Rosfilter

Test report

Coagulation and direct filtration for treatment of surface water

WATER • ENVIRONMENT • HEALTH

Ingenjörsfirma Ros AB
May 2010

Rosfilter

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1 INTRODUCTION

This test plan describes the implementation of a test design developed for verification of the performance of an environmental technology following the DANETV Centre Quality Manual – Water Technology /1/.

1.1 Verification protocol reference

This test report has been prepared in response to the test design established in the Ros-filter verification protocol /2/ and test plan /3/.

1.2 Name and contact of vendor

Ingenjörsfirma Ros AB, Insjövägen 13, 79333 Leksand, Sweden.
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Contact: Lars Niklasson, email: lars@ros.se, phone +46 247 64470
Web site: www.ros.se

1.3 Name of centre/test responsible

The Danish Centre for Verification of Climate and Environmental Technologies, (DANETV), DHI DANETV Water Center, DHI, Agern Allé 5, DK-2970 Hørsholm, Denmark.

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

Test responsible: Gerald Heinicke, e-mail ghe@dhigroup.com, phone +45 4516 9268.

1.4 Technical experts

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

External technical expert: Prof. John Tobiason, University of Massachusetts Amherst, email: tobiason@ecs.umass.edu, phone +1 413 545 5397.

Internal technical expert: Morten Møller Klausen, Urban and Industry department, DHI, email: mmk@dhigroup.com, phone +45 8620 5114.

2 TEST DESIGN

2.1 Test site

The test was conducted as a field test at Lilla Edet water works, 46380 Lilla Edet, Sweden. Lilla Edet waterworks draws raw water from the river Göta älv (Figure 2-1). The raw water is soft, moderately humic (SUVA approximately 2.5) and with varying particle load (Table 2-1 and Appendix 7). The water temperature varies between 0-3°C in February-March and 14-23°C in July-August. The water quality of Göta älv has been widely studied and described in the scientific literature.

Table 2-1 Selected water quality parameters of river Göta älv observed at Lilla Edet water works.

Parameter	Unit	Mean	Minimum	Maximum
pH		7.4	7.2	7.6
Alkalinity	mmol/l	0.30	0.26	0.34
Turbidity	FNU	6.6	1.5	33
Calcium	mg/l	7.6	7.4	7.9
Colour at 405 nm	mg Pt/l	22	15	50
COD-Mn	mg O_2/l	4.4	3	5.9
TOC	mg/l	4.3	n.a	n.a.

n.a: not applicable, since only 2 samples.

Figure 2-1 View of the river Göta älv from the premises of Lilla Edet water works.

2.2 Tests

2.2.1 Test methods

No standard method exists for testing filters intended for treatment of surface water. The test methods have accordingly been prepared for the purpose with reference to the EPA/NSF ETV Equipment Verification Testing Plan Coagulation and filtration for the removal of microbiological and particulate contaminants /3/.

In the corresponding verification protocol, the testing has been divided into four tasks.

Task 1: Characterization of the test site

In the case of testing Rosfilter at Lilla Edet water works, sufficient historical data are available to describe the test site and its raw water quality (section 2.1).

Task 2: Initial operational runs

The objective of the initial runs was to find optimum operational conditions for the Rosfilter pilot plant, and to test both the pilot plant and the online measurement and data logging equipment, to avoid technical problems during the verification testing.

During the initial operation runs, the tasks comprised:

- Identification of optimum coagulant dose that minimizes filtrate turbidity and residual aluminium.
- Adjustment of the backwash flow and backwash time. This is based on the vendor's experience with the product, adapted to the conditions at the test site.
- Identification of the maximum allowable headloss in the pilot plant to avoid backwash problems, specifically to avoid a cake layer not completely broken down, resulting in loss of media and in mud balls.
- Testing of the on-line measurements, of data logging and data communication

The adjustment of the above-mentioned operating conditions such as coagulant dose, backwash flow and time were performed by the vendor, based on their experience with the product. The information was incorporated into the plan for the verification testing, but is not reported here. The testing of equipment for on-line measurement equipment and data logging was done by DHI.

Task 3: Verification testing

The test equipment was operated 24 hours a day, during 14 days. A filter run was terminated automatically when reaching the maximum allowable head loss.

During the tests, data were collected on the operational conditions (on-line and manual), from on-line measurement of water quality, and from analysis of grab samples sent to accredited analytical laboratories. The reported data are found in Appendix 6.

The duration of interruptions was recorded. Only filter runs were be included in the evaluation if the operation conditions differ less than 10% during more than 70% of the filter run. Filter runs in which coagulation dosage temporality failed were not included in the evaluation of filter run times. Data were only evaluated that was not affected by such failures.

The work plan comprises two sub-tasks, to be performed simultaneously:

Task 3a: Verification testing runs. The pilot plant was operated under pre-defined operational conditions (Table 2-6). The times when backwash took place were be extracted from the on-line measurement data.

Task 3b: Evaluation of finished water quality. In this task, grab samples were taken and sent for analysis, while data from on-line parameters were logged and transferred to a remote computer. Sampling and analysis are described in section 2.2.5.

2.2.2 Test staff

Test responsible is Ph.D. Gerald Heinicke (GHE). The daily operation of the pilot plant and the grab sampling will be performed by Bertil Olsson, technician at Lilla Edet waterworks. The on-line analytical and data logging equipment was operated and looked after by Claes Hernebring (CHB), DHI.

2.2.3 Test schedule

The test schedule is given in Table 2-2.

Table 2-2 Test schedule.

Task	Week no. in 2009/2010										
	47	48	49	50	15	16	17	18	19	20	21
Characterization and of test site	x										
Set up of test equipment	x	x									
Initial operation runs		x	x	x							
Verification testing					x	x	x				
Test report draft							x	x	x		
Test report QA										x	x
Test report											x

2.2.4 Test equipment

A containerized Rosfilter pilot plant was provided by Ingenjörsfirma Ros AB and placed outdoors at Lilla Edet water works. The pilot plant used the same technology as Rosfilters in full-scale. DHI provided a trailer equipped with on-line analytical, data logging and data communication equipment.

Figure 2-2 Rosfilter pilot plant and DHI's trailer with analytical equipment at Lilla Edet water works.

The pilot plant filter had a diameter of 1 m, with a filter area of 0.78 m^2. The filter bed consists of five layers: 2.5 m of filter sand on 1 m of gravel support with four grain size fractions (Table 2-3). A grading curve is shown in Appendix 8.

Table 2-3 Specification of filter bed in the Rosfilter pilot plant.

Granular medium	Grain size (mm)	Layer thickness (cm)
Filter sand	0.8-1.2	ca. 250
Gravel	2-4	10
Gravel	4-8	20
Gravel	8-16	30
Gravel	16-32	40

Non-chlorinated raw water was fed directly into the Rosfilter pilot plant. The coagulant was dosed by a membrane pump, with a display showing the chosen flow. The coagulant was added directly before entering the bottom of the filter bed, without a static mixer. pH adjustment was achieved by the choice of coagulant. There was no additional pH adjustment. As in full-scale applications, the dosage of coagulant was adjusted manually by the operator, when deemed necessary.

Figure 2-3 View into the container. On the left hand side is the cylindrical multi-media up-flow filter, in the back the large rectangular tank for backwash water.

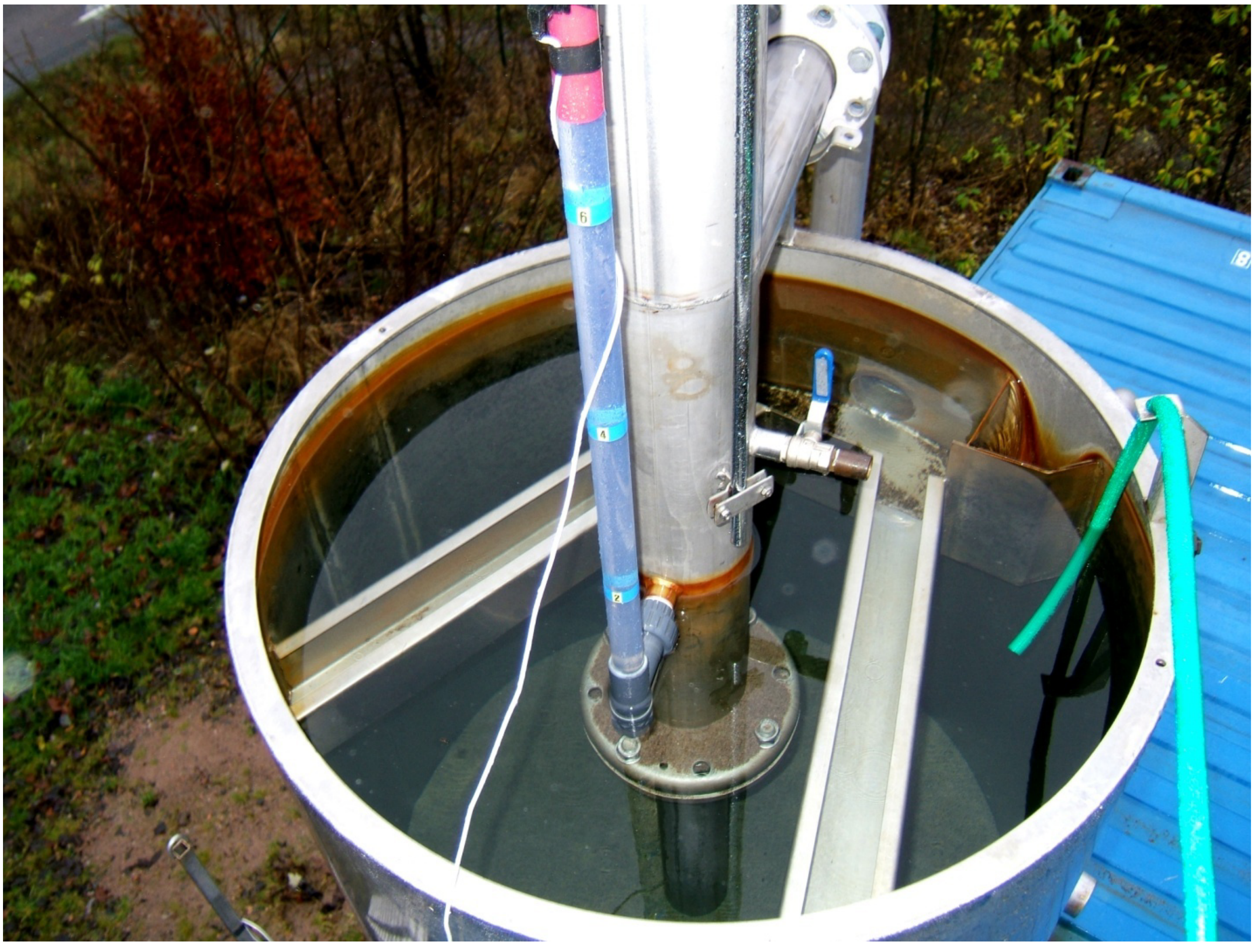


Figure 2-4 View of the filter protruding from the top of the container. The transparent pipe contains the switch that triggers the backwash at a pre-set headloss.

Figure 2-5 View into the trailer with analytical equipment. In the lower right corner is the flow-though channel with the sensors.

A technical drawing of the pilot plant is given in Appendix 8.

2.2.5 Type and number of samples

Feed and filtrate water qualities were be characterized by on-line measurements and grab samples.

On-line measurements of water quality were carried out in the trailer and comprise turbidity, conductivity, UV_{254} and pH (Table 2-4). The measurement shifted between feed water (20 minutes) and filtrate (220 minutes). 1-minute averages were calculated internally from 6 measurements per minute. The data were logged locally and transferred every workday to the DHI office via a GSM modem.

Table 2-4 On-line measurements of feed and filtrate water quality during verification testing.

Parameter	Recording
Turbidity	Data logger, 1-minute averages
Conductivity	Data logger, 1-minute averages
UV_{254}-absorption	Data logger, 1-minute averages
pH	Data logger, 1-minute averages

The initial testing runs indicated filter cycle durations of 14 to 15 hours, while filter cycled during verification testing were around 17 hours. This resulted in 19 filter cycles during verification testing, starting at varying times of the day due to automated backwashing. Grab samples were taken from 4 filter runs. Filter runs for grab sampling were chosen by the test responsible, with regard to suitable sampling times and working hours at the external analytical laboratory. For all filter runs that fulfilled the conditions stated in the verification protocol, on-line parameters were evaluated.

Grab samples of filtrate were taken from a sample ports for filtrate. Raw water samples were taken from the pump sump of the full-scale waterworks. Grab samples of filtrate were taken from the matured filter, and before a possible breakthrough of particles, *i.e.* at least 2 hours after a backwash and only if the filtrate turbidity was below 0.2 NTU. Before taking the sample, the valve of the sampling port was opened for at least 30 seconds, to half of the handle's range. The time of sampling was noted in the data reporting sheets, together with the turbidity at that time (Appendix 6).

Table 2-5 Grab samples of feed and filtrate water quality during verification testing.

Parameter	Number of samples	Sample bottle
COD_{Mn} Colour Alkalinity pH	1 sample from 4 filter runs 1 sample from 4 filter runs 1 sample from 4 filter runs 1 sample from 3 filter runs	500 ml PE bottle
TOC	1 sample from 4 filter runs	130 ml PE bottle
Coliforms Enterococci $HPC_{3\text{-d}, 22°C}$	1 sample from 4 filter runs 1 sample from 4 filter runs 1 sample from 4 filter runs	500 ml sterile single-use PE bottle
Aluminium	1 sample from 4 filter runs	50 ml PP tube

2.2.6 Operation conditions

Table 2-6 summarizes the conditions under which the pilot plant was operated. The real conditions (test value) are stated in comparison to the operating conditions stated in the test plan. The target coagulant feed was decided by the operator, and noted in the data reporting sheets (Appendix 6). A datasheet on the coagulant is included in Appendix 8.

Table 2-6 Operational conditions for the Rosfilter pilot plant during verification testing. If the last column is empty, the parameter was as pre-defined in the test plan.

Parameter	Unit	Pre-defined in test plan	Test value
Feed water flow	m^3/h	3.45-3.6	3.6-3.8
Filtration rate	m/h	4.6-4.4	4.9-4.6
Coagulant type	type, brand	Polyaluminiumchloride, Pluspack 1465	
Coagulant feed, target	ml/h	ca. 110, to be adapted by operator[1]	110
Coagulant feed, real	ml/h	Measured daily by means of a scale	90-105 (Ø 102)
Maximum head loss	cm	150	145
Back wash rate	m/h	55	
Back wash time	minutes	ca. 7	
Consumed water for back wash	L/back wash	5000	
Water temperature	°C	Ambient winter conditions (<3°C)	1.5-4.5°C
Hours of operation per day	hours	24	

[1] The dose is normally set by the operator in full-scale Rosfilter plants.

According to the vendor's experience and the initial operational runs, the backwash rate needed to be 50-55 m/h to ensure fluidization of the fine filter media. The backwash time was chosen by the vendor so that sufficient cleaning of the filter bed is achieved, while longer backwashing would not give further effect.

2.2.7 Operation measurements

During verification testing, operational conditions were recorded (Table 2-7). Feed water flow and feed water pressure were measured on-line on the feed pipe located below the filter, and logged electronically. This also documented the exact times when backwash takes place. The water temperature was retrieved from Lilla Edet water works. The coagulant flow was checked by weighing the coagulant container daily, and the weight and time of weighing manually written into the data reporting sheets (Appendix 6).

Table 2-7 Operational data recorded.

Parameter	Unit	Measurement	Recording
Feed water flow	m^3/h	on-line	Data logger, 1-minute averages
Feed water pressure	Bar	on-line	Data logger, 1-minute averages
Water temperature	°C	on-line	Data logger, at water works
Coagulant feed, real	ml/h	by scale	Manual, several occasions

2.2.8 Product maintenance

Product maintenance was not a part of this verification.

2.2.9 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.

3 REFERENCE ANALYSIS

3.1 Analytical laboratory

Water quality analysis of feed water and produced water was carried out by the analytical laboratory of Göteborg Vatten, except for TOC. The postal address is Lackarebäcks VA-verk, Laboratoriet, Bäckravinsgatan 5, 43166 Mölndal, Sweden, phone +46 31 3687000. Göteborg Vatten's laboratory is ISO 17025 accredited for the analyses applied in this test plan /4/.

TOC was analysed by ALcontrol AB, Olaus Magnus väg 27, 58330 Linköping, Sweden, phone +46 13 254900. ALcontrol performs TOC analysis under ISO 17025 accreditation /5/.

3.2 Analytical parameters

The analytical parameters are stated in Table 3-1 and Table 3-2.

3.3 Analytical methods

The analytical methods consisted of on-line measurements at the test site (Table 3-2), and of methods for the analysis of grab samples sent to the external analytical laboratories (Table 3-1).

3.4 Analytical performance requirements

The methods, limit of detection (LoD) and uncertainty as stated by the analytical laboratory are given in Table 3-1. It was judged that the performance of the analytical methods was sufficient for the verification.

Table 3-1 Analytical methods, LoD and uncertainty for the analytical laboratories. Method designation and range are from the laboratories accreditation statement /4, 5/. Method uncertainty is stated by the laboratories.

Parameter	Method	Range	Uncertainty
Coliforms	SS 028167-2 (Membrane filtering)	n.s.	n.s.
Enterococci	SS-EN ISO 7899-2 (Membrane filtering)	n.s.	n.s.
$HPC_{3\text{-day, }22°C}$	SS-EN ISO 6222 (Inoculation in nutrient agar)	n.s.	n.s.
Aluminium	EPA 200.8 rev5.4 mod (ICP-MS)	5-5000 µg/l	18%
COD_{Mn}	F.d SS028118 utg 1 (Titrimetri)	1-10 mg/l	at 1-2 mg: 17% at 3-10 mg: 11%
TOC	SS-EN 1484, utg 1 (Incineration)	1-100 mg/l	15-20%
Colour	SS-EN ISO 7887 utg1 del4 (Comparator)	5-70 mg/l Pt	5 mg/l Pt
Alkalinity	SS-EN ISO 9963-2 utg1	0.01-4 mmol/l	10%

n.s. = not stated for microbial methods.

For the on-line measurements, range and uncertainty values were retrieved from the respective data sheets (Table 3-2).

Table 3-2 On-line measurements at the test site.

Parameter	Method/instrument	Range	Uncertainty %
Flow	Magnetic inductive[1]	no data	0.5%
Pressure head below filter	Pressure transmitter[2]	0-4 bar	0.2%
Turbidity	Turbidimeter[3, 4]	0.001-20 NTU	2%
pH	pH electrode[3, 5]	0-14	0.1%
Conductivity	Conductivity electrode[3, 6]	0-1000 µS/cm	0.1%
UV_{254}-absorption	UV lamp & sensor[3, 7]	no data	no data
Temperature	Temperature-sensor at water works	no data	no data

[1] Siemens MAG 5000, part of Rosfilter pilot plant
[2] Keller LEO3, 4 bar, installed to Rosfilter pilot plant by DHI
[3] Part of DHI's trailer with analytical equipment
[4] GLI Accu 4 (4-beam radiometric method according to USEPA, GLI Method 2)
[5] GLI P53, with Satron 970070 electrode for cold waters with low ionic strength
[6] GLI C53
[7] Flow cell with lamp Oriel 6035 Hg(Ar) and sensor Newport 818-UV.

3.5 Preservation and storage of samples

Samples were not preserved, but stored cold (1-5ºC) and dark. Samples were delivered to the laboratory within 24 hours, while microbial samples were delivered to the laboratory within 8 hours. TOC samples from sampling occasions no. 1 and 3 were stored cold and sent to ALcontrol the same day. TOC samples nr. 2 and 4 were frozen at -18ºC for one to two days, and then sent to ALcontrol[1].

[1] According to the analytical laboratory, TOC samples may be stored in three ways: Cold storage and immediate sending, preservation with HCl and sending within one week, or freezing of samples for up to one month.

4 DATA MANAGEMENT

In general, the data filing and archiving procedures of DHI Quality System Manual were followed. The data management involved manual recording of operational data and handling of operational data which were stored on a local data logger and transferred to the DHI office. Also, data from the accredited external laboratory were handled.

4.1 Data storage, transfer and control

Data handling consisted of collection and writing into tables prepared in advance (Appendix 6). Excel spread sheets were used for calculation and storage of data concerning water quality. On-line data were transferred from data logger at the test site to the DHI office. Actions and events with relevance to the test plan were written into field log book, including date and time. Samples sent for analyses to an external laboratory were labelled in advance, in order to ensure correct transfer of analytical data.

Data compiled and stored are summarized in Table 4-1.

Table 4-1 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	During collection	Files and archives at DHI
Operational data	Excel files	Test responsible	During operation	Transferred data - files and archives at DHI
Calculations	Excel files	Test responsible	During calculation	Files and archives at DHI
Analytical reports	Paper	Test responsible	When received	Files and archives at DHI

5 QUALITY ASSURANCE

The tests were performed under the Center Quality Manual which is ISO 9001 compliant, but not certified /5/.

5.1 Test plan review

The test plan was subject to review by the internal and external technical experts assigned to the project (1.4).

5.2 Performance control – Sensor calibration

Sensor calibration of the on-line measuring equipment in the trailer was done prior to the initial operation runs. Towards the end of the verification testing (2010.04.27), the sensors were checked against standard solutions.

The turbidity meter was checked against a standard probe of 15.1 NTU, and showed 14.9 NTU, which is within the 2% uncertainty stated in Table 3-2. Nevertheless, the turbidity meter was recalibrated.

The UV-absorbance meter was checked against Purelab ultrapure water as a reference, as obtained from Göteborg Vatten's laboratory. The corresponding reference output from the photocell (transmission) was set to 10.0 V. The transmission signal with no UV-light (lamp turned off) was set to 0.0 V. Initial calibration was performed 2010.04.07, calibration values were checked 2010.04.12 (no adjustments), 2010.04.14 (reference value adjusted from 10.89 V -> 10.0 V) and 2010.04.27 (reference value adjusted from 9.6 V -> 10.0 V). Note that the data logged were absorbance (A) calculated from the transmission (T) values: A=log(1/(T/10.0)).

The pH meter was calibrated in the beginning of the test, but turned out to be too slow for this water, compare deviation no. 5. Therefore, the data were not used, and no further calibration was necessary. The conductivity electrode does not need to be calibrated.

5.3 Test system control

The stability of the pilot plant and on-line analytical equipment was controlled during verification testing. This was done by the test responsible, by checking the data collected by the on-line measuring equipment.

5.4 Data integrity check procedures

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

5.5 Test system audits

Internal audit of the test system was done by Bengt Zagerholm (BZ), responsible for quality assurance of water treatment projects.

5.6 Test report review

The test report was subject to review by the internal and external technical experts assigned to the project (1.4).

6 TEST RESULTS

6.1 Test data summary

This section summarizes the results that are input to the evaluation of performance parameters, retrieved from recorded on-line data, as well as the data reported by the analytical laboratories.

First, the recorded on-line data were used to define the exact start and end times of each filter cycle during verification testing (Appendix 6). Incidents such as a temporary failure of the chemical dosing pump were noted, and assigned to the corresponding filter cycle. An example is shown in Figure 6-1. The 220-min filtrate measuring cycle is marked by a stable turbidity signal. The first peak with the slowly decreasing turbidity value is the filtrate signal after backwash, starting ca. 18 minutes into the filter cycle, after the test plant's ca. 15-minute long build-in filter to drain period. The figure also shows four clearly distinguished 20-minute raw water measuring periods.

For each filter cycle, the filtrate quality from the mature filter was calculated as average of on-line parameters' data points during the 220-minute measurement periods that were not affected by filter backwash or other incidents. On-line data from the matured filter were evaluated from two hours into the filter cycle, to avoid influence from filter ripening. The length of the initial improvement period was evaluated as the time it took until the filtrate consistently measured below 0.5, 0.2 and 0.1 NTU. The minute was reported for which the value dropped under the threshold, followed by at least two more values also below the threshold.

For each filter run, an average of on-line parameters in the raw water was calculated from the last ten 1-minute data points during the second half of the 20-minute raw water measuring periods, excluding the last minutes, which may be affected by the switching to filtrate.

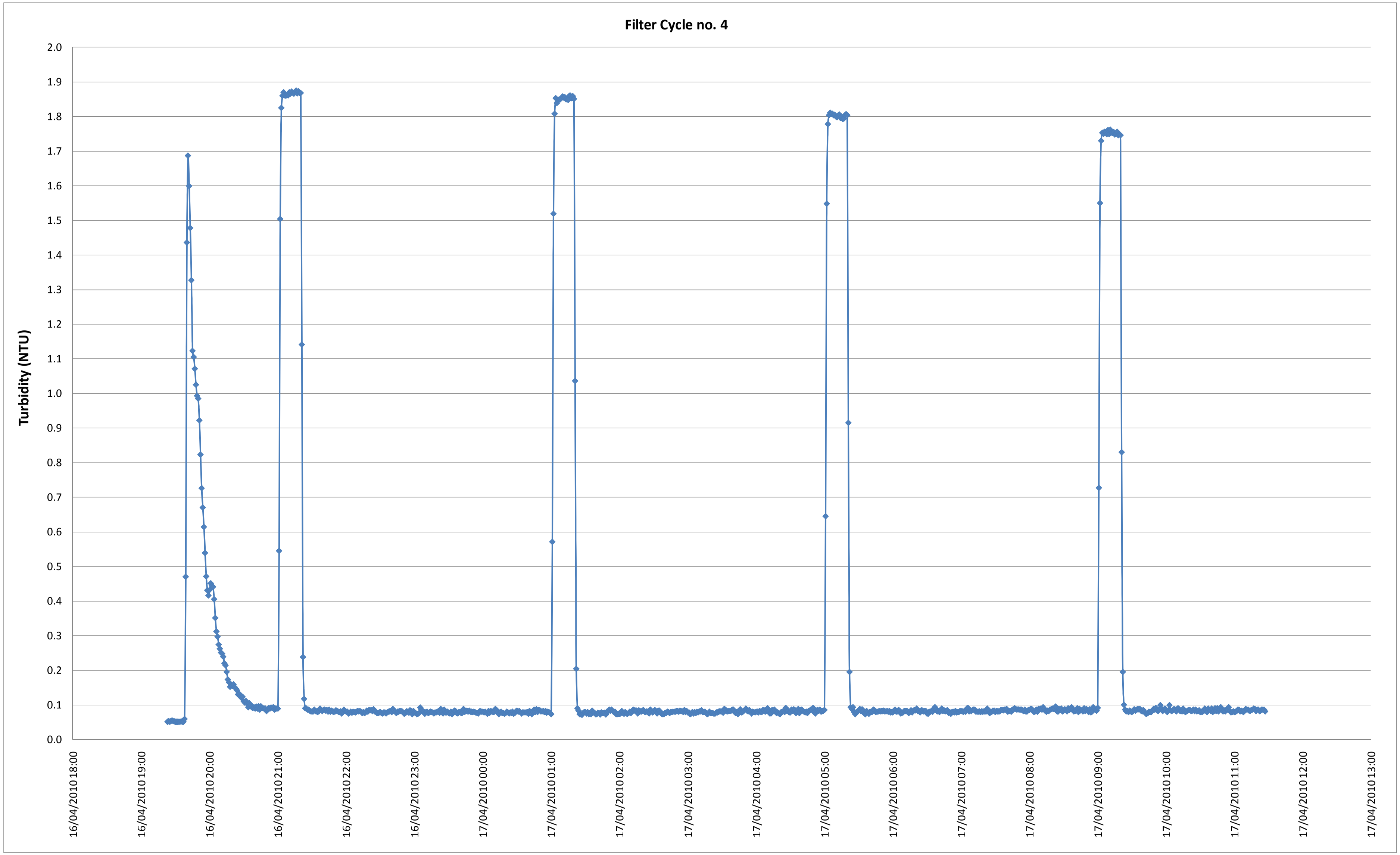


Figure 6-1 Example of on-line turbidity data from one filter cycle, exported to MS Excel. The 20-minute long peaks are the measurement of raw water.

On-line turbidity data are summarised in *Table 6-1*. Initial turbidity was evaluated after 20 minutes instead of 15, for technical reasons (see deviation no. 2, Appendix 7).

Table 6-1 Results of on-line turbidity measurements. n = number of evaluated filter cycles.

Particles		**Value**			
Parameter	**Description**	**Mean**	**Min**	**Max**	**n**
Raw water turbidity	Aver. over filter cycle (NTU)	2.5	1.7	3.7	19
Turbidity from matured filter (percentage of time in turbidity interval)	0.10 NTU or lower	94.4	77.7	100	17
	0.11-0.2 NTU	5.6	0.0	22.3	
	0.21-0.34 NTU	-	-	-	
	0.35-0.5 NTU	-	-	-	
	>0.5 NTU	-	-	-	
Initial turbidity	Filtrate turbidity 20 min into run (NTU)	1.7	1.1	2.7	14
Length of initial improvement period (minutes)	Time to reach 0.5 NTU	39	33	46	16
	Time to reach 0.2 NTU	52	47	64	13
	Time to reach 0.1 NTU	72	55	85	15

The parameters in the raw water that determine the necessary coagulant dose for coagulation, *i.e.* turbidity and the concentration of humic substances (UV-absorbance), varied during verification testing (factor ≈2 for turbidity, ≈1.25 for UV-absorbance). With the coagulant dose kept constant, filtrate UV-absorbance increased with higher raw water UV. Filtrate turbidity was affected to a lesser degree (Figure 6-2).

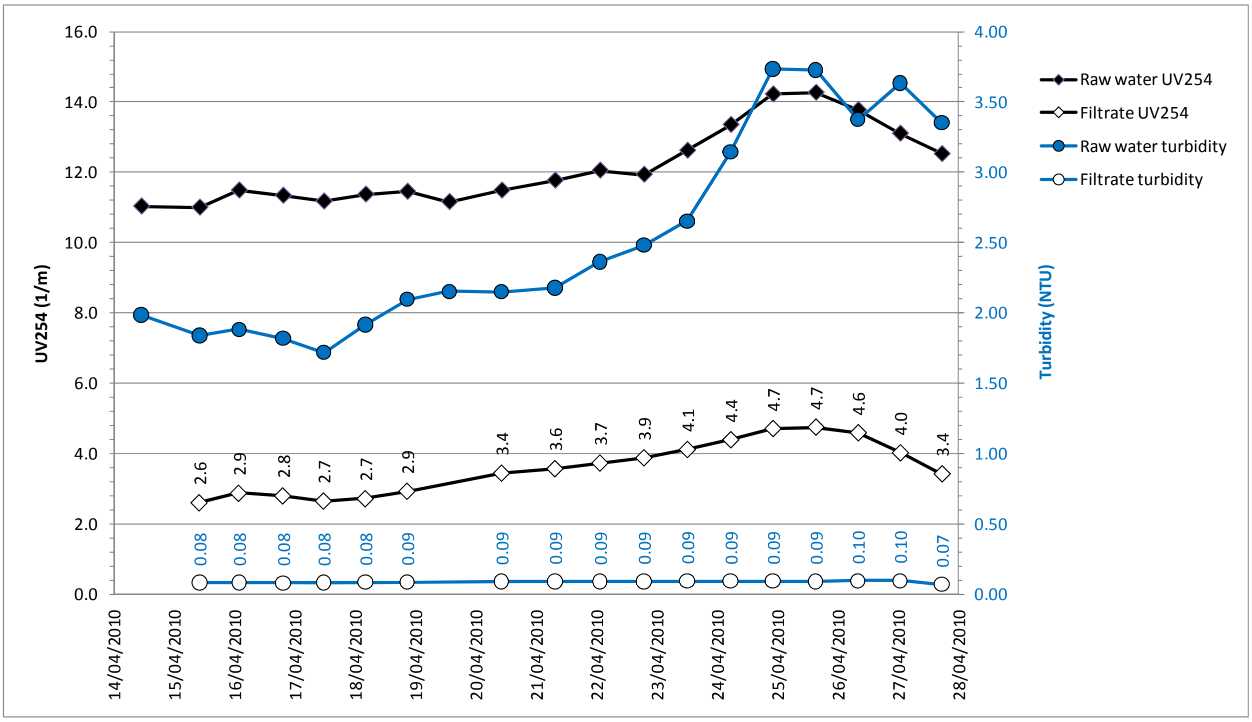


Figure 6-2 Average UV-absorbance and turbidity over each filter cycle, in raw water and filtrate.

The results regarding NOM parameters are summarised in Table 6-2. For the on-line parameter UV_{254}, data were evaluated at the same times as for turbidity. The other NOM parameters are from grab samples.

Table 6-2 Results of NOM analysis: Colour, TOC, and COD (grab samples), and UV-absorbance (on-line). n = number of sampling occasions, except for UV-absorbance (number of evaluated filter cycles).

Natural Organic Matter (NOM)		**Value**			
Parameter	**Description**	**Mean**	**Min**	**Max**	**n**
Colour (mg Pt /l)	Raw water	21	20	25	4
	Filtrate	<5	<5	<5	
	Samples not below 15	0	0	0	
	Samples not below 5	0	0	0	
TOC (mg/l)	Raw water	4.9	4.7	5.1	4
	Filtrate	2.8	2.6	3.0	
	Removal	44%	41%	46%	
COD_{Mn} (mg/l)	Raw water	4	4	4	4
	Filtrate	1.3	1	2	
	Removal	69%	50%	75%	
	Samples not below 4	0	0	0	
UV_{254} (1/m)	Raw water	12.2	11.0	14.3	19
	Filtrate	3.6	2.6	4.7	17
	Removal	71%	67%	76%	17

The results of the chemical analyses are summarised in Table 6-3. From the second sampling occasion, pH was included in the analytical programme for the grab samples (see deviation no. 5, Appendix 7).

Table 6-3 Results of chemical parameters and indicators: Aluminium and pH (grab samples), conductivity (on-line). n = number of sampling occasions, except for conductivity (number of evaluated filter cycles)

Chemical parameters and indicators		**Value**			
Parameter	**Description**	**Mean**	**Min**	**Max**	**n**
Aluminium (mg/l)	Raw water	0.14	0.06	0.25	4
	Filtrate	0.016	0.014	0.020	
	Samples not below 0.1	0	0	0	
pH	Raw water	7.4	7.4	7.5	3
	Filtrate	7.0	6.9	7.0	
Alkalinity (mmol/l)	Raw water	0.31	0.30	0.32	4
	Filtrate	0.23	0.22	0.23	
Conductivity (µS/cm)	Raw water	69	64	78	19
	Filtrate	79	73	87	17

The results of the microbial analyses are summarised in Table 6-4. In the filtrate samples, the concentration of microorganisms was generally below the limit of detection, with the exception of one sample in which heterotrophic bacteria were detected. Therefore, the $\log_{10}$ removal[2] is expressed as "larger than", the value depending on the concentration in the feed water.

[2] The reduction of microbial parameters over water treatment processes is often expressed in logarithmic terms. Regulations often require high removals, which may appear abstract if expressed as per cent. Example: 4-$\log_{10}$ removal = 99.99% removal.

Table 6-4 Results of microbial parameters: Microorganisms, coliforms and enterococci (grab samples). n = number of sampling occasions

Microbial parameters		**Value**			
Parameter	**Description**	**Mean**	**Min**	**Max**	**n**
HPC $_{3\text{-d}, 22°C}$ (no./ ml)	Raw water	250	100	500	4
	Filtrate	<1	<1	2	
	Log_{10} removal	>2.3	>2.0	2.4	
	Samples not below 100	0	0	0	
Coliform bacteria (no./100 ml)	Raw water	230	120	340	4
	Filtrate	<1	<1	<1	
	Log_{10} removal	>2.4	>2.1	>2.5	
Enterococci (no./100 ml)	Raw water	27	12	54	4
	Filtrate	<1	<1	<1	
	Log_{10} removal	>1.4	>1.1	>1.7	

The operational performance is summarised in Table 6-5 as backwash water loss, volume for first filtrate, here calculated as the volume of filtrate produced until turbidity was below 0.2 NTU. There was no trend towards decreased filtrate quality towards the end of the filter cycles. Hence no instances of filter breakthrough were observed.

Table 6-5 Results of operational performance: Backwash water, first filtrate, breakthrough and cycle length. n = number of evaluated filter runs; n.d. = no data. No breakthrough detected in any of the filter cycles

Operational performance parameters		**Value**			
Parameter	**Description**	**Mean**	**Min**	**Max**	**n**
Backwash water loss (%)	Ratio of feed water used for filter backwash	8.1%	6.6%	8.5%	16
First filtrate water loss (%)	Ratio of feed water used until <0.2 NTU	5.3%	4.5%	7.0%	13
Time to reach turbidity breakthrough (hours)	Time to reach turbidity >0.50 NTU	n.d.	n.d.	n.d.	n.d.
Time to reach terminal head loss (hours:minutes)	Time to reach vendor-specified head loss	16:57	15:32	21:03	16

6.2 Test site report

The test plant operated continuously during verification testing. 19 filter cycles were recorded during a period of 14 days. The simultaneous monitoring of the on-line parameters turbidity and conductivity made is possible to identify and interpret incidents. During filter cycles 1, 3 and 8, the coagulant dosage pump lost suction, and no coagulant was dosed for some hours. These filter cycles were excluded from the calculation of filter run times. In filter cycles 1 and 8, the disturbance lasted more than 30% of an average filter cycle. Filter cycles 1 and 8 were therefore discarded from the evaluation of on-line data for the calculation of performance parameters. The first sampling occasion for grab samples was from filter cycle 1, which was discarded from the on-line data. Since the grab sampling was done well before the onset of the disturbance of coagulant dosage, the results could be included in the evaluation. After the restoration of coagulant dosage, the test plant returned to mature-filter turbidity around 0.1 NTU within one hour

Figure 6-3. The figure also illustrates that together, the on-line parameters, here turbidity and conductivity, provided a good indication of the test plant's status and function.

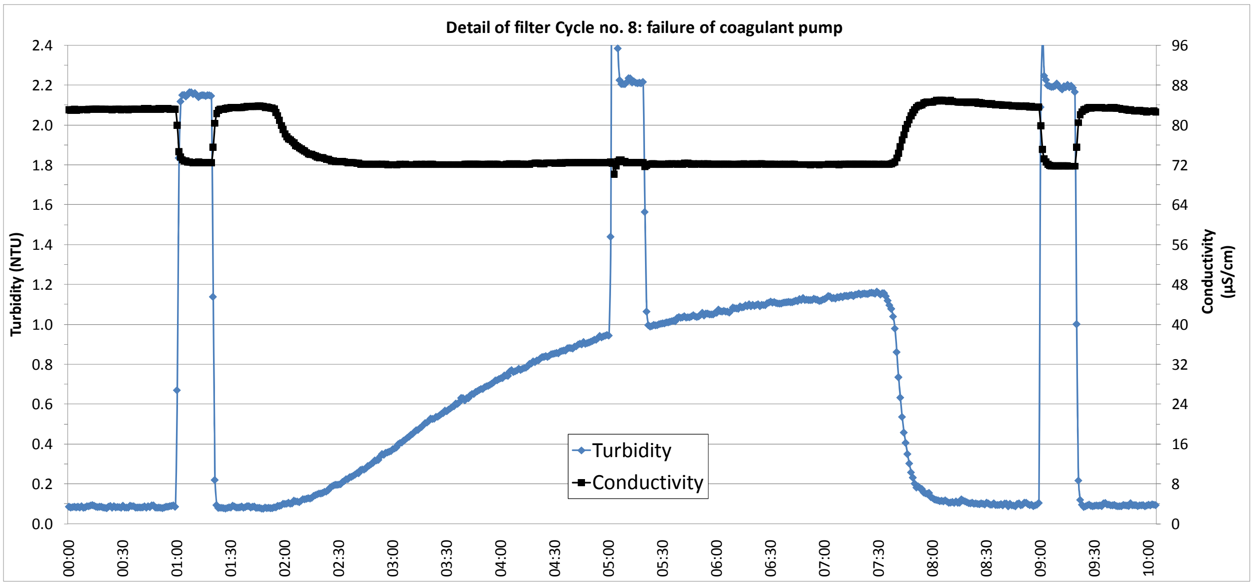


Figure 6-3 Detail of filtrate turbidity and conductivity time series from filter cycle no. 8, showing an incident of coagulant pump failure.

The coagulant solution has an aluminium content of 7.3% and a density of 1.34 kg/l, and contains therefore 97.8 g Al/l. An addition of 110 ml/h, with the planned flow of 3.5 m^3/h, equals an aluminium dose of 3.1 mg Al/l of raw water. The Al doses added, as calculated from seven occasion of weighing the container, ranged from 90 to 105 ml/h. Averaged over the two-week verification testing, the calculated coagulant dose was 102 ml/h. It is concluded that the real coagulant dose was somewhat lower than planned.

The capacity of the feed water pump was slightly affected by the water level on top of the filter bed, which caused a variation of the feed water flow over each filter cycle. In average, the feed flow in the end of the filter cycle was 0.17 m^3/h lower than in the beginning. The range of average feed flows over the filter cycles is reported in Table 2-6.

The calibration of the turbidity meter on 27 April was followed by several hours of unstable turbidity readings (data not shown). There was no indication of a disturbance of filter function, and no unexpected changes in the other on-line parameters. Therefore, turbidity for filter cycle 18 was only evaluated until the beginning of the calibration procedure.

6.3 Amendments and deviations

There were no amendments to the test plan. During the testing, seven deviations to the test plan were noticed. A list of the deviations is included in Appendix 7.

A P P E N D I X   1

Terms and definitions used in the test report

Word	Meaning
Application	The use of a product specified with respect to matrix, target, effect and limitations
Coagulation and direct filtration	Combination of coagulation and media filtration, without flocculation and settling tanks
Coagulation and filtra-tion	Term that includes both Coagulation/direct filtration and Conven-tional treatment
COD	Chemical Oxygen Demand
COD_{Mn}	COD measured by oxidation of the sample with permanganate
Conventional treat-ment	Combination of coagulation, flocculation, settling and media filtra-tion
DHI WMC	(ETV) Water Monitoring Center at DHI
Effect	The way the target is affected
EN	European standard
Experts	Independent persons qualified on a technology in verification or on verification as a process
HPC $_{3\text{-day}, 22°C}$	Heterotrophic plate count, for three days at 22°C. An indicator of water's general bacteriological quality
ISO	International Standardization Organization
Limit of detection LoD	Calculated from the standard deviation of replicate measurements at less than 5 times the detection limit evaluated. Corresponding to less than 5% risk of false blanks
Log_{10} removal	The removal of a particulate or microbial contaminant expressed in logarithmic terms: Log_{10} removal = $-log_{10}$ ($c_{filtrate}$ / c_{raw})
Matrix	The type of material that the product is intended for
Method	Generic document that provides rules, guidelines or characteristics for tests or analysis
NOM	Natural Organic Matter
NTU	Nephelometric Turbidity Unit
Performance claim	The effects foreseen by the vendor on the target(s) in the matrix of intended use
(Environmental) prod-uct	Ready to market or prototype stage product, process, system or service based upon an environmental technology
QA	Quality assurance
SS	Swedish Standard
Standard	Generic document established by consensus and approved by a recognized standardization body that provides rules, guidelines or characteristics for tests or analysis
SUVA	Specific ultraviolet absorbance. DOC (mg/l) divided by UV_{254}. (1/m) Measure of how "humic" the NOM in a water sample is
Target	The property that is affected by the product
Test/testing	Determination of the performance of a product for parameters de-fined for the application
TOC	Total Organic Carbon
TVO	Thematic Verification Organization
USEPA	United States Environmental Protection Agency
Vendor	The party delivering the product to the customer
Verification	Evaluation of product performance parameters for a specified appli-cation under defined conditions and adequate quality assurance

A P P E N D I X   2

References

/1/ DANETV (2009) Centre Quality Manual – Water technology. Version 2, October 2009. www.etv-denmark.com

/2/ DANETV (2010) Rosfilter verification protocol. www.etv-denmark.com

/3/ DANETV (2010) Rosfilter test plan. www.etv-denmark.com

/4/ EPA/NSF ETV Equipment Verification Testing Plan Coagulation and filtration for the removal of microbiological and particulate contaminants. Chapter 3, April 2002. www.epa.gov

/5/ SWEDAC (Swedish Board for Accreditation and Conformity Assessment) Accreditation for Göteborg Vatten's analytical laboratory. Appendix 2, 2009-04-09. www.swedac.se

/6/ SWEDAC Accreditation for ALcontrol's analytical laboratory in Linköping. Appendix 2a, 2008-08-28. 1006-05 Ackr omfattning 080828 - Bil 2A, kemi. www.swedac.se

/7/ DHI Quality System Manual

A P P E N D I X   3

Reference methods

none

A P P E N D I X   4

In-house test methods

none

A P P E N D I X 5

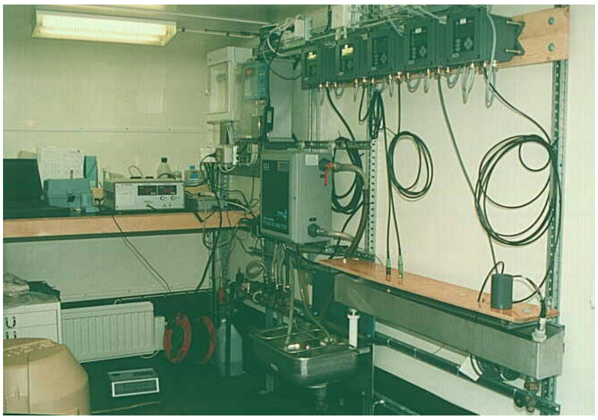
In-house analytical methods

DHI Sweden mobile equipment for on-line water quality parameters in water treatment plants and water distribution systems

The equipment

DHI Sweden has a mobile equipment for on-line measurement of water quality parameters in drinking water treatment plants and at water distribution systems. The instruments are assembled in a trailer transportable by a passenger car. The following instruments and equipment are available:

- UV-absorbance
- Turbidity
- Chlorine residual
- pH
- Redox-potential
- Conductivity
- Oxygen
- Temperature
- Water pressure
- Sample water flow meter
- Sample water valve controller
- Particle counter
- Datalogger with GSM-modem



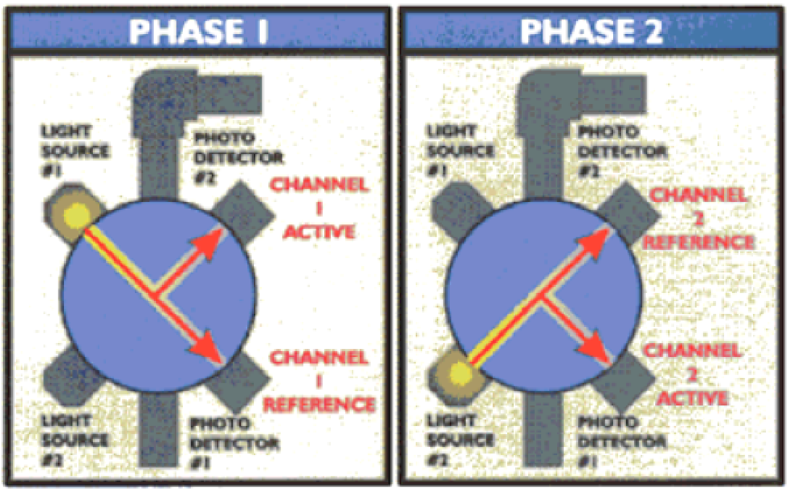
The sample water is led into the trailer normally from a fire hydrant or from a water tap in a plastic tube. The pressure is reduced and the water is led through a measurement channel where the electroanalytical electrodes are inserted, or through the different instruments of flow-through type. The total inflow can be controlled as well as the individual flows through the instruments. The total sample flow is normally 4-6 litres/min, or 8 m3/day. The water is finally discharged via a plastic tube to an appropriate sewer manhole or a drainage ditch.

For water treatment plant studies there are possibilities to use a special UV-absorbance meter together with a sample water valve controller with 4 different inlet sources, thus possible to collect water from various stages in the treatment process in a treatment plant. This equipment can also be combined with optional instruments which are normally used. Two pumps are available to transport water from treatment basins etc.

In the following, those instruments and signals that are relevant for the chemical coagulation treatment step in surface water treatment plants are described in more detail. (The particle counter, however, will be described separately).

Instruments - short description

Turbidity is measured by a GLI instrument (Swedish brand Satron) model Accu 4 with a range of measurements between 0.000-100.0 NTU with four significant digits. The measurement principle is a 4-beam radiometric method according to USEPA (GLI Method 2). The reflection of two different light sources is alternately detected at right angles to incoming light beam.



For calibration a glass cube, factory approved against a known USEPA formazine standard, is used.

Instrument performance

System error ±2% of measurement value for all ranges
Flow velocity 0.2-26.5 l/min
Sensibility 0,001 NTU
Stability 0,1% of measurement range
Integrated air bubble trap for 0.2-1.8 l/min

pH is measured by a GLI instrument (Swedish brand Satron) model P53.
Calibration is performed with buffer solutions with pH 9 and pH 6.

Instrument performance

Measurement range: pH -2.00 to 14.00 pH
Accuracy 0,1% of measurement range
Stability 0,05% of measurement range
Repeatability 0,1% of measurement range

Electrode:
Satron 970070 - for pH-measurements in cold waters with low ionic strength
Combination electrode with closed double KCl reference
0,1-mol KCl i reference part close to the media.
0-14 pH, max 7 bar, max 100 ^{o}C.

Conductivity is measured by a GLI instrument (Swedish brand Satron) model C53

The conductivity measurement cells with internal temperature compensation are at factory calibrated by 1 point so called dry calibration. That means that the cell at factory can be claimed to be exactly measured and marked when temperature- an cell constants are considered.

Measurement units: μS/cm, mS/cm, MΩ · cm, KΩ · cm, ppm, ppb, %

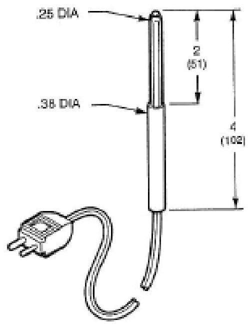
Instrument performance

Cell constants/measurement ranges:
C=0,5 0-1000 μS/cm, 0,001-20 MΩ · cm
Sensibiliy 0,05% av mätområde
Stability 0,05% av mätområde
Repeatability 0,1% av mätområde
Temperature compensation automatisc/manual -20 to +200oC

Temperature information can be fetched as a signal from the conductivity meter.

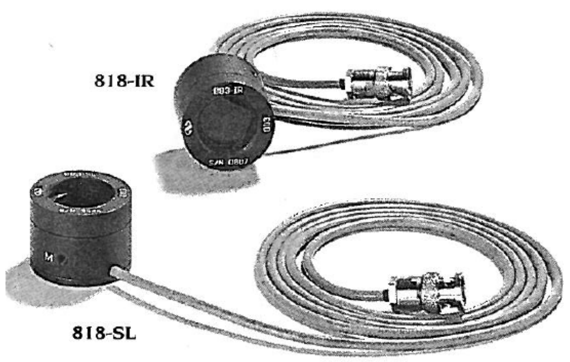
UV-absorbance

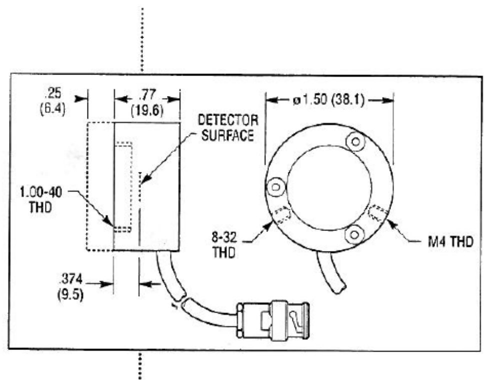
The measurement system for UV-absorbance is constructed by DHI. The sample water is continuously led through a cuvette with a measuring compartment of 4 cm from the light source window to the detector window.



The light source is a spectral calibration lamp Oriel 6035 HG(Ar) with irradiance more than 10 $\mu W/cm^2$ at 50 cm of wavelength 253.7 nm.

An Oriel UV-interference filter 254 nm with bandwidth 10 nm is placed before the detector to ensure that light of the right wavelength is measured.





The detector is a Newport 818-UV detector with an active area 1 cm^2.

The windows in the measurement cell are made of optical quartz glass to ensure that a minimum of the UV light is absorbed on the way.

From the detector a voltage signal is produced as a measure of the amount of transmitted light. The signal is amplified to a voltage of 0-10 V. The amplification can be adjusted by a potentiometer. Calibration is perfomed by putting the light off (0% transmission) and reading the response with the lamp on and the cuvette filled with ultra pure water (100% transmission). The absorbace during measurements is then calculated according to Beers law:

$$ABS_{4cm}=\log(V_{100\%transmission} / V_{Measuredt\ ransmission})$$

A P P E N D I X 6

Test data report

1 Water Quality Sampling (grab samples)

Water quality sampling from analyzed filter run no. 1 (filter cycle no. 1).

Grouped after sample bottles. Fields marked with bold borders to be filled in manually during sampling. Turbidity should be below 0.2 NTU when sampling.

Parameter	Unit	Raw 1	Filtrate 1	Date	Time
COD-Mn	mg O_2/l	4	1	2010-04-14	13:00
Colour	mg Pt/l	20	<5		
Alkalinity	mmol/l	0.31	0.23		
TOC	mg/l	4.7	2.6		
Coliforms	no./100 ml	290	<1		
Enterococci	no./100 ml	13	<1		
HPC $_{3\text{-d},\ 22°C}$	no./ ml	200	<1		
Aluminium	mg/l	0.090	0.020		
pH	-	not taken	not taken		
Turbidity reading	NTU		0.088		

Water quality sampling from analyzed filter run no. 2 (filter cycle no. 7)

Parameter	Unit	Raw 2	Filtrate 2	Date	Time
COD-Mn	mg O_2/l	4	1	2010-04-19	11:00
Colour	mg Pt/l	20	<5		
Alkalinity	mmol/l	0.30	0.23		
TOC	mg/l	5.1	3.0		
Coliforms	no./100 ml	160	<1		
Enterococci	no./100 ml	12	<1		
HPC $_{3\text{-d},\ 22°C}$	no./ ml	100	<1		
Aluminium	mg/l	0.060	0.014		
pH	-	7.4	6.9		
Turbidity reading	NTU		0.087		

Water quality sampling from analyzed filter run no. 3 (filter cycle no. 10)

Parameter	Unit	Raw 3	Filtrate 3	Date	Time
COD-Mn	mg O_2/l	4	1	2010-04-21	11:30
Colour	mg Pt/l	20	<5		
Alkalinity	mmol/l	0.31	0.22		
TOC	mg/l	4.9	2.8		
Coliforms	no./100 ml	340	<1		
Enterococci	no./100 ml	30	<1		
HPC $_{3\text{-d}, 22°C}$	no./ ml	180	<1		
Aluminium	mg/l	0.25	0.014		
pH	-	7.4	7.0		
Turbidity reading	NTU		0.086		

Water quality sampling from analyzed filter run no. 4 (filter cycle no. 18)

Parameter	Unit	Raw 4	Filtrate 4	Date	Time
COD-Mn	mg O_2/l	4	2	2010-04-27	10:30
Colour	mg Pt/l	25	<5		
Alkalinity	mmol/l	0.32	0.23		
TOC	mg/l	4.8	2.6		
Coliforms	no./100 ml	120	<1		
Enterococci	no./100 ml	54	<1		
HPC $_{3\text{-d}, 22°C}$	no./ ml	500	2		
Aluminium	mg/l	0.17	0.015		
pH	-	7.5	7.0		
Turbidity reading	NTU		0.098		

2 Operational data

Coagulant flow

The real coagulant flow was monitored by the operator. The weight of the container with coagulant solution was noted for six times during verification testing[3]. The coagulant flow set point was not changed, but kept constant at 110 ml/h.

Day no.	Date	target ml/h	container weight kg	Time	Volume used	Comment
1	2010-04-14	110	33.5	12:35		Weighed by GHE
2	2010-04-17	110	24.9 → 35.2	15:00	8.6	Added 10.3 kg to container
3	2010-04-19	110	29.3	11:15	5.9	
4	2010-04-20	110	26.2 → 35.1	15:30	3.1	Added 8.9 kg to container
5	2010-04-21	110	32.7	11:30	2.4	Weighed by CHB
6	2010-04-23	110	Not noted	10:00		Added 10.5 kg to container
7	2010-04-26	110	Not noted	9:00		Added 10.7 kg to container
8	2010-04-27	110	34.2	10:40	19.7	Weighed by CHB
9	2010-04-29	110	Not noted	8:30		
10						
11						
12						
13						
14						

[3] Deviation no. 6: The container was supposed to be weighed daily.

3 Filter cycles

Data from on-line pressure sensor.

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Filter run no.	From	To
	Date & time	Date & time
1	14/04/2010 10:58	15/04/2010 10:03
2	15/04/2010 10:11	16/04/2010 01:43
3	16/04/2010 01:51	16/04/2010 19:15
4	16/04/2010 19:23	17/04/2010 11:27
5	17/04/2010 11:35	18/04/2010 04:03
6	18/04/2010 04:11	18/04/2010 20:39
7	18/04/2010 20:47	19/04/2010 13:19
8	19/04/2010 13:28	20/04/2010 10:13
9	20/04/2010 10:21	21/04/2010 07:25
10	21/04/2010 07:33	22/04/2010 01:18
11	22/04/2010 01:26	22/04/2010 18:46
12	22/04/2010 18:55	23/04/2010 12:03
13	23/04/2010 12:12	24/04/2010 05:17
14	24/04/2010 05:26	24/04/2010 22:07
15	24/04/2010 22:15	25/04/2010 15:08
16	25/04/2010 15:17	26/04/2010 07:58
17	26/04/2010 08:06	27/04/2010 00:41
18	27/04/2010 00:49	27/04/2010 17:17
19	27/04/2010 17:25	28/04/2010 10:02
20		
21		
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25		
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A P P E N D I X 7

Amendments and deviations

Deviation report

Rosfilter verification

Deviation number	Verification protocol or test plan reference	Test method step	Deviation	Cause	Impact assessment	Corrective action, if any	Date	Signature test or field responsible	Date	Signature verification responsible
1	Section 8 verification protocol	Verification schedule	The verification testing was started 14 April instead of 13 April	Needed to wait for stable operation and on-line measurements after start-up of equipment	No effect	None	2010-04-14	[signature]	3/5 2010	MTA
2	Performance parameters, tab 4-2 verification protocol	Parameter "Initial turbidity"	Impossible to get stable turbidity reading after 15 minutes.	Test plant sends first filtrate to drain for 10-12 minutes, to avoid dirty water in the backwash tank.	Turbidity after 15 min. cannot be evaluated. This is not critical, since it is not advisable to use the filtrate for drinking water so short into the filter run.	Evaluate "Initial turbidity" after 20 or 30 minutes instead.	2010-04-14	[signature]	3/5 2010	MTA

Deviation number	Verification protocol or test plan reference	Test method step	Deviation	Cause	Impact assessment	Corrective action, if any	Date	Signature test or field responsible	Date	Signature verifycation responsible
3	Test plan section 2.2.5	Taking of grab samples from sample ports	The grab samples for feed water are taken from the raw water pump sump of Lilla Edet water works, by letting down the bottles attached to a stick and submerging them below the water surface	Consistency with normal operations at this site. All raw water samples at Lilla Edet water works are taken this way.	No effect expected	None	2010-04-14	[signature]	3/5 2010	MTA
4	Test plan section 2.2.5	Taking of grab samples	None of the sample bottles are rinsed with sample water.	The bottles for microbial analysis may not be rinsed, since they are pre-conditioned with a chemical. It is not practical to rinse the bottles for sampling of feed water.	No effect expected	None	2010-04-14	[signature]	3/5 290	MTA
5	Test plan section 3.4	pH measurement	The signal from the pH electrode is changing too slowly	Low ionic strength water or faulty electrode	On-line pH data not possible to evaluate	From the second sampling occasion, include pH in the analysis of the grab samples	2010-04-17	[signature]	3/5 2010	MTA

Deviation number	Verification protocol or test plan reference	Test method step	Deviation	Cause	Impact assessment	Corrective action, if any	Date	Signature test or field responsible	Date	Signature verifycation responsible
6	Test plan table 2.6	Frequency of weighing coagulant container	The coagulant container was weighed in total nine times during verification testing, instead of daily. At three of the nine occasions, only the volume filled into the container was noted, not the weight of the container.	Attendance of the technician, weekends, misunderstanding.	Lower resolution in calculation of real coagulant dose, since only data from six instances of weighing are available. No major impact on data quality.	None	2010-05-10	[signature]	12/5 2010	[signature]
7	Test plan table 2.6	Raw water temperature	The raw water temperature exceeded 3 °C during the second week of verification testing	Rapid increase of raw water temperature during verification testing, from 1.5 to 4.5 °C in 14 days	No significant impact. Filtrate quality and operational performance do not appear to be better during the second week.	None	2010-05-10	[signature]	12/5 2010	[signature]

A P P E N D I X   8

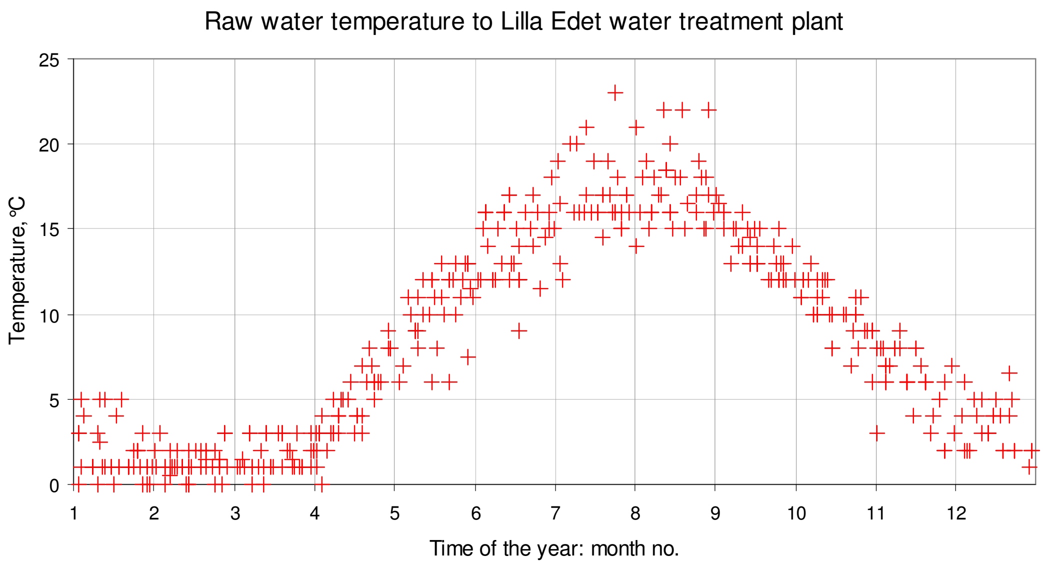
Historical raw water quality at Lilla Edet water works

Raw water quality at Lilla Edet water treatment plant

In the table below is summarized some raw water quality parameters at Lilla Edet water treatment plant. The figures are based on reported chemical analyses from a certified laboratory (ALcontrol laboratories) 2000-2008.

Parameter	unit	mean	max	min	Number of samples
Alkalinity, $HCO3^-$	mg/l	18	21	16	*21*
Aluminium, Al	mg/l	0.16	0.62	0.05	*21*
Color at 405 nm	mg Pt/l	22	50	15	*21*
Iron, Fe	mg/l	0.16	0.49	0.06	*21*
Calcium, Ca	mg/l	7.6	7.9	7.4	*8*
COD-Mn	mg/l	4.4	5.9	3.0	*21*
Chloride, Cl	mg/l	7.5	8.3	6.6	*8*
Conductivity 25°C	mS/m	8.84	9.44	8.10	*21*
Magnesia, Mg	mg/l	1.7	1.8	1.5	*8*
pH 25°C		7.4	7.6	7.2	*21*
Sulphate, SO4	mg/l	9.6	11.0	6.5	*8*
TOC	mg/l	4.3	4.4	4.2	*2*
Turbidity FNU	FNU	6.6	33.0	1.5	*21*

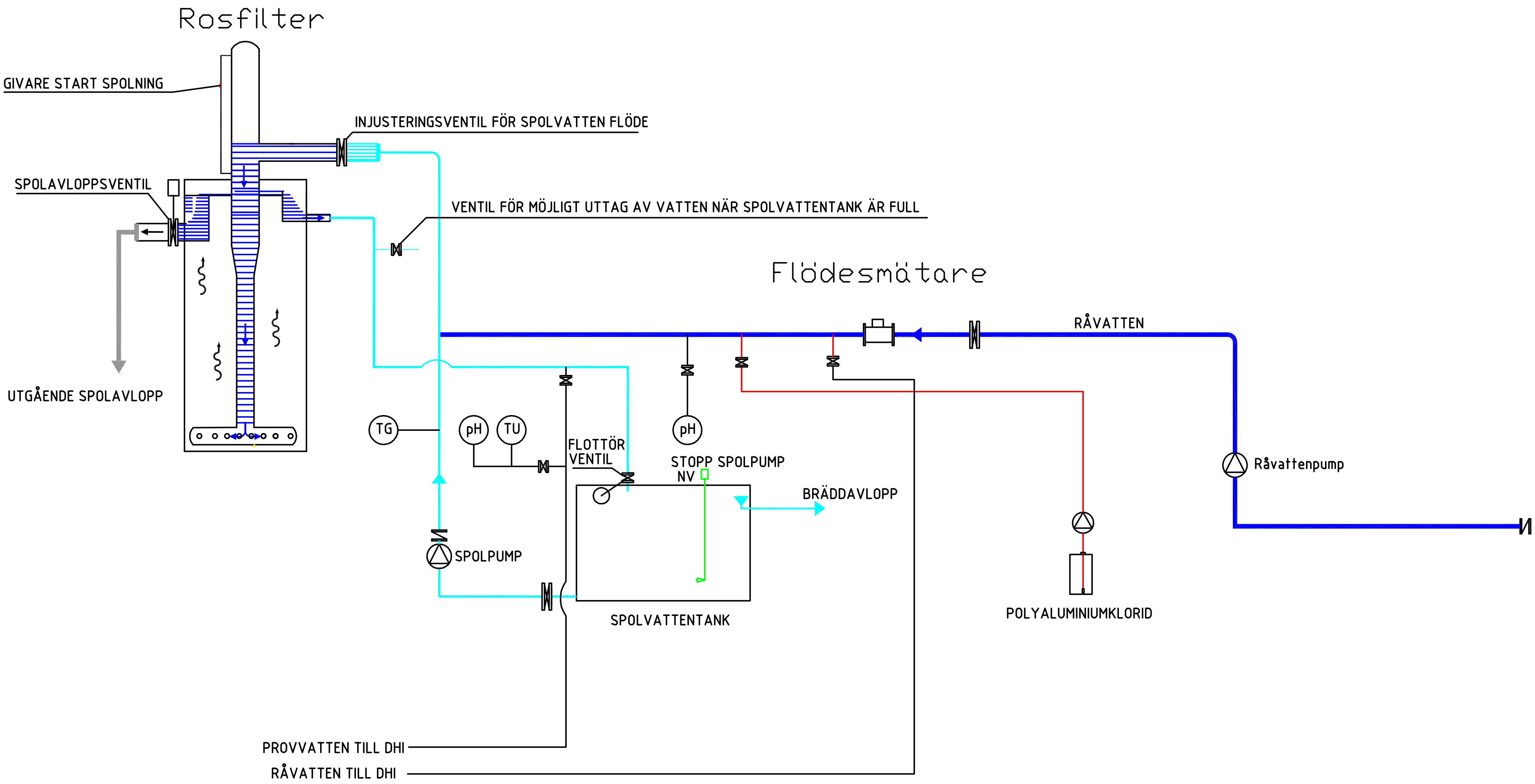
Raw water temperature to Lilla Edet water treatment plant. The figure is based on reported temperaure at sampling for microbiological and chemical raw water analyses. The values are sorted according to time of the year, 2000-2009.



A P P E N D I X 9

Information about the pilot plant (supplied by vendor)

PRINCIP PROVFILTER



INGENJÖRSFIRMA ROS AB
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E-Post lars@ros.se

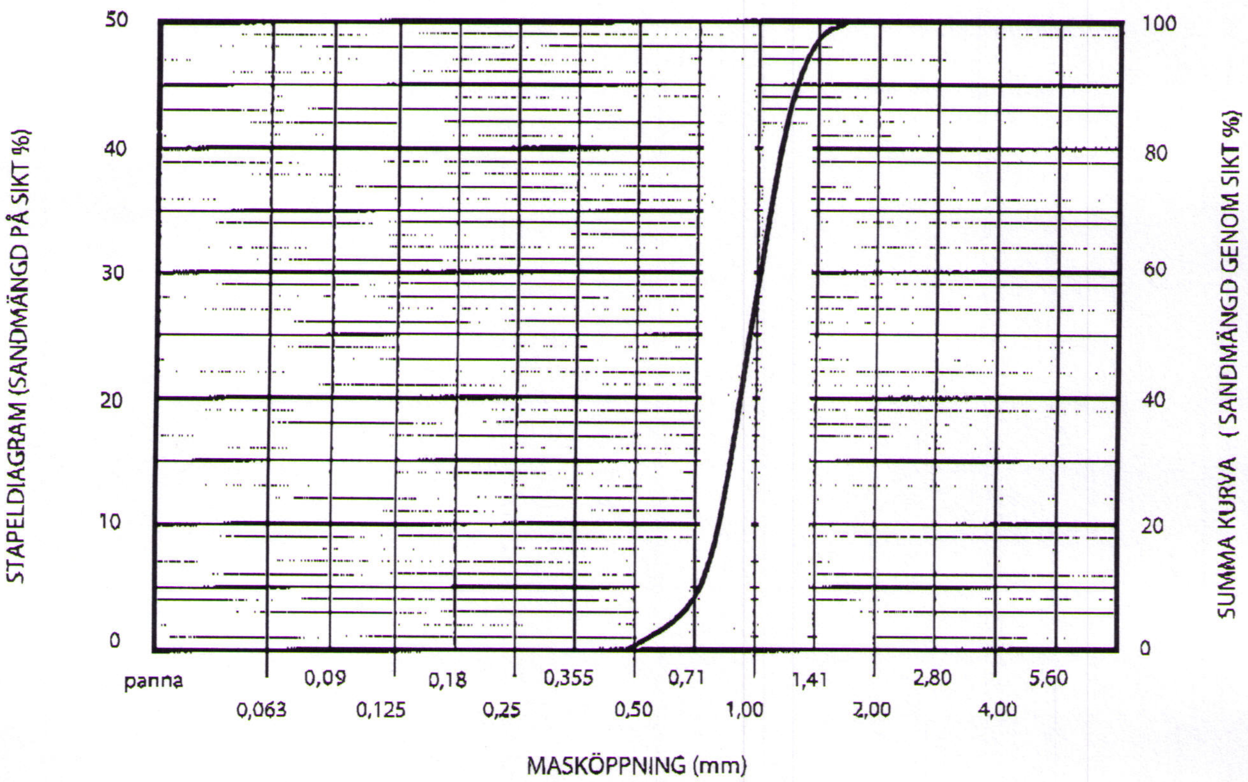
0,8-1,2 mm

TEKNISK DATA

Tvättad sand
Kornform: kantrund
Glödgningsförlust vid 900 grader Celsius: 0,49%
Medelkornstorlek : 1,119 mm
Kornkoncentration : 79,5
Teo.specifika ytan : 24 cm2/g

Mask-öppning mm	ASTM nr.	Sand på sikt (%)	Sand genom sikt (%)
2,00	10	0	100
1,41	14	2, 7	97,3
1,00	18	42,1	55,2
0,71	25	47,0	8, 2
0,500	35	8, 1	0, 1
0,355	45	0, 1	0
0,250	60	0	0
0,180	80	0	0
0,125	12	0	0
0,090	170	0	0
0,063	230	0	0
panna	0	0	

Kemisk analys		
SiO_2	80,70	%
Al_2O_3	10,30	%
Fe_2O_3	1,20	%
CaO	1,19	%
MgO	0,35	%
Na_2O	2,67	%
K_2O	2,92	%



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Ciba

Value beyond chemistry

PLUSPAC 1465

Polyaluminiumkloridlösning

PLUSPAC 1465 är en högkoncentrerad polyaluminiumkloridlösning med hög prestanda. Den aktiva komponenten utgörs i huvudsak av ett polynukleärt högladdat sjuvärdigt aluminiumkomplex. Produktens allmänna formel kan skrivas:

$$[Al_2(OH)_nCl_{6-n} \times H_2O]_m$$

PLUSPAC 1465 neutraliserar laddningen av kolloidal och suspenderad substans och kompakta flockar bildas. Flockarna kan enkelt avlägsnas från vattnet genom sedimentering eller flotation.

PLUSPAC 1465 har upp till 40 % högre laddningstäthet per aluminiumjon än de flesta på marknaden förekommande polyaluminiumkloridprodukter.

Produktegenskaper

- Hög reduktion av turbiditet och suspenderad substans
- Hög basicitet ger mindre pH-sänkning
- Effektiv för slamkonditionering
- Effektiv även vid låga temperaturer
- Låg slamproduktion

Produktspecifikation

Utseende:	gulaktig vätska	
Egenskap:	irriterande	
Al:	7,3 %	± 0,2 %
Cl:	17 %	± 2,0 %
Basicitet:	64 %	± 3 %
Densitet, 20°C:	1,34 g/ml ± 0,2 %	
Viskositet:	21 cP	
pH, 20°:	1,7 ± 0,4	
Fryspunkt:	- 30°C	
Hållbarhet	minst 6 månader	

Spårämnen, medel

Arsenik (As):	<	0,05	mg/kg
Kadmium (Cd):	<	0,04	mg/kg
Kobolt (Co):	<	0,1	mg/kg
Krom (Cr):		0,3	mg/kg
Koppar (Cu):		0,1	mg/kg
Kvicksilver (Hg):	<	0,002	mg/kg
Nickel (Ni):		0,2	mg/kg
Bly (Pb):	<	0,3	mg/kg
Zink (Zn):		1,3	mg/kg

PLUSPAC 1465 möter de krav som ställs i SS-EN 883 svensk standard för processkemikalier för beredning av dricksvatten.

Applikationer

- Dricks- och avloppsvattenrening
- Industriell avloppsvattenrening
- Processvattenrening
- Slamkonditionering
- Laddningsneutralisation inom pappers- och massaindustrin
- Rening av oljeförorenade vatten

Dosering

Produkten doseras med lämplig doserpump, t.ex. av membrantyp direkt i råvattnet eller avloppsvattnet. Tack vare produktens reaktivitet bör doserpunkten väljas så att en god inblandning av koagulanten erhålls. Optimal dos kan bestämmas med flockningsförsök i bägarskala.

Fällnings-pH beror på användningsområdet.

Lagring

Lagertankar skall vara av glasfiberarmerad polyester eller gummerat stål. Undvik detaljer i mässing eller kolstål. Rörledningar och ventiler bör vara i PVC, glasfiberarmerad polyester eller annat syra- och kloridresistent material.

Regelbunden inspektion och rengöring av lagertankar och doseringsutrustning rekommenderas.

Leverans

PLUSPAC 1465 levereras med tankbil eller i plastbehållare (IBC 800-1000 liter).

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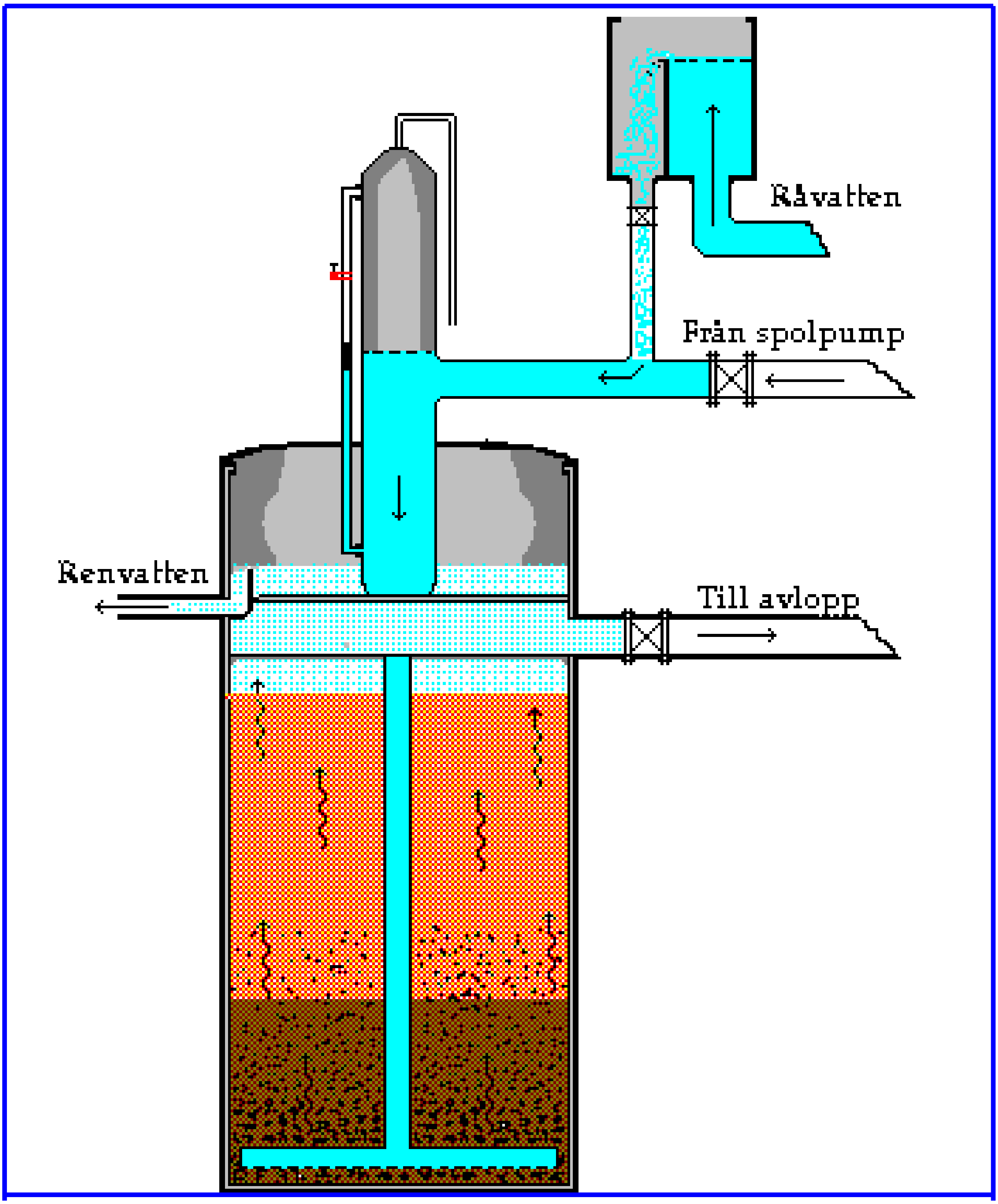
Rev.datum 2007-08-22

A P P E N D I X   1 0

Information about the product (supplied by vendor)

INGENJÖRSFIRMA ROS AB

FÖR VATTENRENING OCH AUTOMATISERING



Kemisk fällning och filtrering med ROS-*FILTER*

Inga flockningsbassänger eller sedimenteringsbassänger behövs.
Flockning, koagulering och avskiljning av flockar sker i filtren.
Genom tillsats av polyaluminiumklorid kan vattnets färg och låsta ämnen flockas ut som fina partiklar som får passera en tre meter hög sandbädd där de utflockade föroreningarna filtreras bort. Vattnet är efter denna behandling rent men kan fortfarande innehålla en del bakterier. När kontaktfiltren är fulla med flockar backspolas de.

Bild från Vattenverket i Tanumshede.
Anläggningen består 10 styck filter 2500 mm diameter, vilka spolas ett i taget medan övriga är idrift.
När vattnet har passerat filtren sker pH justering.
Desinfektion sker med UV-ljus.
Kapaciteten på anläggningen är 250 m3/h.
Färgtal på råvatten ca 40 pt, färgtal på utgående dricksvatten mindre än 5 pt.
Aluminium (Al) på utgående dricksvatten är mindre än 0,05mg/l.

ROS-FILTER®

FÖRDELAR MED METODEN

- Säker drift och perfekt vattenkvalitet under hela driftperioden.
- Ingen risk för igensättningar i filterbotten
- Stillastående filterbädd ger låg grumlighet i utgående vatten.
- Lågt spolvattenbehov och inget behov av tryckluft för att tvätta sanden.
- Filtren kan startas och stoppas helt godtyckligt utan risk för igensättningar eller andra driftsproblem.
- Inget behov av polymerer eller andra hjälpkoagulanter då även mycket små flockar avskilj effektivt i filtret.
- Inga sedimenteringsbassänger eller flockningsbassänger behövs.
- Både flockning koagulering och frånskiljning av flocken sker i filtren.
- Kompakt anläggning ger små uppvärmningskostnader och lägre anläggningskostnad.
- Låga skötselkostnader.
- Låga underhållskostnader.
- Vid flera filter används en fördelningslåda med thomsonskiboard för att få en jämn fördelning till respektive filter.

FUNKTION ROSFILTER

Vattnet tillförs filtren uppifrån genom avgasningskolonnen och strömmar sedan nerifrån och uppåt genom filterbädden.
Fällningskemikalien som tillsätts före filtren gör att det bildas en flock som ansamlas i filterbädden, allteftersom filtret blir igensatt ökar filtermotståndet för att vid ett bestämt värde starta renspolningen.
Endast ett filter i taget spolas, övriga filter kan fortsätta att producera vatten.
Renspolning sker i samma riktning som filtrering men med 10 ggr högre hastighet, normal tid för renspolning är ca 5-7 min, därefter körs vattnet från det nyspolade filtret till avlopp under en tid (första filtrat) för att klarna, därefter går filtret in för produktion igen

INGENJÖRSFIRMA ROS AB
FÖR VATTENRENING OCH AUTOMATISERING

ROSFILTRET
När driftsekonomin avgör

Filtrering genom sandbädd som reningssteg vid kemisk behandling av humushaltiga råvatten har länge varit en beprövad metod för att framställa dricksvatten.

Med ROSfiltret har problemen med filtrering genom en filterbädd i vila fått sin lösning .

Härigenom har de höga driftskostnaderna för spolning av filtren kunnat elimineras.

Metoden ger även möjlighet att spola filtren med luft vilket är en stor fördel framförallt vid slutfiltrering av avloppsvatten.

Filtrets spolsystem bygger på principen att hela filterbädden på traditionellt sätt rengörs på en gång genom en kraftig renspolning med vatten, eller luft och vatten.

Normalt sker spolning en gång per dygn.

Filtrets robusta och enkla konstruktion med ett övergångslager av grovt material vid botten, eliminerar helt igensättningsproblematiken i bottensystemet vid start och stopp.

Stor hålarea i fördelningssystemet eliminerar helt risken för igensättningar.
Spolvattnet kan återvinns i lamellsedimentering eller flotation.
Erfarenheter från över 25-års oavbruten drift vid tidvis svåra råvattenförhållanden.

Filterhall Tanumshede

Det är spolmetoden som ger den låga driftskostnaden.

Fördelar med konstruktionen:

- **Mycket låg energiförbrukning.**
- **Endast drivluft till ventiler erfordras**
- **Filterbädd i vila ger goda reningsresultat**
- **Klarar hög halt av suspenderat material.**
- **Ingen dyrbar kompressorinstallation.**
- **Inget behov av kyld luft för kompressorrum**
- **Ingen restflock till efterföljande filtersteg**
- **Relativt låg bygghöjd ger besparing i anläggningskostnad och uppvärmning**
- **Kan köras med låg belastning utan att ekonomin försämras**
- **Spolvattnet kan återanvändas för renspolning av filter eller som råvatten.**
- **Det ger möjligheter att använda spolvattnet även där återanvänt spolvatten kan ge lukt och smakförsämring i renvattnet**

INGENJÖRSFIRMA ROS AB

FÖR VATTENRENING OCH AUTOMATISERING

ROS-FILTER®

STORLEKAR OCH KAPACITETER

Filter diameter mm	Filterkap l/m vid 5 m/h	m3/dygn vid 22 tim drift
1000	65	78
1200	94	124
1400	128	169
1500	147	193
1800	212	279
2000	262	345
2200	317	418
2500	409	540

FÖR TEST OCH PROVFILTRERING HAR VI TRANSPORTABLA FILTERANLÄGGNINGAR

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INSJÖVÄGEN 13
793 33 LEKSAND

VERKSTAD
BYGGNINGEN
793 90 LEKSAND

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www.ros.se

ROSFILTER

**HÖGEFFEKTIVT FILTER
FÖR VATTENRENING**

Fördelningslåda med tomsonskiboard
för att få ett jämt flöde till respektive filter

Fördelningslåda invändigt

Bilder från byggandet av vattenverket i Tanumshede

INGENJÖRSFIRMA ROS AB

FÖR VATTENRENING OCH AUTOMATISERING

Referens lista för *ROS-FILTER*®

ARVIKA Kommun
Edane vattenverk

Byggtid	–06
Rening av sjövatten	1 st ROS-filter (1350 mm)
Kapacitet dricksvatten	7 m3/ h

NÄSSJÖ Affärsverk AB
Forserums Vattenverk

Byggtid	-06
Rening av sjövatten	3 st ROS-filter (2300 mm)
Kapacitet dricksvatten	62m3 / h

SÅTENÄS F7

Byggtid	-05
Rening av sjövatten	3 st ROS-filter (2000 mm)
Kapacitet dricksvatten	45 m3/ h

HAGFORS Kommun
Ullenverket
Komplettering av befintliga vattenverket

Byggtid	–04/05
Rening av sjövatten	4 st ROS-filter (2500 mm)
Kapacitet dricksvatten	100 m3/ h

Årjängs kommun
Töcksfors vattenverk

Byggtid	-04
Rening av Sjövatten	3 st ROS-filter (1600 mm)
Kapacitet dricksvatten	30 m3/ h

TANUMS kommun
Tanums vattenverk

Byggtid	–02/03
Rening av Sjövatten	10 st ROS-filter (2500 mm)
Kapacitet dricksvatten	250 m3/ h

OSCARSHAMN Kommun
Fredriksbergs vattenverk

Byggtid	–00/01
Rening av sjövatten	17 st ROS-filter (2700 mm)
Kapacitet dricksvatten	400 m3/ h

ARVIKA Kommun
Edane vattenverk

Byggtid	–99
Rening av sjövatten	2 st ROS-filter (1350 mm)
Kapacitet dricksvatten	14 m3/ h

LIDKÖPING Kommun
Läckö vattenverk

Byggtid	–98
Rening av sjövatten	2 st ROS-filter (1200 mm)
Kapacitet dricksvatten	11 m3/ h

HAGFORS Kommun
Ullenverket

Byggtid	–97/98
Rening av sjövatten	8 st ROS-filter (2500 mm)
Kapacitet dricksvatten	210 m3/ h

INGENJÖRSFIRMA ROS AB

FÖR VATTENRENING OCH AUTOMATISERING

NÄSSJÖ Affärsverk AB

Nässjö Vattenverk

Byggtid	–96
Rening av sjövatten	12 st ROS-filter (2600 mm)
Kapacitet dricksvatten	6500m3 / dygn

Kostrzynskie Zakladsky

Pappersbruk, Polen

Byggtid	–94/95
Rening av flodvatten	12 st ROS-filter (2500 mm)
Kapacitet processvatten	6000 m3/ dygn

NORA Kommun

Stribers vattenverk

Byggtid	–93/94
Rening av sjövatten	10 st ROS-filter (2000 mm)
Kapacitet dricksvatten	3000 m3/ dygn

LERUMS Kommun

Annekärrs vattenverk

Byggtid	–93
Rening av sjövatten	ROS_filter (1150 mm)
Kapacitet dricksvatten	5,4 m3/ h

VALDEMARSVIK Kommun

Koppartorps vattenverk

Byggtid	–92
Rening av sjövatten	3 st ROS-filter (1800 mm)
Kapacitet dricksvatten	750 m3/ dygn

Lilla Edets Kommun
Lilla Edets vattenverk
Segrare i tävlingen Sveriges godaste kranvatten 2005

Rening av älvvatten	Varit i drift sedan 1978
Kapacitet dricksvatten	200 m3/ h