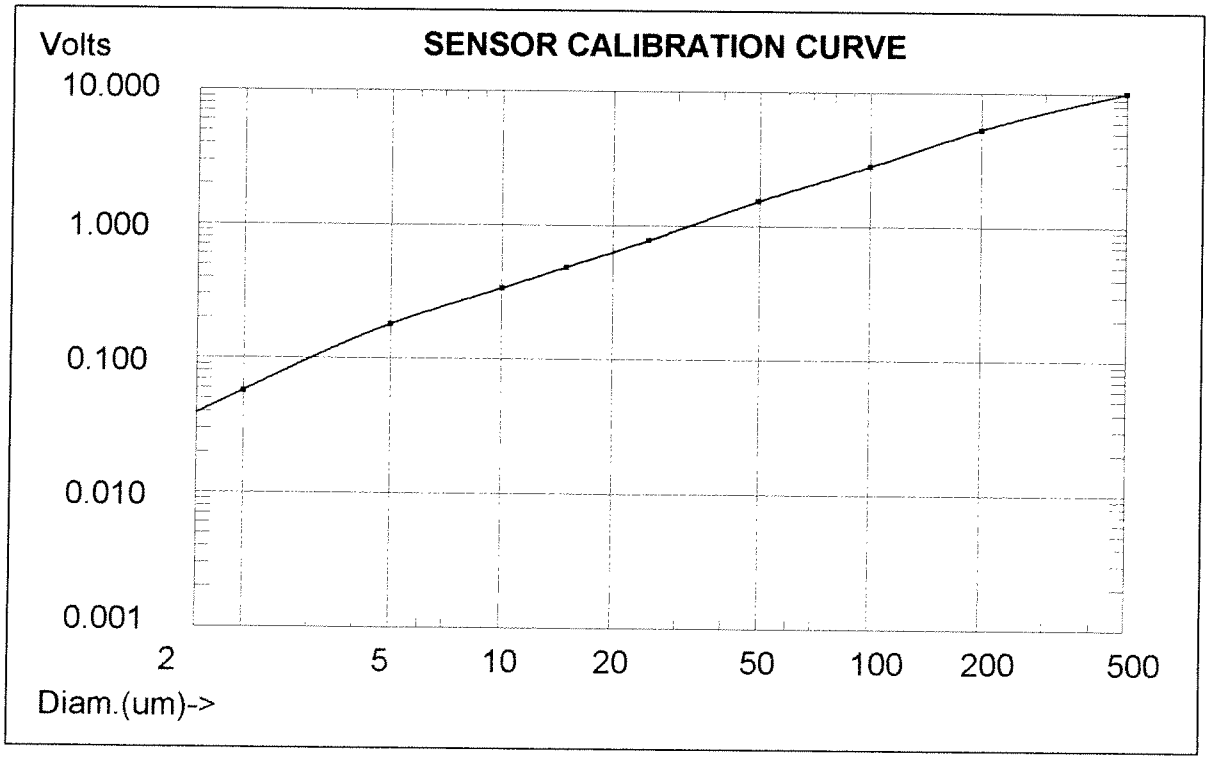
Model 780 AccuSizer

DHI
Sensor File: 0301906e.sns
Sensor Model: LE400-1
Flow Rate: 30 ml/min
EXT Voltage: 15.0 volts

Date: 10-01-09
Serial No: 0301906
Sensor Range: Extinction
SUM Voltage: 15.0 volts

Stnd	Size (um)	Voltage (V)
1	1.998	0.0568
2	4.996	0.1784
3	10.030	0.3352
4	15.020	0.4831
5	25.090	0.7698
6	49.700	1.5198
7	100.000	2.7952
8	200.000	5.3018
9	499.000	9.9999
10	0.000	0.0000
11	0.000	0.0000
12	0.000	0.0000
13	0.000	0.0000
14	0.000	0.0000
15	0.000	0.0000
16	0.000	0.0000

Stnd	Size (um)	Voltage (V)
17	0.000	0.0000
18	0.000	0.0000
19	0.000	0.0000
20	0.000	0.0000
21	0.000	0.0000
22	0.000	0.0000
23	0.000	0.0000
24	0.000	0.0000
25	0.000	0.0000
26	0.000	0.0000
27	0.000	0.0000
28	0.000	0.0000
29	0.000	0.0000
30	0.000	0.0000
31	0.000	0.0000
32	0.000	0.0000



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Sievers*

Certificate of Calibration

Model Number: 800 **Serial Number:** 0311-3345

Calibration Date: 6/4/2009 **Recalibration Date:** 6/4/2010

Note: Calibrations are typically valid for one year from date of installation. However, rough handling or use of samples, or in applications, other than described in the instrument user manual may degrade accuracy and require more frequent calibration.

☐ **Instrument Returned for Recalibration**			
Received --	☐ Within Tolerance	☐ Out of Tolerance	☒ Operational Failure
	☐ Other:		
Returned --	☒ Within Tolerance	☐ Upgraded	☐ Limitations:

TEST	MODEL 800 SPECIFICATION	TEST RESULTS	STANDARDS	STANDARD BATCH NUMBER
DIFFERENCE BETWEEN CHANNELS	≤ 750 ppb	-47.1	25 ppm Carbon as Na2CO3	060609
TOC	24.25-25.75 ppm	25.1	25 ppm Carbon as KHP	061509
ACCURACY VERIFICATION	±5% of TC	1.0 %	500 ppb Carbon as sucrose	070609

Technician Signature: Carl Campbell Date: 6/4/09

Technician's Name (Printed): Carl Campbell

GE Analytical Instruments does hereby certify that the above listed instrument meets or exceeds all manufacturer's published specifications or agreed upon contract concessions. Using GE Analytical Instruments controlled procedures, the instrument has been calibrated using standards whose accuracy is traceable to NIST or have been derived from accepted values of natural physical constants. The calibration environment was 10° to 40° C and <70% RH unless otherwise noted. This certificate is not to be reproduced, except in full, without the written approval of the Director of Quality for GE Analytical Instruments.

A P P E N D I X 4

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Ordrenr.:	460493
Prøvenr.:	10665316
Sagsnr.:	11800378-2
Modt. dato:	2009.12.01
Sidenr.:	1 af 1

ANALYSERAPPORT

Rekvirent.....: DHI, Institut for Vand og Miljø
Agern Alle 5, 2970 Hørsholm
Prøvested.....: **1 time efter returskyl/ EFTER FILTER**
Prøvetype.....: Bassinvand
Prøveudtagning...: 2009.11.30
Prøvetager.....: Rekvirenten (SK)
Kundeoplysninger.:
Analyseperiode...: 2009.12.01 - 2009.12.10

Prøvenr.:	10665316			
Prøve ID:				
Prøvemærke:		Detekt. grænse	Metoder	RSD (%)
Hårdhed, total	**3.9 H grader**	0.5	SM3120-ICP	4.3
Trihalomethaner			*	
Trichlormethan (Chloroform)	**18 µg/l**	0.50	GC-ECD	2
Bromdichlormethan	**5.5 µg/l**	0.10	GC-ECD	4
Dibromchlormethan	**1.4 µg/l**	0.10	GC-ECD	5
Bromoform	**0.16 µg/l**	0.10	GC-ECD	5
Sum af Trihalomethaner	**25 µg/l**	1	GC-ECD	4

*) Ikke omfattet af akkrediteringen.

Tegnforklaring:
RSD : Relativ Analyseusikkerhed.
< : mindre end. i.p.: ikke påvist.
> : større end. i.m.: ikke målelig.
: ingen af parametrene er påvist.

10. december 2009

Anette Nielsen
Kontaktperson

Anette Nielsen
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DHI
Institut for Vand og Miljø
Agern Alle 5
2970 Hørsholm

Att.: Bodil Mose Pedersen

Registernr.:	A44018
Kundenr.:	70498
Ordrenr.:	460493
Prøvenr.:	10665317
Sagsnr.:	11800378-2
Modt. dato:	2009.12.01
Sidenr.:	1 af 1

ANALYSERAPPORT

Rekvirent.....: DHI, Institut for Vand og Miljø
Agern Alle 5, 2970 Hørsholm
Prøvested.....: **23,5 timer efter returskyl/ EFTER FILTER**
Prøvetype.....: Bassinvand
Prøveudtagning...: 2009.12.01
Prøvetager.....: Rekvirenten (SK)
Kundeoplysninger.:
Analyseperiode...: 2009.12.01 - 2009.12.10

Prøvenr.: / Prøve ID: / Prøvemærke:	10665317	Detekt. grænse	Metoder	RSD (%)
Hårdhed, total	**4.0 H grader**	0.5	SM3120-ICP *	4.3
Trihalomethaner				
Trichlormethan (Chloroform)	**21 µg/l**	0.50	GC-ECD	2
Bromdichlormethan	**5.4 µg/l**	0.10	GC-ECD	4
Dibromchlormethan	**1.1 µg/l**	0.10	GC-ECD	5
Bromoform	**0.13 µg/l**	0.10	GC-ECD	5
Sum af Trihalomethaner	**28 µg/l**	1	GC-ECD	4

*) Ikke omfattet af akkrediteringen.

Tegnforklaring:
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> : større end. i.m.: ikke målelig.
: ingen af parametrene er påvist.

10. december 2009

Anette Nielsen
Kontaktperson

Anette Nielsen
Kvalitetssikring

Prøvningsresultaterne gælder udelukkende for de(n) undersøgte prøve(r).
Rapporten må ikke gengives, undtagen i sin helhed, uden prøvningslaboratoriets skriftlige godkendelse.

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Att.: Bodil Mose Pedersen

Registernr.: A46424
Kundenr.: 70498
Ordrenr.: 460493

Modt. dato: 2009.12.17

Sidenr.: 1 af 2

ANALYSERAPPORT

Rekvirent.....: DHI, Institut for Vand og Miljø
Agern Alle 5, 2970 Hørsholm
Prøvested.....:
Prøvetype.....: Bassinvand
Prøveudtagning...:
Prøvetager.....: Rekvirenten (SEK)
Kundeoplysninger.:
Analyseperiode...: 2009.12.17 - 2010.01.04

Prøvenr.:	10665318	10665319	10665320	10665321				
Prøve ID:						Detekt.		RSD
Prøvemærke:					Enheder	grænse	Metoder	(%)
Hårdhed, total	4.5	4.4	0.8	0.6	H grader	0.5	SM3120-ICP	4.3
Calcium (Ca)	24	24	4.6	3.4	mg/l	0.50	SM3120-ICP	15
Magnesium (Mg)	4.8	4.7	0.76	0.54	mg/l	0.10	SM3120-ICP	15

Tegnforklaring:
RSD : Relativ Analyseusikkerhed.
< : mindre end. i.p.: ikke påvist.
> : større end. i.m.: ikke målelig.
: ingen af parametrene er påvist.

A P P E N D I X 5

Microbial analyses – DHI

PRØVEUDTAGNING OG FORBEHANDLING

Prøverne blev udtaget af rekvirenten i 0,5 L flasker udleveret af DHI og leveret på DHI. Alle prøver blev tilsat 1 mL 8% natriumthiosulfat for at reducere frit klor.

ANALYSERESULTAT

Dato	Mærke	Metode	Resultat kim/mL
12-11-2009	Til Pool, før returskyl, Gladsaxe Svømmehal, 11800378	SF 30/810:02	< 0,5
12-11-2009	Fra Pool, før returskyl, efter filter, Gladsaxe Svømmehal, 11800378	SF 30/810:02	< 0,5
12-11-2009	Til Pool, efter returskyl, Gladsaxe Svømmehal, 11800378	SF 30/810:02	< 0,5
12-11-2009	Returskyllevand, Gladsaxe Svømmehal, 11800378	SF 30/810:02	460
30-11-2009	11800378-2, en time efter returskyl/før filter	SF 30/816:02	5
30-11-2009	11800378-2, en time efter returskyl/efter filter	SF 30/816:02	20
01-12-2009	11800378-2, 23.5 timer efter returskyl/før filter	SF 30/816:02	< 5
01-12-2009	11800378-2, 23.5 timer efter returskyl/efter filter	SF 30/816:02	15
09-12-2009	11800378-2, Cometas 0,5 time efter returskyl/før filter	SF 30/816:02	10
09-12-2009	11800378-2, Cometas 0,5 time efter returskyl/efter filter	SF 30/816:02	14
10-12-2009	11800378-2, 23.5 timer efter returskyl/før filter	SF 30/816:02	< 5
10-12-2009	11800378-2, 23.5 timer efter returskyl/efter filter	SF 30/816:02	18
14-12-2009	Cometas 0,5 time efter returskyl/før filter	SF 30/816:02	< 5
14-12-2009	Cometas 0,5 time efter returskyl/efter filter	SF 30/816:02	< 5
15-12-2009	Cometas 23,5 time efter returskyl/før filter	SF 30/816:02	5
15-12-2009	Cometas 23,5 time efter returskyl/efter filter	SF 30/816:02	5

A P P E N D I X 6

Test data – tables

Table 1: Summary of back washes during the test and duration of the back wash process or processes.

Week day	Date	Back wash Start Time	Back wash Stop Time	Duration Back wash minutes	Comment	Supervision by DHI
Sunday	29.11.2009	18:46 19:21	18:54 19:29	00:08 00:08		
Monday	30.11.2009	09:50	09:59	00:09	The 3rd filter did not open automatically. Manually started back washes	X
Tuesday	01.12.2009	10:49 11:05	11:01 11:40	00:12 00:35	Manually started back washes	X
Wednesday	02.12.2009	11:47	11:54	00:07		
Thursday	03.12.2009	10:00 10:10 10:18	10:06 10:20 10:31	00:06 00:10 00:13	The 2nd and 3rd filter did not open automatically. Manual started back washes	X
Friday	04.12.2009	10:18	10:31	00:13	Power cut-off between 3 and 4 Dec. 21:47-01:34 for installation of new relay. No automatic back wash. Manually started back washes	X
Saturday	05.12.2009	12:38 14:02 17:30	12:46 14:07 17:38	00:08 00:05 00:08		
Sunday	06.12.2009	13:46	14:13	00:27		
Monday	07.12.2009	10:07	11:20	01:13		
Tuesday	08.12.2009	10:07	10:14	00:07	Manually started back washes	X
Wednesday	09.12.2009	09:57	10:07	00:10	No automatic back wash. Manually started back washes	X
Thursday	10.12.2009	10:17 10:25 10:56	10:23 10:33 11:04	00:06 00:08 00:08	Manually started back washes for measurement of back wash volume	X
Friday	11.12.2009	11:52	12:00	00:08		
Saturday	12.12.2009	14:46	16:56		Difficulties concerning measurements of pressure	
Sunday	13.12.2009	18:23	18:31	00:08		
Monday	14.12.2009	10:13 10:21 14:33 16:09	10:19 10:23 16:05 16:10	00:06 00:02 01:32 00:01	No automatic back wash. Manually started back washes Last sampling for particle counting 14:32	X
Tuesday	15.12.2009	09:58 10:37	10:18 10:44	00:20 00:07	No automatic back wash. Manually started back washes	X

Table 2: Flow reading on the flow meters measuring the flow passing the filter plant (filter) and the flow that re-circulates over the warm water pool (GS).

Week day	Date	Time	Flow filter m^3/h	Flow GS m^3/h	Ratio %	Comment
Monday	30.11.2009	10:00	29	81.5	35.6	
Tuesday	01.12.2009	08:00	25.9	83.6	31.0	
		09:30	24.96	81.6	30.6	
		11:10	30.16	83.8	36.0	
Wednesday	02.12.2009					
Thursday	03.12.2009	10:00	26.27	83.9	31.3	Before back wash
		10:25	30.91	83.9	36.8	After back wash
		10:55	30.02	81.3	36.9	
		11:25	29.65	81.4	36.4	
		12:25	29.05	81.3	35.7	
Friday	04.12.2009	08:24	23.4	85.1	27.5	
		09:54	23.9	85.3	28.0	
		10:35	23.79	85.5	27.8	Before back wash
		10:40	28.1	84.4	33.3	After back wash
Saturday	05.12.2009					
Sunday	06.12.2009					
Monday	07.12.2009					
Tuesday	08.12.2009	10:29	30.9	91.4	33.8	
		10:42	27.66	91	30.4	
		11:10	26.3	81.7	32.2	
		12:10	24.4	81.1	30.1	
		14:10	22.94	80.9	28.4	
Wednesday	09.12.2009	08:18	21.85	82.7	26.4	
		09:40	22.45	81.5	27.5	
		10:40	28.49	82.3	34.6	
		11:10	28.1	83.2	33.8	
		12:10	25.94	84.3	30.8	
		14:10	25.04	83.7	29.9	
Thursday	10.12.2009					
Friday	11.12.2009					
Saturday	12.12.2009					
Sunday	13.12.2009					
Monday	14.12.2009	10:15	26.87	80.6	33.3	Before back wash
		10:45	32.6	83	39.3	0.5 h after back wash
		11:15	32.52	83.2	39.1	1 h after back wash
		12:15	32.97	84.1	39.2	2 h after back wash
		14:15	32.45	81.6	39.8	4 h after back wash
Tuesday	15.12.2009	08:26	31.04	84.9	36.6	
		09:46	29.72	81.3	36.6	
		10:50	31.43	82	38.3	
		11:17	32.6	81.8	39.9	
		11:47	32.67	82.5	39.6	
		12:47	32.96	81.7	40.3	
		14:57	32.99	81.3	40.6	
Wednesday	16.12.2009	09:08	29.67	82.4	36.0	
		10:17	29.2	81	36.0	
Count			38	38	38	
Minimum			21.85	80.6	26.4	
Maximum			33.99	91.4	40.6	
Average			28.4	83.1	34.2	
Std.dev.			3.4	2.4	4.3	

Table 3: Flow, pressure, flux, specific fllux measured 3 minutes before back wash and after back wash. The recovery and loss of flux is calculated. Membrane area 3 * 6.9 m^2 = 20.7 m^3.

Week day	Date	Back wash Start Time	Back wash Stop Time	Flow [m^3/h] 3 min before back wash	Flow [m^3/h] 3 min after back wash	Flux [m^3/m^2*h] Before back wash	Flux [m^3/m^2*h] After back wash	Transmembrane pressure [bar] Before back wash	Transmembrane pressure [bar] After back wash	Specific flux [$m^3/m^2*h*bar$] Before back wash	Specific flux [$m^3/m^2*h*bar$] After back wash	Recovery %	Loss of flux %
Sunday	29.11.2009	18:46	18:54	25.5	30.5	1.23	1.47	0.11	0.13	11.20	11.33	1.2	
		19:21	19:29										
Monday	30.11.2009	09:50	09:59	28	28.7	1.35	1.39	0.09	0.09	15.03	15.41	2.4	-32.6
Tuesday	01.12.2009	10:49	11:01	25.2	30.5	1.22	1.47	0.12	0.06	10.14	24.56	58.7	34.1
		11:05	11:40										
Wednesday	02.12.2009	11:47	11:54	25.7	29.5	1.24	1.43	0.13	0.09	9.55	15.83	39.7	61.1
Thursday	03.12.2009	10:00	10:06	25.7	31.5	1.24	1.52	0.13	0.10	9.55	15.22	37.2	39.7
		10:10	10:20										
		10:18	10:31										
Friday	04.12.2009	10:18	10:31	23.7	28.5	1.14	1.38	0.14	0.08	8.18	17.21	52.5	46.3
Saturday	05.12.2009	12:38	12:46	22.2	29	1.07	1.40	0.15	0.12	7.15	11.67	38.8	58.5
		14:02	14:07										
		17:30	17:38										
Sunday	06.12.2009	13:46	14:13	25.5	30	1.23	1.45	0.16	0.12	7.70	12.08	36.3	34.1
Monday	07.12.2009	10:07	11:20	23.7	28.7	1.14	1.39	0.13	0.09	8.81	15.41	42.8	27.1
Tuesday	08.12.2009	10:07	10:14	21.7	29	1.05	1.40	0.16	0.10	6.55	14.01	53.2	57.5
Wednesday	09.12.2009	09:57	10:07	23	28.5	1.11	1.38	0.13	0.08	8.55	17.21	50.3	39.0
Thursday	10.12.2009	10:17	10:23	25.5	30	1.23	1.45	0.13	0.08	9.48	18.12	47.7	44.9
		10:25	10:33										
		10:56	11:04										
Friday	11.12.2009	11:52	12:00	25	30.5	1.21	1.47	0.13	0.09	9.29	16.37	43.3	48.7
Saturday	12.12.2009	14:46	16:56	21.5	32	1.04	1.55	0.21	0.08	4.95	19.32	74.4	69.8
Sunday	13.12.2009	18:23	18:31	32	36.2	1.55	1.75	0.12	0.11	12.88	15.90	19.0	33.3
Monday	14.12.2009	10:13	10:19	30.2	32	1.46	1.55	0.11	0.08	13.26	19.32	31.4	16.6
		10:21	10:23										
		14:33	16:05	32.5	33	1.57	1.59	0.10	0.11	15.70	14.49	-8.3	18.8
		16:09	16:10										
Tuesday	15.12.2009	09:58	10:18	30.5	31.5	1.47	1.52	0.11	0.11	13.39	13.83	3.2	7.6
		10:37	10:44										
Wednesday	16.12.2009	11:36	00:19										
Number				18	18	18	18	18	18	18	18	18	17
Minimum				21.5	28.5	1.04	1.38	0.09	0.06	5	11	-8.3	-32.6
Maximum				32.5	36.2	1.57	1.75	0.21	0.13	16	25	74.4	69.8
Average				26.0	30.5	1.25	1.48	0.13	0.10	10	16	34.6	35.5
Std.dev.				3.4	2.0	0.16	0.09	0.03	0.02	3.0	3.2	22.6	24.2

Table 4: Quality of the pool water. Samples taken after the filter.

Day	Date	Time sampling	Hardness Total °H	Trichlor-methan µg/l	Brom-dichlormethan µg/l	Dibrom-chlormethan µg/l	Bromo-form µg/l	Sum THM µg/l
Detection limit			0.5	0.5	0.10	0.10	0.10	1
Requirement								50
Monday	30.11.2009		3.9	18	5.5	1.4	0.16	25
Tuesday	01.12.2009		4.0	21	5.4	1.1	0.13	28
Wednesday	02.12.2009							
Thursday	03.12.2009	11:01	4.5					
Friday	04.12.2009	09:56	4.4					
Saturday	05.12.2009							
Sunday	06.12.2009							
Monday	07.12.2009							
Tuesday	08.12.2009	12:10	0.8					
Wednesday	09.12.2009	10:10	0.6					
Thursday	10.12.2009	09:42	0.7					
Friday	11.12.2009							
Saturday	12.12.2009							
Sunday	13.12.2009							
Monday	14.12.2009	10:50	2.1	26	2.5	0.23	<0.1	29
Tuesday	15.12.2009	09:46	2.2	27	2.7	0.26	<0.1	30
Friday	16.12.2009	09:30	2.6					
Count			10	4	4	4	4	4
Min			0.6	18	2.5	0.23	0.13	25
Max			4.5	27	5.5	1.4	0.16	30
Average			2.6	23	4.0	0.75	0.15	28
Std.dev.			1.6	4.2	1.6	0.6	0.0	2.2

Table 5: Reading of on-line meters measuring pH, ORP (oxidation reduction potential), temperature and free chlorine in Gladsaxe Svømmehal.

Day	Date	Time	pH	Redox mV	Temperature °C	Free chlorine mg/l
Requirement			6.7-7.4			0.5-2.0
Monday	30.11.2009	10:00	6.99	744	33.2	1.14
		11:00	7.01	740	33.2	1
		12:00	6.98	736	33.2	1.1
		14:00	7.01	734	33.3	1.22
Tuesday	01.12.2009	08:00	7.03	738	33	1.05
		09:30	7.01	740	32.8	1.14
		11:10	7.00	741	32.9	1.07
Wednesday	02.12.2009					
Thursday	03.12.2009	10:00	6.98	749	33	1.02
		10:55	7.02	744	33	1.2
		11:24	6.97	746	33	1.16
		12:24	7.04	742	32.9	1.31
		14:24	6.96	741	33	1.06
Friday	04.12.2009	08:24	6.93	705	32.1	1.14
		09:54	7.02	720	32.2	1.04
		10:34	7.02	722	32.3	1
		10:40	7.03	724	32.4	0.98
Saturday	05.12.2009					
Sunday	06.12.2009					
Monday	07.12.2009					
Tuesday	08.12.2009	10:30	7.01	736	32.9	0.92
		10:40	7.04	734	32.9	1.47
		11:10	7.01	737	32.9	1.13
		12:10	6.99	733	32.9	1.23
		14:10	7.00	729	33	1.1
Wednesday	09.12.2009	08:19	7.01	728	33	1.07
		09:40	7.02	730	32.8	1.19
		10:40	7.00	732	32.7	1.21
		11:10	7.02	730	32.7	1.17
		12:10	7.01	726	32.9	1.07
		14:10	7.00	731	33	1.15
Thursday	10.12.2009	08:20	7.36	697	32.9	1.09
		09:40	7.04	714	32.8	1.01
		10:00	7.04	715	32.9	1.16
		10:11	7.01	717	33.9	1.05
Friday	11.12.2009					
Saturday	12.12.2009					
Sunday	13.12.2009					
Monday	14.12.2009	10:15	7.02	730	32.9	1.24
		10:45	7.00	731	32.9	1.06
		11:15	7.01	730	32.9	1.05
		12:15	7.00	726	32.9	1.04
		14:15	7.01	724	32.9	1.04
Tuesday	15.12.2009	08:26	7.02	726	32.9	1.02
		09:46	7.01	729	32.9	1.1
		10:50	7.02	729	33	1.15
		11:17	7.02	729	32.9	1.23
		11:47	7.01	729	32.9	1.2
		12:47	7.01	725	32.9	1.21
		14:57	7.00	722	32.7	1.13

Table (continued)

Day	Date	Time	pH	Redox mV	Temperature °C	Free chlorine Mg l
Requirement			6.7-7.4			0.5-2.0
Friday	16.12.2009	09:08	7.00	731	32.7	1.07
		10:17	7.00	733	32.8	1.13
Number			45	45	45	45
Average			7.02	730	32.9	1.12
Minimum			6.93	697	32.1	0.92
Maximum			7.36	749	33.9	1.47
Std.dev.			0.06	10.2	0.3	0.10

Table 6: TOC analysed in samples taken before (in) and after (out) the filter.

Date	Hours after back wash	In TOC µg/l	Out TOC µg/l
30-11-2009	1	3,050	2,960
	1	3,070	2,960
01-12-2009	23.5	3,030	3,010
	23.5	3,110	3,010
08-12-2009	2	2,870	3,130
	2	3,020	3,120
09-12-2009	23.5	3,390	3,150
	23.5	3,210	3,170
14-12-2009	0.5	4,390	3,020
	0.5	4,410	3,010
15-12-2009	23.5	3,030	2,990
	23.5	3,020	2,960
Count		12	12
Average		3,300	3,041
Minimum		2,870	2,960
Maximum		4,410	3,170
Std.dev.		529	79

Table 7: TOC-analyses from initial operational runs

Sampling point	Date	TOC inlet mg/l	TOC outlet mg/l
Before back wash	12.11.2009	3.43	3.44
After back wash	12.11.2009		3.09
Before back wash	20.11.2009	2.8	2.85
Before back wash	20.11.2009	2.82	2.85
After back wash	20.11.2009	2.81	2.84
After back wash	20.11.2009	2.85	2.86

Table 8: Manually started back washes and measured water volume for back wash of the three filters.

Day	Date	Time	Volume	Comment
Tuesday	01.12.2009	10:50	170	Manually started back wash
		11:01	390	
Thursday	10.12.2009	10:01	223	Duration of back wash: 9 minutes
		10:37	207	Duration of back wash: 7 minutes
		11:08	215	Duration of back wash: 8 minutes
Average			241	
Minimum			170	
Maximum			390	
Std.dev.			85.7	

Table 9: Overview of samples taken for particle counting during the test.

Hours after back wash	Monday 30.11 file	file	Tuesday 01.12 file	file	Thursday 03.12 file	file	Friday 04.12 file	file
in								
0.5	3011-09a	3011-09b			0312-25a	0312-25b		
1	3011-11a	3011-11b			0312-27a	0312-27b		
2	3011-13a	3011-13b			0312-29a	0312-29b		
4	3011-15a	3011-15b			0312-31a	0312-31b		
22			0112-17a	0112-17b			0412-33a	0412-33b
23.5			0112-19a	0112-19b			0412-36a	0412-36b
out								
0.5	3011-10a	3011-10b			0312-24a	0312-24b		
1	3011-12a	3011-12b			0312-26a	0312-26b		
2	3011-14a	3011-14b			0312-28a	0312-28b		
4	3011-16a	3011-16b			0312-30a	0312-30b		
22			0112-18a	0112-18b			0412-32a	0412-32b
23.5			0112-20a	0112-20b			0412-35a	0412-35b
	Tuesday 08.12 file	file	Wednesday 09.12 file	file	Wednesday 09.12 file	file	Thursday 10.12 file	file
in								
0.5	0812-38a	0812-38b			0912-50a	0912-50b		
1	0812-40a	0812-40b			0912-52a	0912-52b		
2	0812-42a	0812-42b			0912-54a	0912-54b		
4	0812-44a	0812-44b			0912-56a	0912-56b		
22			0912-46a	0912-46b			1012-58a	1012-58b
23.5			0912-48a	0912-48b			1012-60a	1012-60b
out								
0.5	0812-37a	0812-37b			0912-49a	0912-49b		
1	0812-39a	0812-39b			0912-51a	0912-51b		
2	0812-41a	0812-41b			0912-53a	0912-53b		
4	0812-43a	0812-43b			0912-55a	0912-55b		
22			0912-45a	0912-45b			1012-57a	1012-57b
23.5			0912-47a	0912-47b			1012-59a	1012-59b
	Monday 14.12 file	file	Tuesday 15.12 file	file	Tuesday 15.12 file	file	Wednesday 16.12 file	file
in								
0.5	1412-64a	1412-64b			1512-77a	1512-77b		
1	1412-66a	1412-66b			1512-79a	1512-79b		
2	1412-68a	1412-68b			1512-81a	1512-81b		
4	1412-70a	1412-70b			1512-83a	1512-83b		
22			1512-72a	1512-72b			1612-85a	1612-85b
23.5			1512-74a	1512-74b			1612-87a	1612-87b
out								
0.5	1412-63a	1412-63b			1512-76a	1512-76b		
1	1412-65a	1412-65b			1512-78a	1512-78b		
2	1412-67a	1412-67b			1512-80a	1512-80b		
4	1412-69a	1412-69b			1512-82a	1512-82b		
22			1542-71a	1542-71b			1612-84a	1612-84b
23.5			1542-73b	1542-73a			1612-86a	1612-86b

Table 10: Particle size distribution concentrations (1.5-4.99 µm, 5.00-10.32 µm and 10.33-20.39 µm) in feed water and produced water. Percent of removed particles is calculated. Date from 30.11.2009 – 01.12.2009 and 03.12.2009 to 04.12.2009.

Date	Time	Hour after back wash 09:56	Sample in	Number of particles per mL - in 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Time	Sample out	Number of particles per mL - out 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Percent removed particles 1.5-4.99 µm %	5.00-10.32 µm %	10.33-20.39 µm %	Total %
30-11-2009	10:30	0.5	3011-09a	542	81	103	740	10:44	3011-10a	141	18	10	171	74	78	91	77
30-11-2009	10:36	0.5	3011-09b	153	33	78	276	10:47	3011-10b	26	2	2	30	83	94	98	89
30-11-2009	11:00	1	3011-11a	194	33	59	294	11:15	3011-12a	46	4	5	55	76	86	92	81
30-11-2009	11:07	1	3011-11b	124	24	47	202	11:22	3011-12b	94	10	8	113	24	56	84	44
30-11-2009	12:00	2	3011-13a	83	18	40	148	12:12	3011-14a	30	4	4	39	63	79	90	74
30-11-2009	12:06	2	3011-13b	86	18	39	153	12:20	3011-14b	34	3	3	41	60	83	92	73
30-11-2009	14:00	4	3011-15a	75	13	22	115	14:11	3011-16a	32	3	3	39	58	75	84	66
30-11-2009	14:06	4	3011-15b	100	18	21	144	14:17	3011-16b	68	10	6	85	32	43	70	41
01-12-2009	08:00	22	0112-17a	321	43	32	401	08:15	0112-18a	59	7	9	77	82	83	72	81
01-12-2009	08:07	22	0112-17b	97	10	14	124	08:22	0112-18b	46	6	2	55	52	44	83	56
01-12-2009	09:30	23.5	0112-19a	201	23	23	250	09:48	0112-20a	26	3	3	33	87	87	86	87
01-12-2009	09:40	23.5	0112-19b	83	11	20	117	09:54	0112-20b	57	7	5	71	31	34	74	40
Average				171	27	42	247			55	7	5	67	68	76	88	73
Minimum				75	10	14	115			26	2	2	30				
Maximum				542	81	103	740			141	18	10	171				
Std.dev.				137.0	19.7	26.7	178.4			33.7	4.5	2.6	40.8				

Date	Time	Hour after back wash	Sample in	Number of particles per mL - in 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Time	Sample out	Number of particles per mL - out 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Percent removed particles 1.5-4.99 µm %	5.00-10.32 µm %	10.33-20.39 µm %	Total %
03-12-2009	10:56	0.5	0312-25a	99	15	37	158	11:08	0312-24a	63	4	3	71	36	74	91	55
03-12-2009	11:01	0.5	0312-25b	95	17	40	157	11:13	0312-24b	40	5	7	52	58	69	83	67
03-12-2009	11:24	1	0312-27a	115	21	46	188	11:32	0312-26a	50	4	4	60	56	81	90	68
03-12-2009	11:29	1	0312-27b	111	23	50	190	11:37	0312-26b	36	3	3	43	68	88	94	78
03-12-2009	12:24	2	0312-29a	122	21	51	203	12:33	0312-28a	51	7	3	61	58	68	94	70
03-12-2009	12:29	2	0312-29b	99	16	39	160	12:38	0312-28b	25	3	3	31	74	85	92	80
03-12-2009	14:24	4	0312-31a	188	31	51	278	14:42	0312-30a	17	1	1	20	91	95	98	93
03-12-2009	14:32	4	0312-31b	156	27	44	235	14:49	0312-30b	24	2	2	27	85	94	96	88
04-12-2009	08:24	22	0312-33a	129	24	20	177	08:38	0312-32a	46	6	3	55	65	75	85	69
04-12-2009	08:35	22	0312-33b	100	13	14	130	08:50	0312-32b	54	6	3	64	46	55	76	51
04-12-2009	09:54	23.5	0312-36a	169	27	43	247	10:06	0312-35a	43	3	2	48	75	90	95	81
04-12-2009	10:00	23.5	0312-36b	167	28	48	251	10:11	0312-35b	38	2	2	42	77	92	97	83
Average				129	22	40	198			41	4	3	48	69	83	93	76
Minimum				95	13	14	130			17	1	1	20				
Maximum				188	31	51	278			63	7	7	71				
Std.dev.				32.7	5.6	12.1	45.7			13.4	1.8	1.5	15.5				

Table 11: Particle size distribution concentrations (1.5-4.99 µm, 5.00-10.32 µm and 10.33-20.39 µm) in feed water and produced water. Percent of removed particles is calculated. Date from 08.12.2009 – 09.12.2009 and 09.12.2009 to 10.12.2009.

Date	Time	Hour after back wash	Sample in	Number of particles per mL - inl 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Time	Sample out	Number of particles per mL - out 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Percent removed particles 1.-4.99 µm %	5.00-10.32 µm %	10.33-20.39 µm %	Total %
08-12-2009	10:58	0.5	0812-38a	119	16	18	157	10:42	0812-37a	76	7	3	87	36	55	83	45
08-12-2009	11:05	0.5	0812-38b	199	29	20	252	10:56	0812-37a	63	4	2	69	69	86	91	73
08-12-2009	11:21	1	0812-40a	110	15	18	146	11:12	0812-39a	24	2	1	28	78	86	94	81
08-12-2009	11:28	1	0812-40b	116	18	23	161	11:19	0812-39b	35	3	2	40	70	84	90	75
08-12-2009	12:19	2	0812-42a					12:10	0812-41a								
08-12-2009	12:24	2	0812-42b	69	9	14	96	12:16	0812-41b	25	2	2	29	64	75	87	69
08-12-2009	14:20	4	0812-44a	313	39	43	404	14:10	0812-43a	206	24	25	26	34	39	42	94
08-12-2009	14:25	4	0812-44b	289	40	45	381	14:17	0812-43b	95	5	3	104	67	88	93	73
09-12-2009	08:27	22	0912-46a				110	08:18	0912-45a								
09-12-2009	08:34	22	0912-46b				65	08:26	0912-45b								
09-12-2009	09:49	23.5	0912-48a				67	09:40	0912-47a								
09-12-2009	09:56	23.5	0912-48b				73	09:48	0912-47b								
Average				174	24	26	174			75	7	6	55	57	72	79	69
Minimum				69	9	14	65			24	2	1	26				
Maximum				313	40	45	404			206	24	25	104				
Std.dev.				95.6	12.2	12.6	121.1			63.9	7.7	8.7	31.8				

Date	Time	Hour after back wash	Sample in	Number of particles per mL - in 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Time	Sample out	Number of particles per mL - out 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Percent removed particles 1.5-4.99 µm %	5.00-10.32 µm %	10.33-20.39 µm %	Total %
09-12-2009	10:48	0.5	0912-50a	49	5	6	60	10:40	0912-49a	33	3	2	38	32	44	73	37
09-12-2009	10:53	0.5	0912-50b	43	4	4	51	10:45	0912-49b	23	2	1	27	45	47	63	48
09-12-2009	11:17	1	0912-52a	55	8	12	77	11:10	0912-51a	29	3	2	34	47	63	84	55
09-12-2009	11:25	1	0912-52b	74	10	19	106	11:15	0912-51b	25	2	1	29	66	76	95	73
09-12-2009	12:24	2	0912-54a	77	10	19	108	12:10	0912-53a	47	5	4	56	39	48	81	49
09-12-2009	12:29	2	0912-54b	74	10	16	104	12:20	0912-53b	33	1	2	36	56	89	90	65
09-12-2009	14:21	4	0912-56a	56	6	7	71	14:10	0912-55a	34	3	2	40	39	48	75	44
09-12-2009	14:27	4	0912-56b	80	9	10	100	14:17	0912-55b	54	5	5	64	33	47	49	36
10-12-2009	08:30	22	1012-58a	96	12	8	118	08:17	1012-57a	29	2	1	33	69	83	91	72
10-12-2009	08:36	22	1012-58b	83	8	6	99	08:25	1012-57b	37	3	1	42	55	62	82	58
10-12-2009	09:51	23.5	1012-60a	95	17	28	146	09:40	1012-59a	41	4	3	48	56	78	90	67
10-12-2009	09:57	23.5	1012-60b	95	14	26	139	09:49	1012-59b	27	3	1	32	72	78	95	77
Average				73	9	13	98			34	3	2	40	53	68	85	60
Minimum				43	4	4	51			23	1	1	27				
Maximum				96	17	28	146			54	5	5	64				
Std.dev.				18.6	3.8	8.0	29.1			9.1	1.1	1.3	11.1				

Table 12: Particle size distribution concentrations (1.5-4.99 µm, 5.00-10.32 µm and 10.33-20.39 µm) in feed water and produced water. Percent of removed particles is calculated. Date from 14.12.2009 – 15.12.2009 and 15.12.2009 to 16.12.2009.

Date	Time	Hour after back wash	Sample in	Number of particles per mL - in 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Time	Sample out	Number of particles per mL - out 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Percent removed particles 1.5-4.99 µm %	5.00-10.32 µm %	10.33-20.39 µm %	Total %
14-12-2009	11:02	0,5	1412-64a	80	12	15	110	10:46	1412-63a								
14-12-2009	11:07	0,5	1412-64b	89	11	16	119	10:56	1412-63b	81	7	7	102	9	32	55	14
14-12-2009	11:24	1	1412-66a	76	11	15	106	11:16	1412-65a	71	8	4	83	6	30	76	22
14-12-2009	11:31	1	1412-66b	80	12	18	113	11:22	1412-65b	36	7	6	49	55	39	64	57
14-12-2009	12:24	2	1412-68a	59	9	19	91	12:16	1412-67a	18	1	1	21	69	86	93	77
14-12-2009	12:30	2	1412-68b	56	9	17	86	12:22	1412-67b	32	5	6	43	43	49	66	50
14-12-2009	14:28	4	1412-70a	196	28	37	267	14:16	1412-69a	32	1	1	34	84	96	98	87
14-12-2009	14:32	4	1412-70b	181	25	36	247	14:27	1412-69b	41	1	1	44	77	95	97	82
15-12-2009	08:33	22	1512-72a	63	7	6	78	08:21	1512-71a								
15-12-2009	08:39	22	1512-72b	60	6	6	73	08:28	1512-71b	23	2	3	28	62	64	55	62
15-12-2009	09:53	23,5	1512-74a	78	11	14	106	09:47	1512-73a	24	2	2	28	69	85	87	74
15-12-2009	09:59	23,5	1512-74b	70	9	14	96	09:52	1512-73b	24	2	1	28	65	80	91	71
Average				91	13	18	124			38	4	3	46	58	71	82	63
Minimum				56	6	6	73			18	1	1	21				
Maximum				196	28	37	267			81	8	7	102				
Std. dev.				46.7	6.7	9.7	63.7			21.2	2.9	2.5	26.5				

	Time	Hour after back wash	Sample in	Number of particles per mL -in 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Time	Sample out	Number of particles per mL - out 1.5-4.99 µm	5.00-10.32 µm	10.33-20.39 µm	Total	Percent removed particles 1.5-4.99 µm %	5.00-10.32 µm %	10.33-20.39 µm %	Total %
15-12-2009	11:27	0,5	1512-77a	65	8	15	91	11:17	1512-76a	22	1	0	24	66	86	98	74
15-12-2009	11:32	0,5	1512-77b	86	11	17	118	11:52	1512-76b	22	0	1	23	75	97	97	81
15-12-2009	11:56	1	1512-79a	86	11	21	122	11:47	1512-78a	28	2	2	31	68	85	92	74
15-12-2009	12:01	1	1512-79b	62	8	18	92	11:52	1512-78b	20	1	0	22	68	88	99	77
15-12-2009	12:54	2	1512-81a	52	4	12	71	12:47	1512-80a	23	1	0	24	57	87	96	66
15-12-2009	12:59	2	1512-81b	51	7	13	74	12:52	1512-80b	21	1	0	22	59	92	98	71
15-12-2009	14:55	4	1512-83a	101	12	15	131	14:47	1512-82a	66	6	4	76	35	51	71	42
15-12-2009	15:01	4	1512-83b	105	14	22	145	14:52	1512-82b	38	2	1	41	63	87	95	72
16-12-2009	09:19	22	1612-85a	102	13	26	146	09:10	1612-84a	52	5	3	60	49	60	90	59
16-12-2009	09:25	22	1612-85b	91	9	20	123	09:16	1612-84b	44	4	3	51	51	57	85	58
16-12-2009	10:26	23,5	1612-87a	63	8	12	86	10:27	1612-86a	22	1	1	24	66	90	91	72
16-12-2009	10:30	23,5	1612-87b	60	9	9	80	10:24	1612-86b	44	4	3	51	27	57	72	37
Average				77	10	17	107			33	2	1	37	57	77	91	65
Minimum				51	4	9	71			20	0	0	22				
Maximum				105	14	26	146			66	6	4	76				
Std. dev.				20.2	2.7	4.9	27.2			15.2	2.0	1.3	18.3				

A P P E N D I X 7

Test data – figures

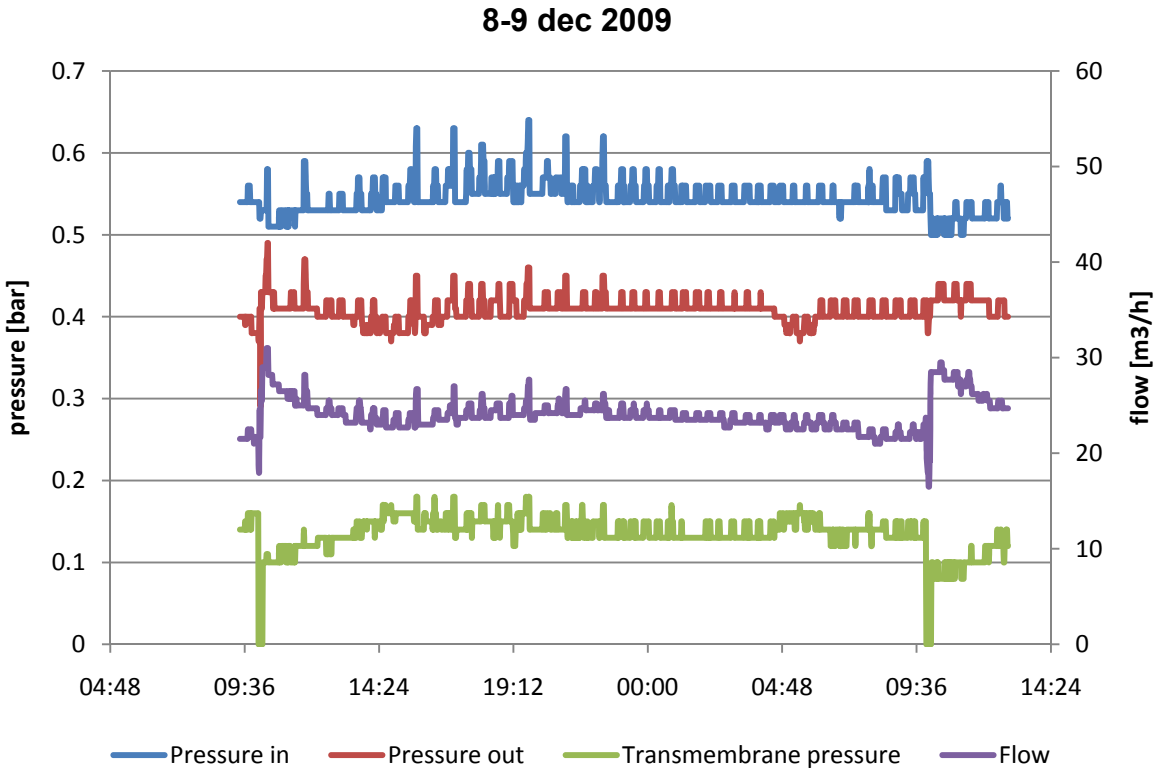

Figure 1: Time series plot of pressure in and out, transmembrane pressure and flow from 08.12.2009 to 09.12.2009.

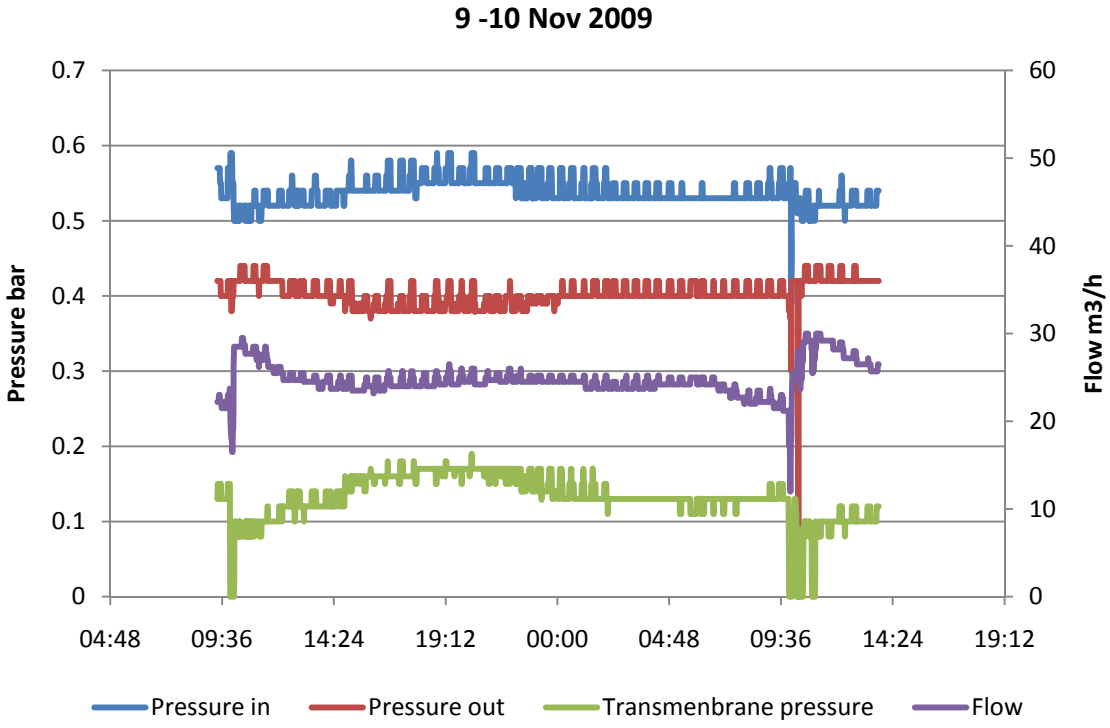

Figure 2: Time series plot of pressure in and out, transmembrane pressure and flow from 09.12.2009 to 10.12.2009.

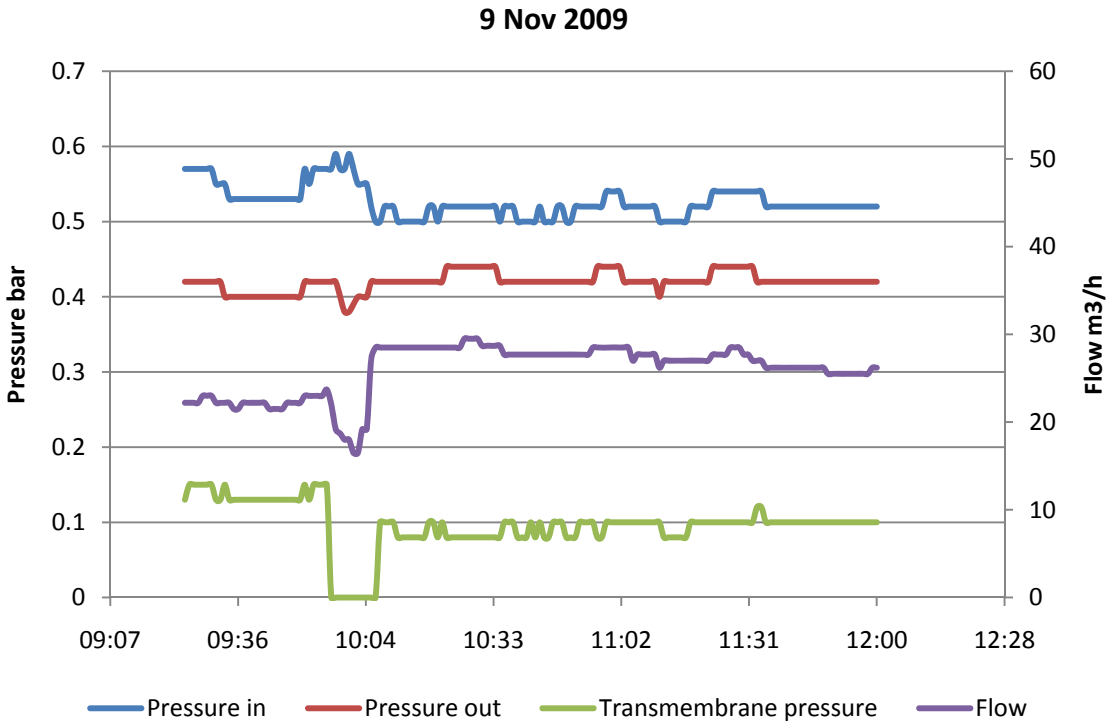

Figure 3: Time series plot of pressure in and out, transmembrane pressure and flow on 09.12.2009 at the time when the back wash took place.

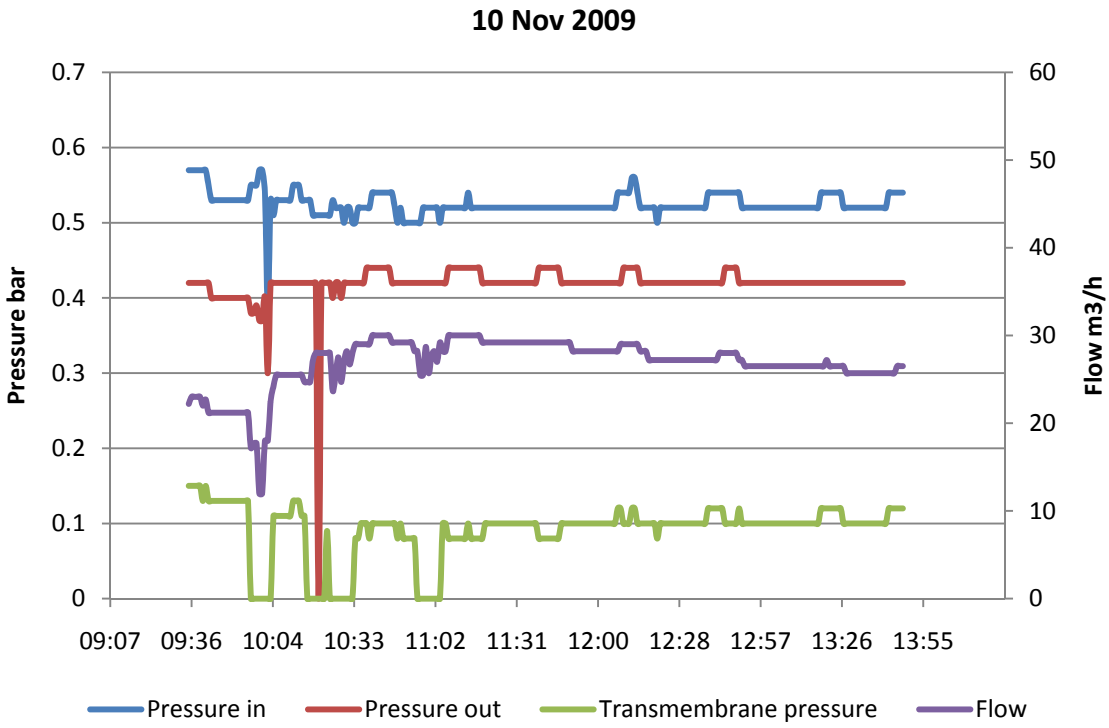

Figure 4: Time series plot of pressure in and out, transmembrane pressure and flow on 10.12.2009 at the time when the back wash took place.

A P P E N D I X 8

Sampling plan

Particle counts to be carried out as determination in duplicate on water taken before and after the filter

				Particle counts										
Date	Weekday	Hours after backwash	Time	Before filter (1) At	After filter (1) At	Before filter (2) At	After filter (2) At	Backwash Water	Hardness after filter	TOC before filter	TOC after filter	THM after filter	Microbiology before filter	Microbiology after filter
30.11.2009	Monday	Backwash	10:00											
30.11.2009	Monday	0,5		10:30	10,44	10:36	10:47		x	x	x	x	x	x
		1		11:00	11:15	11:07	11:22							
		2		12:00	12:12	12:06	12:20							
		4		14:00	14:11	14:06	14:17							
01.12.2009	Tuesday	22	08:00	08:00	08:15	08:07	08:22							
		23,5	09:30	09:30	09:48	09:40	09:54		x	x	x	x	x	x
01.12.2009	Tuesday	3 started backwashes	11:01		11:10		11:26	2 particle counts						
03.12.2009	Thursday	Backwash	10:24	10:38	10:26	10:46	10:33							
03.12.2009	Thursday	0,5	10:56	11:08	10:56	11:13	11:01		x					
		1	11:24	11:32	11:24	11:37	11:29							
		2	12,24	12:33	12:24	12:38	12:29							
		4	14,24	14:42	14:24	14:49	14:32							
04.12.2009	Friday	22	8,24	08:38	08:24	08:50	08:35							
		23,5		10:06	09:54	10:11	10:00		x					
08.12.2009	Tuesday	Backwash	10:10											
08.12.2009	Tuesday	0,5	10:42	10:58	10:42	11:05	10:56		x	x	x			
		1	11:10	11:21	11:10	11:28	11:19							
		2	12:10	12:19	12:10	12:24	12:16							
		4	14:10	14:20	14:10	14:25	14:17							
09.12.2009	Wednesday	22	08:10	8,27	08:18	08:34	08:26							
		23,5	09:40	09:49	09:40	09:56	09:48		x	x	x			
		Backwash	10:10											
		0,5	10:40	10:48	10:40	10:53	10:45						x	x
		1	11:10	11:17	11:10	11:25	11:15							
		2	12:10	12:24	12:10	12:29	12:20							
		4	14:10	14:21	14:10	14:27	14:17							
10.12.2009	Thursday	22	08:10	08:30	08:17	08:36	08:25							
		23,5	09:40	09:51	09:40	09:57	09:49		x				x	x
10.12.2009	Thursday	3 started backwashes						2 particle counts						
14.12.2009	Monday	Backwash	10:16										x	x
14.12.2009	Monday	0,5	10:46	11:02	10:46	11:07	10:59		x	x	x	x		
		1	11:16	11,24	11:16	11:31	11:22							
		2	12:16	12,24	12:16	12:30	12:22							
		4	14:16	14,28	14:16	14:32	14:27							
15.12.2009	Tuesday	22	08:21	08:33	08:21	08:39	08:28							
		23,5	09:46	09:53	09:47	09:59	09:52		x	x	x	x	x	x
								2 particle counts						
		Backwash	10:47											
		0,5	11:17	11,27	11:17	11:32	11:23							
		1	11:47	11,56	11:47	12:01	11:52							
		2	12:47	12:54	12:47	12:59	12:52							
		4	14:47	14,55	14:47	15:01	14:52							
16.12.2009	Wednesday	22	09:10	09:19	09:10	09:25	09:16		x					
		23,5		10:26	10:17	10:30	10:24							

A P P E N D I X 9

Information about the test plant (supplied by vendor)

Information til DHI vedr. testanlæg hos Gladsaxe Svømmehal

1 Contents

2 Beskrivelse af testsystem

2.1 Systemet indeholder:

- 3 stk. SiC membraner, Ø144x800, 2x2, 3 µm
- 1 stk. Komplet PolyPropylen system inkl. filterhuse
- 12 stk. Pneumatiske butterfly ventiler, inkl. pilotventiler og tilbagemelder
- 3 stk. Pneumatiske membranventiler inkl. pilotventiler
- 1 stk. Ringkammerblæser, 3.4 kW, 380V
- 1 stk. Kompressor, 1,86 kW (2,5 HP), 230 V
- 1 stk. Hovedtavle inkl. Smart Server, software, motorværn og softstarter
- 2 stk. Styrekasser inkl. kontrollere
- 1 stk. Flowmåler

- 5 stk. Tryksensorer

2.2 Driftsmanual:

Da filtersystemet er installeret med et fuldautomatisk styresystem, vil der ikke være nogen manuelle driftsfunktioner. Styresystemet er programmeret til kontinuerligt at måle og logge flow igennem systemet samt trykket på ind- og udgangen af systemet, og ud fra disse data og den til systemet specielt udviklede algoritme bestemme tidspunktet for bagskylning af filterne.

Det er muligt at påbegynde en tvungen bagskyl af systemet, ved at aktivere kontakten på hovedtavlen. Endvidere er det muligt via hovedtavlen at tænde og slukke systemet.

Ligeledes er det muligt via den internetbaserede brugerflade, som medfølger systemet. På brugerfladen er det muligt at se de loggede data fra flow, tryk, bagskyl og alarmer. Det er muligt selv at bestemme tidsperiode for de loggede data. Ved fejl på systemet genereres en fejlmeddelelse som sendes til de ansvarlige personer via e-mail.

Brugerfladen viser aktuelle data på temperatur og pumpens procentvis ydelse. Det er ikke muligt for brugeren at se andre ting eller ændre på noget i systemet. Ønskes der ændringer i systemet, skal Provital kontaktes.

2.3 Driftsinformation:

2.3.1 IP adresse på brugerflade

- 80.251.198.150 (HTTP)
- 80.251.198.150 (FTP)
- Login: ilon
- Password: ilon

2.3.2 Returskylle tid

- Det tager ca. 10 minutter at returskylle alle membraner.

2.3.3 Logning af data

- Interval: 15 min.
- Modtager af data
    - Provital
    - DHI
- Datalogning:
    - Flow
    - Tryk på ind- og udgang
    - Antal tilbageskyl
    - Alarm
    - Temperatur

3 Driftforhold

- Udgangstryk 0,5-0,6 bar
- Indgangstryk 0,6-0,75 bar
- Transmembrantryk 0,1-0,25 bar
- Flow 20-60 m^3/h

4 Instrumenter

4.1 Flowsensor, Krohne Optiflux 2000 med IFC 100D signalkonverter

- Måleområde: 0-150 m3/h
- Udgang/signal: 4-20 mA
- Nøjagtighed: ± 0,5 % af målt værdi ved hastighed ≥ 0,4 m/s
- Spændingsforsyning: 230 V

4.2 Jumo MIDAS tryktransmitter

- Måleområde: 0-2,5 bar
- Udgang/signal: 0-10 V, 3-leder
- Procestilslutning: G ½ iht. DIN 3852 T11
- Materiale: Rustfrit stål
- Spændingsforsyning: 24 VDC
- Beskyttelsesklasse: IP65 med kabeldåse
- Karakteristikafvigelse: ≤ 0,5 % af skala max.
- Hysterese: ≤ 0,2 % af skala max.
- Indstillingstid: ≤ 3 ms max.

4.3 Grundfos RPS tryktransmitter

- Måleområde: 0-1,6 bar
- Udgang/signal: 0,5-3,5 V
- Materiale, housing: EPDM og PPS
- Materiale, sensor: Silicon-based MEMS sensor
- Spændingsforsyning: 5 VDC
- Beskyttelsesklasse: IP44
- Nøjagtighed: ± 1,5 % skala max.
- Indstillingstid: < 0,5 s.

4.4 Grundfos RPS tryktransmitter

- Måleområde: 0-2,5 bar
- Udgang/signal: 0,5-3,5 V
- Materiale, housing: EPDM og PPS
- Materiale, sensor: Silicon-based MEMS sensor
- Spændingsforsyning: 5 VDC
- Beskyttelsesklasse: IP44
- Nøjagtighed: ± 1,5 % skala max.
- Indstillingstid: < 0,5 s.

4.5 Grundfos RPS Temperatursensor

- Måleområde: 0-100 °C
- Udgang/signal: 0,5-3,5 V, 3-leder
- Materiale, housing: EPDM og PPS
- Materiale, sensor: Silicon-based MEMS sensor
- Spændingsforsyning: 5 VDC
- Beskyttelsesklasse: IP44

- Nøjagtighed: ± 1 °C (temp. mellem 25-80 °C)
- Indstillingstid: < 1,5 s.

5 Konstruktion

5.1 Rør materiale:

- PP (polypropylen)
- Temperatur: 0 - + 80 °C
- Længdeudvidelses-koefficient: 0,16mm/m°C
- Bestandig overfor:
  - Syre, base, svage opløsningsmidler, deioniseret vand
  - Bestandig overfor natriumhypoklorit v. 2 % aktiv klor og 20-40 °C
  - Bestandig overfor saltsyre v. > 30 % koncentration ved 20-40 °C
- Densitet: 0,91 g/cm3

5.2 Ventiler:

- Butterfly ventil: DN100
- Pakning: EPDM
- Aktuator:
  - PP20
  - Lukketid: 0,58 sek. ved 5,9 bar tryk
  - Styring:Magnetventil – 24 VDC

5.3 Membranventil:

- Membran: EPDM
- O-ring: Vitron

6 Drift

6.1 Normal drift mode

Ved normal drift forstås kontinuerlig rensning af svømmebadsvandet og filtreringsanlægget kører i systemets normal mode. Systemet har to hoved-modes, som systemet agere ud fra, normal-mode og returskylle-mode.

Normal-mode er i systemet defineret som den indstilling, hvor svømmebadsvandet filtreres gennem membranerne og returneres til bassinet. Denne indstilling er aktiv indtil systemet initiere et returskyl via systemets interne ur ellers via manuel aktivering vha. returskylleknappen på styrekassens front.

- Tidsindstilling
- Manuelt returskyl

Returskyl initieres primært af en i styresystemet indstillelig tid, som tvinger systemet til returskyl. Denne tid er ”default” indstilling til at foregå kl. 00.00 hver dag.

Et returskyl kan dog også påtvinges systemet via returskylle-knappen, som er placeret på hovedtavlens front. Denne holdes inde i 2 sek. hvorefter returskylle-mode initieres.

6.2 Returskylle mode

Som beskrevet i 6.1 vil et returskyl initieres automatisk eller manuelt. Som beskrevet initieres returskyl hver dag kl. 00.00.

Når systemet aktivere et returskyl, lukkes for tilgangen og afgangen på den pågældende membran, og tilgangen til kloakken åbnes. Samtidig startes blæseren og herefter ventilen for lufttilførsel.

7 Vedligeholdelse

Systemet er som udgangspunkt vedligeholdelses frit. Der vil ikke være nogen daglig vedligeholdelse på systemet, da systemet er fuldautomatisk og returskyller sig selv. Hvis der sker en fejl på systemet, således systemet ikke længere drifter optimalt, vil systemet give en alarm i form af en email eller sms, der automatisk genereres af systemet.

Det er vigtig for optimal drift af systemet at pumpe, blæser og kompresser efterses i overensstemmelse med disses vejledning. Ligeledes kan et årligt eftersyn af ventiler og aktuatorer være nødvendigt for sikker drift.

Hvis systemet ikke formår selv at regenerere membraner vha. returskyl kan det være nødvendigt at rense membranerne kemisk. Herved kan de regenereres 100 %.

Yderligere er det vigtigt at der hele tiden er salt på blødgøringsanlægget, da det kan være belastende for membranerne, hvis vandpåfyldningsvandet ikke er blødgjort.

A P P E N D I X 1 0

Amendment and deviations

Deviation report
CoMeTas verification

Deviation	Reference document	Deviation description	Cause	Impact	Corrective action	Date	Signature test responsible	Date	Signature Verification responsible
1	Test plan 2.1 and 3.2.2	Run-in testing was performed on AQS 144-800 (5*5) 3 micron filters	Smaller membrane area	The filter was less efficient than expected	Installation of AQS 144-800-(2*2) 3 micron filters	29.11.2009	BOP	22/6-10	MTA
2	Test plan Section 3.2.3	No automatic started back wash	Technical problems	The back wash didn't start unless it was started manually	Manually start of back wash by the staff	30.11.2009	BOP	22/6-10	MTA
3	Test plan Section 3.2.3	No automatic started back wash of the second and the third filter	Technical problems	Delay of the sampling for particle counting	Manually start and stop of the valves controlling the back wash cycle	30.11.2009, 03.12.2009 14.12.2009 and 15.12.2009	BOP	22/6-10	MTA

Deviation report
CoMeTas verification

Deviation	Reference document	Deviation description	Cause	Impact	Corrective action	Date	Signature test responsible	Date	Signature Verification responsible
4	Test plan Section 3.2.3	Flux not calculated on the FTP-server/PC	Calculations of flux was not included in the program on the FPT-server	No flux pressure profile was developed	No	30.11.2009	BOP	22/6-10	MTA
5	Test plan Section 3.2.3	Glass column on the particle counter broke	The glass column broke when air bubbles were removed	No more particle counting were performed that day	A new glass column was installed	04.12.2009	BOP	22/6-10	MTA
6	Test plan Section 5.1	Software on the PC connected to the FTP-server was replaced by a new version	Up-dating of the software	No logging of data when the software was replaced	No	14.12.2009	BOP	22/6-10	MTA