GRAF Maintenance Manual for SBR Wastewater Treatment Systems

EPro System/EClean System

No mechanical parts
in the wastewater

No pumps
in the wastewater

No electrical parts
in the wastewater

Art. no. 307-EN-0318

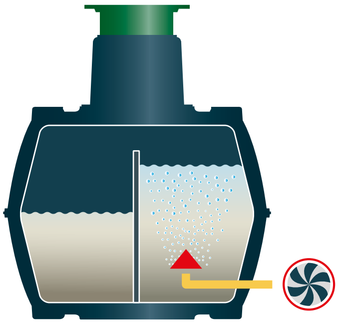
Table of contents

Status: 03/2018 *Technical changes are reserved!*

1. Introduction

GRAF wastewater treatment systems have been on the market since 2001, providing optimal cleaning performance and a long service life. Two treatment systems have been in use since 2015: The classic Epro-SBR procedure with two chambers – an upstream sludge storage/buffer and a downstream biological cleaning stage. The newer SBR treatment system Eclean has only one large aeration chamber in which contaminants are biodegraded and mineralised.

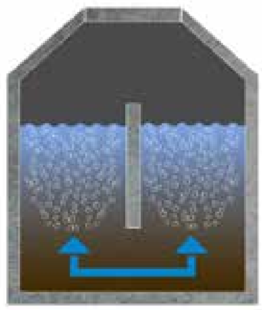
Wastewater treatment system Epro



This revised manual provides recommendations on how to successfully perform maintenance in a professional and effective manner, which includes equipment tips, detailed descriptions of work steps, proper assessments of results, description of impairment causes and rectification. Furthermore, there are many tips and tricks on how to optimally configure the systems and a wealth of background knowledge. Differences between the respective treatment systems are explicitly indicated.

The manual is to be understood as a recommendation based on many years of practical experience.

Wastewater treatment system Eclean



We recommend

- Each maintenance procedure is to be documented with the GRAF maintenance protocol (annex).
- Work steps are to be performed in sequence as described in this manual (and in the maintenance protocol).
- For further enquiries, always note the serial number of the control cabinet (printed on the type plate or cabinet).

2. Safety instructions

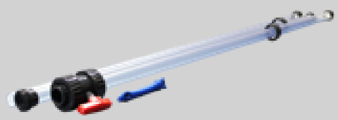
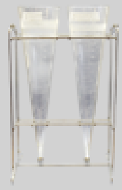
Special safety measures must be implemented when performing maintenance on treatment systems since wastewater and surfaces contacted by wastewater may be contaminated with viruses, pathogenic germs and worm eggs. Inadequate or insufficient hygienic measures can cause illnesses (avoid direct contact with wastewater and surfaces contacted by wastewater).

Safety instructions:

- Protective-clothing requirements
- Wear hygienic gloves. Wash and disinfect hands after contacting wastewater.
- Vaccination for tetanus and hepatitis B recommended
- Consult a doctor in case of wastewater ingestion.
- A second person must always secure the entry to the system since harmful gasses may occur within the system.
- Open shaft covers are hazardous. Use caution when walking backwards and leaving the system for a short period of time (e.g. to check the control cabinet). Ensure that the shaft cover is secure and locked after maintenance.
- Do not eat or drink while working.

3. Equipment and accessories

We have provided a list of equipment, tools and replacement parts that should be available so that maintenance measures can be performed in a professional manner.

Maintenance accessories	Purpose/Characteristics	Illustration
Sludge pipette	• To determine the level of sludge in pre-treatment/sludge storage • Benefit Sludge is clearly visible.	
Sludge-level measurement device	• To determine the level of sludge in pre-treatment/sludge storage • Advantage: simple handling	
Sampler	• Used to scoop samples from the treatment outflow and sludge samples (SV_{30}) from the SBR basin • Plastic cup 600 ml • Telescopic 1.0 - 3.0 m	
Measurement cylinder	• To determine the volume of sludge (SV_{30}) • 1000 ml, Ø 65 mm • Plastic or glass cylinder, graduated and fully transparent	
Imhoff funnel + rack	• To determine the level of sediment (SS_{120}) • Funnel glass with partition • 1000 ml	
Measurement cup	• Odour, colouring, opacity assessment • Beaker	

Maintenance accessories	Purpose/Characteristics	Illustration
Sample bottles + cooling box	• HDPE Sealable bottles • For laboratory examinations • 1000 ml for BOD_5 and SS_{120} • 500 ml for COD, N, P (mixed with 2 ml H_2SO_4)	
COD cuvettes	• Reagent cuvettes with chemicals for photometric COD measurement	
COD photometer	• Analysis of COD value	
Safety glasses	• Eye protection when handling dangerous chemicals	
Oxygen measurement device	• Measuring dissolved oxygen [mg/l] in activation basins and sampling in combination with temperature measurement [°C] • E.g. HACH LANGE HQ30d with sensor LDO101	
Ammonium test strips	• Ammonium measurement • Assessment of whether aeration is sufficient • Measurement range: 0 to 400 mg/l NH_4^+	
Nitrate/Nitrite test strips	• Nitrate measurement • Measurement range: 0 to 500 mg/l NO_3^- • Nitrite measurement • Measurement range: 0 to 80 mg/l NO_2^-	

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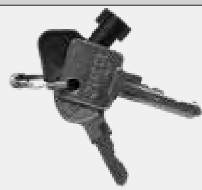
Maintenance accessories	Purpose/Characteristics	Illustration
Phosphate test strips	• Phosphate measurement PO_4^{3-} • Measurement range: 0 to 80 mg/l	
pH measurement strips	• To determine the pH value • Measurement range: pH 4.5 - 10	
Hygienic gloves	• Protection against germs	
Quick-test kits for various parameters	• PO_4-P 0 - 5 mg/l • NH_4^+ 0.5 - 15 mg/l • NO_2^- 0 - 0.5 mg/l • NO_3^- 1 - 120 mg/l • Hardness from 1°d	
Disinfectant	• Germ protection	
Cover lifter	• Lifting concrete/cast-iron shaft covers	
Socket wrench	• Socket wrench 17 mm for opening GRAF shaft covers	

Maintenance accessories	Purpose/Characteristics	Illustration
Folding ruler	• To determine the level of sludge and water in Dosin	
Cabinet key	• For opening all GRAF control cabinets (interior and exterior)	
Screwdriver	• Slot screwdriver for controls disassembly for exterior columns (“Geyer columns”) • Blade length: 14 cm minimum	
Socket wrench	• Socket wrench 7 mm, 8 mm, 10 mm for hose clamps and compressor	
SD card	• Controls readout (KLplus controls)	
Hose clamps	• For securing SBR Hoses, made from stainless steel • With designation W5	
Manometer	• Checking the filling-level measurement and membrane wear • Connections 4/6 mm • Measurement range 0 - 0.6 bar	

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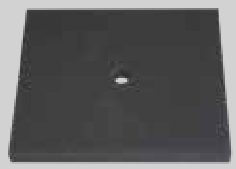
Maintenance accessories	Purpose/Characteristics	Illustration
Multimeter	• Measurement of capacity, voltage, current, throughput in the control cabinet	
Portable compressor	• Cleaning of air filters, valves, compressors	
Allen key	• 5 mm for maintenance Becker compressor	
Smoke cartridge	• Aeration check in the treatment system	
Work gloves	• Hand protection while working on the treatment system	
Battery	• Replacement batteries for ZK and ZK-plus controls • Internal 9-V block battery for limited operation for operating voltage failure	
Controls	• Replacement controls (KLbasic and KLplus) for magnetic valves (230 V) • Replacement controls (KL24base and KL24plus) for stepper motor valves (24 V)	

3. Equipment and accessories

Maintenance accessories	Purpose/Characteristics	Illustration
Magnetic valve	• Replacement coil with anchor and spring • With straight tappet from 07/2002 to 05/2006 • With conical tappet from 06/2006	
Wear-part sets piston compressor	• **Content:** Pistons, gaskets, air filters	
Wear parts for rotary-slide compressor	• Filter cartridges • Carbon-slider replacements	
Wear-part set for membrane compressor	• **Content:** Print hammer, membranes, accessories	
Air filter fleeces for cabinets and compressor	• Air filter for compressor Nitto or Hiblow • Air filter for ventilation screen 120 x 120 mm or 280 x 280 mm depending on cabinet type	
Microfuses	• Replacement fuses for all control types • 2 A (time-delay) • 6.3 A (medium time-delay) • 8 A (medium time-delay)	
Disc aerator	• Replacement of defective aeration discs • Ø 340 mm • Connection ¾”	

Maintenance accessories	Purpose/Characteristics	Illustration
Weighted disc aerators	• Replacement of all types of defective aerators • Can simply be lowered into basin • Ø 340 mm • Hose connection 19 mm	
Hose with hose bracket	• Replacement for dosing pumps • Various types per pump and flow rate	
Cooling fan	• As replacement for cabinets with rotary-slide compressor or for retrofitting cabinets with piston compressor	
Nozzles	• As replacement in case nozzles break off • Angled or straight	
Sealing tape	• For subsequent sealing of hose connections and threads	
Maintenance case	• **Content:** 1 measurement cylinder 1000 ml, 1 measurement cup 800 ml, pH measurement strips, disposable hygienic gloves 100 pcs., smoke cartridges 5 pcs., ammonium measurement strips	

4.1 Visual impression

Visual check of the treatment system

Minimum water level

After opening the shaft cover, the technician gets an overall visual impression of the Epro treatment system.

The following determinations must be made:

General accessibility to the system
→ **Shaft cover easily accessible/not blocked?**

- State of the shaft cover
  → **Breakage, tears, child-safety function for PE covers...?**
- State of the inflow and outflow pipe
  → **Indications of blockages?**
- Completeness and correct arrangement of installation parts
  → **Aeration equipment, air-lift pump, air hoses, sampling?**
- Water levels of individual chambers
  → **Indications of chamber overflow, hydraulic overload, problems with air-lift pumps?**
- Possible foaming in the aeration chamber
  (see page 45)
  → **Surfactant foam:** White foam, compact, stable, does not disintegrate upon contact, shines in rainbow colours
  → **Protein foam** Light-grey or beige foam, often piled up high, immediately disintegrates upon contact
  → **Bubbly floating layer:** Grey or brown, bubbly, viscous, compact layer, covers the entire surface of the SBR basin, does not pile up, does not disintegrate upon contact, cannot be destroyed with spray water
- Indications of fat deposits especially for restaurants
  → **Fat separator missing, overloaded or disposal required**
- System ventilation
  → **Via roof, shaft cover or other ventilation equipment**
- External seal tightness of the septic tank
  → **Intrusion of drainage water and high water levels, leakage indication if the filling level is below “Minimum water level”**
- Indications of possible corrosion damage
  → **In particular for concrete pits, often concomitant with technical problems and lack of ventilation**

4.2 Sampling for laboratory examinations

4.2.1 Sampling

A random outflow sample of the treatment system can be taken for subsequent laboratory examinations within the context of maintenance. The sample can be extracted from a sampling device (rule) or directly from the SBR basin (exception).

The following must be taken into account:

Extraction from sampling device

Outflow sampling without contacting the walls

An SBR treatment system normally has a sampling device. The device is perfused with wastewater during each clear-water extraction phase, replacing "old" with "fresh" water. Procedure: Water is carefully extracted with a scoop from the integrated sampling device or the downstream sampling shaft. The walls of the sampling tank are not to be contacted because deposits may loosen and deteriorate the sample disproportionately.

NOTICE: Make a note in the maintenance protocol as to where and how the sample was taken.

Extraction from SBR basin

Outflow sampling after sufficient settling time

The sample must be directly extracted from the SBR basin in case a sampling device is not available. In exceptional cases, it may also be useful to sample directly from the SBR chamber despite the fact that a sampling device is available. **Example:** Maintenance of a vacation home that is unoccupied for longer periods of time with sampling water that must be many days or weeks old.

Procedure: The activated sludge must settle sufficiently prior to sampling. We recommend a settling time of at least 30 min. Check the current system phase at the controls. You can immediately perform the sampling if the system has already been in the settling phase for more than 30 min. Otherwise wait. For all other phases, the system should be currentless for the required settling time. The sample should be extracted as close to the surface as possible or slightly below the waterline Carefully push away any foam or film on the surface. Please take into account that the timing of the sampling can make a difference. In the worst-case scenario, the sampling is performed at the beginning of the cleaning cycle when the contamination concentration is higher than at the end.

4.2.2 Filling, storage, transport

Random samples for laboratory examinations are carefully filled into sealable sample bottles. Various sample bottles exist depending on the laboratory and parameters to be examined.

Examples:

BOD_5

The bottle must be filled completely with as few bubbles as possible in order to determine BOD_5. Carefully knock against the filled, open bottle so that air bubbles are released from the edge of the bottle. Fill up the sample bottle again until it overflows. Then seal it.

COD, N and P compounds

Bottles that already contain sulphuric acid (H_2SO_4) are often used to determine COD, N and P compounds as these immediately stop all degradation processes in the water so that the sample is not falsified on the way to the laboratory.

SS

Approx. 0.5 l of the random sample must be filtered and the filter residue weighed in order to determine SS. Fibreglass filters or paper filters with a pore size of 0.3 µm to 1 µm are normally used for filtration. Thus, the same random sample can be used as for BSB_5. An additional sample bottle is not required.

SS_{120}

Exactly 1.0 l of the random sample is required for the determination of SS_{120}. For this reason, we recommend filling an additional random sample into a different sample bottle in order to precisely determine sedimentable substances. The random sample is to be carefully removed from the sampling container and refrigerated until the time of analysis.

The sample bottles must be labelled in a comprehensible manner (name/date/place). Subsequently, the samples must be refrigerated and stored in a dark place. A cooling box with cold packs is ideal. The samples should be brought to the laboratory as quickly as possible since compositions change over time.

Local requirements determine the parameters for the sample examination.

Various sample bottles

NOTICE: An explanation of the following wastewater parameters and abbreviations is listed from page 50.

4.2.3 Odour, colouring, opacity assessment

Traditional characteristics

Odour, colouration and opacity are traditional characteristics of a wastewater sample. The evaluation of these semi-qualitative parameters provides a very good status indication of the treatment system's cleaning performance – without the use of measurement devices. It is best to assess parameters immediately after extracting the random sample.

Odour

The measuring cup with the sample is swivelled during the odour test. The type of odour is differentiated (none, weak, strong). The sample should smell neutral or earthy. The cleaning performance of the treatment system is impaired if the sample smells mouldy, foul or mucky (e.g. due to insufficient aeration).

Colouration

For the colouration determination, colour strength and colour hue are best viewed and assessed against a white background. The random sample should be clear to yellow. A brown or grey colouration indicates insufficient cleaning.

Opacity

For the opacity determination, the random sample in the measuring cup is held against natural light, and the degree of light weakening is assessed. The sample is clear if no suspended substances are contained in the random sample. The sample is opaque if lots of suspended substances are contained in the random sample. Strong opacity or lots of suspended substances indicate poor sludge-flake sedimentation.

No colouration and no opacity

Slight beige colouration and no opacity

Opacity

Brown colouration and opacity

4.3 On-site measurements

A series of simple but extremely effective measurement methods exist for assessing the functionality of wastewater treatment and detecting impairments. These will be presented in detail in the following.

4.3.1 Sludge volume (SV_{30}) in the SBR basin (activation)

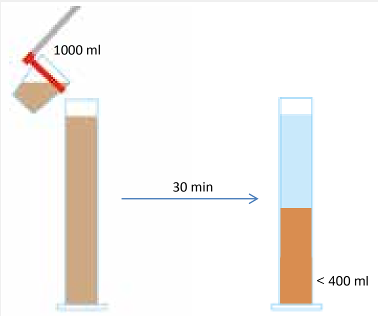
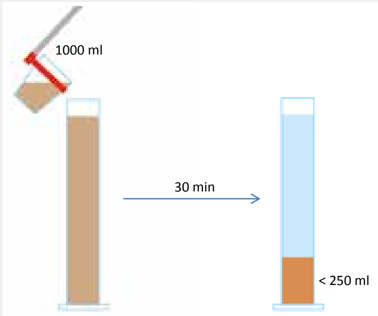
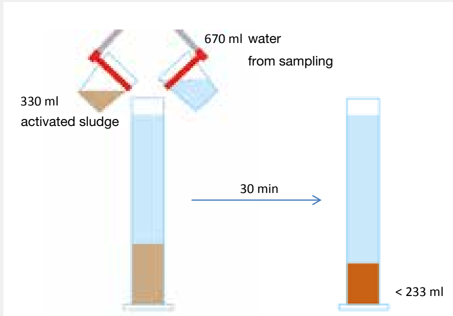
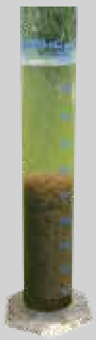
Extraction of a sludge sample from the activation basin

SV_{30} indicates the sludge volume in a 1-litre activated sludge sample from the activation basin after a settling time of 30 minutes. The sludge volume is a measure of the amount of biologically active sludge. This value provides an important variable for wastewater analytics since the performance capacity of the activation system is controlled via the sludge volume. For *Eclean*, it is also a characteristic variable for determining whether the sludge must be removed or not.

The determination of SV_{30} is regulated in DIN EN 14702-1. Accordingly, high sludge volumes (> 250 ml/l) are not representative. **Justification:** An altered settling process occurs in the comparatively narrow measurement cylinder since the walls of the container and interactions amongst individual flakes disrupt the settling process. Thus, the measurement for larger sludge volumes (> 250 ml/l) is performed with dilution. This especially applies to *Eclean* systems, which can be operated with high sludge content. The content is usually less and the measurement accuracy less relevant for Epro systems with pretreatment. Dilution can be omitted in this case.

Preparation:
Aeration of the activation basin must be active or turned on in manual mode. An activated sludge sample can be extracted from the activation basin with a scoop as soon as the activation basin has been mixed sufficiently. Measurement cylinders must be protected from vibration and direct sunlight.

4.3.2 Measurement performance

Epro	Eclean	
One-time determination: Undiluted	Double determination with 2 measurement cylinders: 1x undiluted, 1x diluted	
		
Fill up sludge sample up to the 1000 ml mark.	Fill up sludge sample up to the 1000 ml mark.	Only fill in 330 ml of the sludge sample, then fill wastewater from the sampling up to the 1000 ml mark.
Read after 30 min and round off to 10 ml/l.		
Note the value. Done.	< 250 ml/l: Note the value. > 250 ml/l: Discard measurement, use dilution.	< 250 ml/l: Multiply value by 3, note the result. > 250 ml/l: Note the result ">750 ml/l".
Measures: < 400 ml/l: None/OK > 400 ml/l: Check pretreatment whether sludge removal is necessary, increase the sludge (T12) return.	**Measures:** < 250 ml/l: None/OK	**Measures:** < 700 ml/l: None/OK > 700 ml/l: Initiate sludge removal, increase aeration.
Example: Undiluted measurement result: 550 ml/l → Moderately increase the sludge return. 	**Example:** Undiluted measurement result: 750 ml/l → Discard 	**Example:** Diluted measurement result: 190 ml/l → 190 * 3 = 570 → Result: 570 ml/l 

4.4 Oxygen in the outflow and SBR basin

Sufficient oxygen supply is a basic precondition for successful wastewater cleaning. Oxygen supply is sufficient when oxygen remains at the end of the treatment cycle (after the settling phase). As a check, oxygen is measured in the outflow sample and not in the activation basin. The oxygen concentration is determined with measurement devices, which requires certain basic knowledge (calibration, maintenance, storage, etc.) as well as reading and understanding the manual. Measurement values are precise when the procedure is properly executed. Ammonium test strips can also be used as an alternative. This simplified, semiquantitative method roughly assesses whether sufficient oxygen is present (see page 23).

4.4.1 Measurement in the outflow

The measurement probe is held directly into the sampling container or cup containing the outflow sample. Now the measurement device can be started. It automatically measures dissolved oxygen content in the water, which should ideally be above 4 mg/l, but never below 2 mg/l. An adjustment of aeration times at the controls is recommended for apparent deviations (see chapter "Configuring optimal operating values").

Oxygen measurement

- O_2 < 2 mg/l → Increase aeration
- O_2 = 4 to 8 mg/l → Do not change aeration
- O_2 > 8 mg/l → Aeration can be reduced

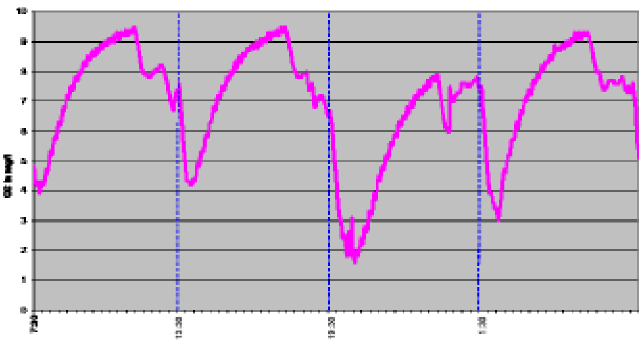
The following must be taken into account:

- Seasonal fluctuations may occur. The solution behaviour of oxygen is better in cold than in warm water. Therefore, measurement values are often a little higher in winter than in summer.
- The oxygen concentration also depends on the amount of activated sludge (SV_{30}). More oxygen is consumed, and the oxygen concentration is lower if the amount of activated sludge increases. This aspect must especially be taken into account for systems with seasonal fluctuations and changes to sludge return times at the controls.
- Operating with increased aeration and higher oxygen content is especially recommended for *Eclean* systems as this most often has a positive impact on water quality and sludge mineralisation.
- Too much aeration is only rarely a problem.
  → Flake disintegration (see page 48)
  → Denitrification (see page 54)

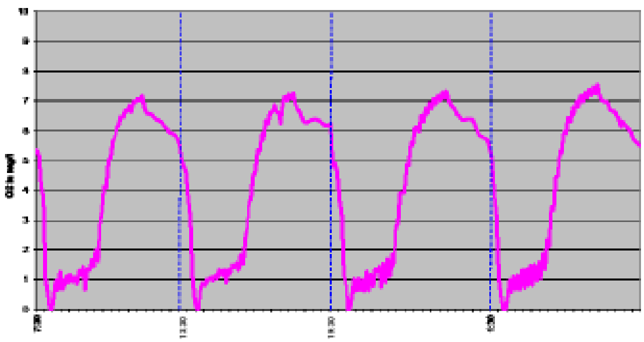
4.4.2 Measurement in the activation basin

In addition to the outflow measurement, another measurement can be performed in the activation basin, which specifically relates to the nitrification and denitrification assessment. Aeration of the activation basin remains activate when measuring the oxygen concentration. The probe of the measurement device must be immersed in the activation basin.

Oxygen concentration increases during the aeration phase since wastewater cleaning occurs sequentially in 4 phases (loading, aeration, sedimentation and discharge/sludge return) for the SBR procedure in the activation basin. However, the oxygen concentration decreases before and after the aeration phase, i.e. during the loading, sedimentation and extraction phase (see the following diagrams).



Typical daily progression of the O_2 concentration in the Epro-SBR chamber



Daily progression of the O_2 concentration in the SBR chamber with additional deni phase

For Epro treatment systems, which are additionally designed for denitrification, low-oxygen circulation of the activation basin is achieved (the so-called deni phase) by means of short aeration bursts – prior to the actual aeration phase. Denitrifying microorganisms are stimulated to convert nitrate to elementary nitrogen. The oxygen concentration decreases greatly during the deni phase ($O_2 \approx 0$ mg/l). The oxygen concentration may not be more than 0.5 mg/l during the deni phase in order to ensure optimal denitrification. Thus, the oxygen concentration in the activation basin of the treatment system depends on the respective phase of the SBR procedure, often making it difficult to accurately interpret the measured oxygen concentration directly from the basin.

4.4.3 Aeration observation in the SBR basin

Aeration and bubble formation are observed in the activation chamber during active aeration in order to assess the aeration functionality for the wastewater.

The following characteristics should be taken into account

- **Moderate to intensive**
  → Circulation clearly discernible?
- **Course or fine bubbles**
  → Pinhead-sized bubbles (approx. 2 cm in diameter) should appear and burst at the surface.
- **One-sided or consistent**
  → Membrane aerators should work at equal strength if multiple aerators are installed in the tank.

Fine-bubble aeration

4.5 Water temperature in the outflow

Water temperature has an impact on important physical and biological processes (e.g. the solution behaviour of oxygen in water, nitrification, etc.). Temperatures are usually measured in the outflow sample concurrently with the oxygen determination since the measurement device also displays the temperature. A scoop thermometer can be used as an alternative.

4.6 Conductivity

Conductivity is regarded as a total parameter for ion concentration and thus for salt content in wastewater. A conductivity measurement device or sensor is used for the measurement. For small-scale treatment systems, values between 800 - 1400 µS/cm (or 0.8 – 1.4 mS/cm) are usually detected in the outflow. This type of measurement is not mandatory for small-scale treatment systems, but useful since it can indicate possible problems.

- < 800 µS/cm → Indication for foreign water inflow
- >1400 µS/cm → Indication for overfull pretreatment/required sludge removal, intrusion of problematic substances, many cleaning agents, etc.
- > 2500 µS/cm → Indication for a decalcification system, possible biological damage (→ Flake disintegration, see page 48)

4.7 pH values in the outflow

The pH value should be in the range of 6 - 8 for biological wastewater cleaning since most microorganisms are damaged or become inactive outside of this tolerance.

Special indicator paper or test strips are the easiest way to determine the pH value. Indicator paper with a rough measurement range of pH 1 -12, a narrower range (e.g. pH 5 - 8) and with higher accuracy are available. The indicator paper is briefly immersed in the outflow sample, and the colouration is compared on a scale. Measurement devices that measure the pH value in 0.1-pH units are also available. An accuracy of 0.5 is sufficient for our purposes.

pH measurement with test strips

A further examination of water hardness and acid capacity can be helpful in case of permanently low pH values and problems with the cleaning performance.

4.8 Water hardness

The content of dissolved calcium and magnesium salts (hardeners) in water is referred to as water "hardness". Most natural waters only contain calcium and magnesium compounds. The total hardness represents the total of carbonate and non-carbonate hardness. Carbonate hardness occurs when combining calcium and magnesium with carbon dioxide dissolved in water. Soft water has a low content of calcium and magnesium. Thus, the critical factor for wastewater treatment is carbonate hardness. Carbonate hardness and not total hardness contains important components that stabilise the pH value, preventing extreme pH values and ensuring the functionality of a small-scale treatment system.

Water has different degrees of hardness depending on the region. Since its revision in 2007, the Washing and Cleansing Agents Act has classified water hardness according to three degrees:

- **Soft:** < 1.5 mmol calcium carbonate per litre (or 8.4 °dH)
- **Medium:** 1.5 to 2.5 mmol calcium carbonate per litre (or 8.4 to 14 °dH)
- **Hard:** > 2.5 mmol calcium carbonate per litre (or more than 14 °dH)

The unit °dH stands for degrees of German hardness.

4.9 Acid capacity

Acid capacity is a measure of the buffer capacity of water in regard to acids and thus critical for the stability of the pH value. There is a connection between acid capacity and water hardness (carbonate hardness) since acid capacity is essentially determined by the hydrogen carbonates of calcium, magnesium and sodium dissolved in water. Thus, acid capacity can be converted to carbonate hardness. Acid capacity x 2.8 = Carbonate hardness (°dH). The higher the water hardness, the less sensitive the pH value in regard to acid increases in water and the higher the buffer capacity. Water hardness can be increased by adding buffering agents. The acid capacity of water plays an important role for the stability of wastewater treatment. Acids that consume the buffer capacity are especially generated during nitrification. The buffer capacity is increased in denitrification. The acid capacity of water should at least be 2 mmol HCO_3-/l to ensure that wastewater treatment can occur without problems.

Consequences of low acid capacity

Both nitrification performance and flake formation decrease if the acid capacity is not sufficient for maintaining a pH value over 7.0. Additionally, an acid capacity that is too low results in the propagation of undesired filamentous bacteria, which can also lower the treatment performance. Concrete corrosion can even occur over longer periods of time in case of poor buffer capacity.

Measurement

Acid capacity can be determined with titration or cuvette tests. For titration, the water sample is initially mixed with an indicator before hydrochloric acid is added in drops until the colour of the sample rapidly changes. The amount of added hydrochloric acid in ml corresponds to the acid capacity in mmol HCO_3-/l.

Regulation

The acid capacity is influenced negatively if phosphorous is eliminated in the system with the usage of acidic precipitation agents. Natron-containing precipitation agents increase the capacity. Both acid capacity and pH value can be increased with denitrification. The addition of auxiliary agents such as chalk or hydrated lime can further increase the acid capacity.

4.10 Nitrogen parameters Ammonium, nitrite and nitrate

Threshold values for ammonium (NH_4-N), nitrite (NO_2-N) and nitrate (NO_3-N) are usually determined in the laboratory if these parameters are required. For outflow class N, NH_4-N is measured in the outflow; for outflow class D, the total of NH_4-N + NO_2-N + NO_3-N is also observed. There are also simple quick-tests for a (rough) determination on-site, which is beneficial because the technician can immediately detect to what extent nitrification/denitrification has occurred, whether optimisation is required or whether biological inhibition is present due to extremely high nitrogen loads in the inflow.

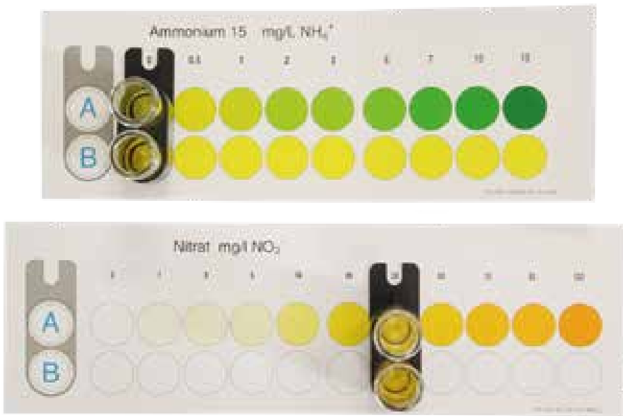
Test strips

Simultaneous determination of NO_2 and NO_3

The examination with test strips is easy and quick. Test strips are available for all three parameters. Nitrate and nitrite can be measured simultaneously with a strip.

Caution: The nitrate measurement is no longer reliable when nitrite is present. However, in most cases, the accuracy of an initial on-site assessment is usually sufficient.

Quick-test kit



Measurement with ammonium and nitrate quick-tests

As an alternative, on-site measurements can also be performed with test strips rather than with quick-tests. The test procedure is a little more elaborate, but offers much better accuracy than test strips. The measurement principle is based on concentration-dependent sample colourations. A few millilitres of the sample are distributed into two glasses. One glass is used as a comparative sample and the other as the measurement sample. Chemicals are then added to the measurement sample according to the instructions, which results in a colour change. The concentration in the measurement sample is determined visually by means of a colour scale and the comparative sample.

Notice:
The measurement results for quick-tests are usually provided as NH_4^+, NO_2^- and NO_3^- and must still be converted to NH_4N, NO_2N and NO_3N!

Ammonium quick-tests can also be useful when an oxygen measurement device is not available: Oxygen supply must be sufficient if good nitrification is detected.

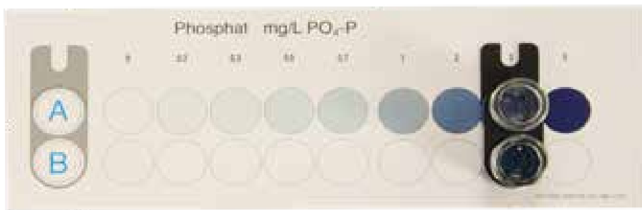
Conversion
$NH_4 - N = NH_4^+ * 0.78$
$NO_2 - N = NO_2^- * 0.30$
$NO_3 - N = NO_3^- * 0.23$

Only the outflow can be measured for *Eclean* systems. For Epro systems, samples from pretreatment can additionally be examined. Conclusions can be drawn from the results in regard to the effectiveness of nitrification (NH_4-N degradation). The sample concentration from pretreatment/sludge storage should be approx. 70 mg/l and < 10 mg/l for the outflow sample. Inflow conditions must be checked if the sample concentration from pretreatment/sludge storage is much greater than 70 mg/l.

	Pretreatment/ Sludge storage	Outflow sample	Result
Nitrification NH_4N-content	Approx. 70 mg/l	< 10 mg/l	Gute Nitrifikation, O_2-Gehalt ausreichend
	Approx. 70 mg/l	> 10 mg/l	Poor nitrification
	> 70 mg/l	> 10 mg/l	Poor nitrification
Denitrification NO_3N-content	Approx. 0 mg/l	< 15 mg/l	Very good denitrification
	Approx. 0 mg/l	< 25 mg/l	Good denitrification
	Approx. 0 mg/l	> 25 mg/l	Insufficient denitrification

4.11 Phosphate

The parameter P_{tot} is usually relevant if phosphate threshold values must be maintained. This parameter can only be determined in the laboratory. However, P_{tot} for household wastewater mostly consists of orthophosphates (PO_4-P), which can be determined relatively easily with quick-tests. A measurement of this parameter on-site is extremely useful since the maintenance technician can immediately determine whether the dosage of the precipitation agent is sufficient or adjustments must be made. The measurement accuracy is certainly sufficient for this purpose. Alternatively, a photometer offers more precise measurements for PO_4-P.



Measurement with phosphate quick-test.

Notice:

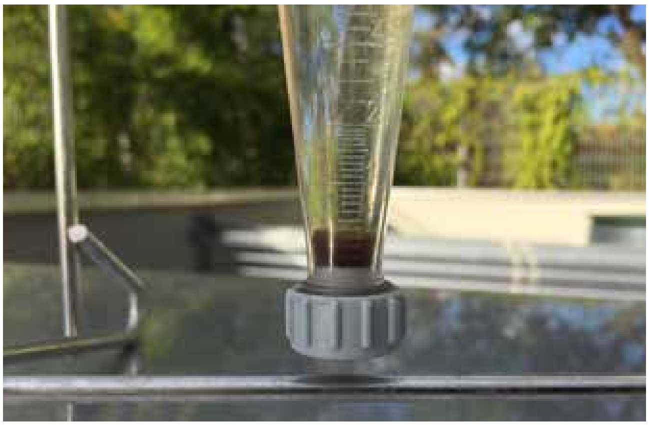
Depending on the measurement method, the result may still have to be converted. Check how the result is issued. We require PO_4-P.

Conversion
PO_4-P = $PO_4^+ * 0.326$

4.12 Sedimentable substances (SS_{120}) in the process

Sedimentable substances contained in the outflow sample (SS_{120}) indicate the ratio of solid content and include sedimentable, undissolved contaminants. The determination of sedimentable substances is performed with the Imhoff funnel (funnel-shaped glass). The Imhoff funnel must be placed in the rack in an upright position. The outflow sample is filled to the 1000 ml mark in the Imhoff funnel. The amount of sedimentable substances is determined by reading the substance volume in the funnel tip after a standing time of 2 hours. The funnel is rotated back and forth 15 minutes before the standing time lapses since solids may attach themselves to the slanted funnel wall. Generally, no threshold value is determined for SS_{120}. The amount of sedimentable substances in the outflow should not exceed the **guidance value < 0.3 ml/l**. We recommend to not perform this measurement on site, but later on company premises or in the laboratory since the determination of sedimentable substances takes 2 hours. The sample is to be stored in a refrigerator.

Imhoff funnels with two outflow samples



Measurement result after 2 hours of settling time in ml/l

4.13 Sludge-level measurements in pretreatment (only Epro)

The sludge height in pretreatment/sludge storage directly impacts the cleaning performance of the treatment system. Thus, checking the sludge height is very important.

Sludge consists of bottom and floating sludge. The floating-sludge thickness is to be estimated and entered in the report. The bottom-sludge thickness can either be determined with a sludge pipette or an electronic sludge-level measurement device.

4.13.1 Sludge pipette

The sludge pipette consists of a transparent PVC pipe with a sealing mechanism – ball valve or swinging flap – at the end.

Procedure: The floating sludge layer is carefully pushed aside so as not to clog the lifter during immersion. The pipe with opened valve is slowly pressed into the pretreatment/sludge storage up to the bottom of the container. The valve is closed, and the pipette can be extracted again via a control cable (in case of ball valve) or with an abrupt movement (in case of a check valve). The system's chamber content takes the form of a closed column in the sludge pipette, which allows for a direct reading of the sludge layer for pretreatment/sludge storage. The sludge layer – i.e. solid components – must be clearly differentiated from the solid-free zone. It is recommended to rest the full sludge pipette for a few minutes in an upright position so that the interior sludge-water layers can settle, making it easier to take the reading. The measured sludge height is recorded in the report. The sludge removed with the sludge pipette is returned to the pretreatment/sludge storage. The pipette is cleaned on the inside by immersing it in the aerated chamber.

It is best to store the sludge pipette in a PVC pipe after usage due to hygienic reasons. The storage pipe is sealed at the bottom with a stopper in order to catch residual liquids.

Advantages: Measurement is always possible even when the sludge-water phase cannot be clearly discerned.
Disadvantages: Measurement apparatus is relative large; the pipe must be extended for deep pits.

Measurement with the sludge pipette

Sludge thickness is subsequently measured with a folding ruler.

4.13.2 Sludge-level measurement device

The sludge-level measurement device indicates the transition between the clear phase and the settled sludge.

Procedure: The floating sludge layer is carefully pushed aside in order to not cover the sensor head with paper during immersion. The sensor is slowly immersed. The installed digital display shows the current immersion depth of the measurement probe.

A signal light concurrently indicates when the sensor has reached the sludge layer. Total water depth minus the immersion depth equals the sludge height.

Advantages: The device is small, compact and easy to clean and transport.
Disadvantages: Measurement is difficult if the sludge-water phase is not clearly separated.

Measurement with the sludge-level measurement device

Thickness of the clear phase is indicated, sludge phase below.

4.14 Sludge removal

The maintenance technician informs the system operator whether sludge must be removed from the system. This should be clearly indicated in the maintenance report. The operator is responsible for promptly initiating the sludge removal.

Epro

The chamber must be cleared at the latest when the sludge storage is 70 % full. Systems that are measured with “pretreatment” (425 L/EW) must be cleared at a filling level of 50 %. “Sludge storage” or “pretreatment” is the space from the bottom of the tank to the minimum water depth in the first chamber.

Procedure:

- First, floating sludge is suctioned from the surface; the suction pipe is then placed on the bottom of the pit.
- A residual water amount of approx. 10 cm should remain at the bottom in pretreatment.
- After emptying, the sludge storage or pretreatment chamber should be filled again with fresh water.
- A complete emptying of small-scale treatment systems is only appropriate in case of a malfunction whose cause cannot be determined or if the interior of the tank requires repairs below the water edge.

Eclean

Sludge removal is stipulated for a sludge volume exceeding 70 %. Measurement see page 17

Procedure:

- Insert the suction hose in the sludge-extraction pipe all the way to the ground and pump.
- For multi-chamber systems, the suction hose is to be inserted in the first chamber.
- Sufficient residual sludge automatically remains in the system if the sludge-removal pipe is used. Approx. 30 cm of wastewater and sludge should remain in the treatment system as seed sludge.

NOTICES:

- The disposer must immediately refill the chamber with clear water after sludge removal.
- Dates for maintenance and sludge disposal are to be coordinated jointly. It does not make sense to perform maintenance immediately after emptying.

5. Machine-technology maintenance

5.1 Air filter

The air filters at the control cabinet (ventilation screen to the left and right in the casing wall of the interior cabinet or at the back of the exterior cabinet) are to be checked and possibly cleaned or exchanged. The screen on the exterior side of the cabinet must be removed. The clip-lock must be loosened by pressing lightly with a screwdriver; the screen is then removed by hand. The filter mat is located in the ventilation shaft without additional fastening and can be shaken or blown out.

NOTICE:
Clogged filter mats impact the ventilation of the control cabinet. Possible permanent consequences:

Removal of the ventilation screen

Checking the filter mat

5.2 Controls

5.2.1 Impairment notification readout

The control logbook is to be checked in order to determine which impairment notifications have occurred since the last maintenance performance. Perform the following steps in the operator menu of the controls:

- “Readout of old impairments” (for type plus)
- “Show errors” (for type basic)

The most recent notification is displayed here with date and time. The user navigates to the previous notifications by pressing the buttons  or  .

NOTICE:
128 impairment notifications can be saved. The oldest one is deleted when the maximum number is reached. The maintenance specialist can delete stored values in the service menu via the command “Empty logbook”.

5.2.2 Operating hours

The total operating hours of consumers (valves, compressor, ...) as well as utilisation (only for type plus) are to be viewed and protocolled.

Perform the following steps in the operator menu for the controls:

- “Operating hours counter reading” (for type plus)
- “Show op. hrs.” (for KLbasic and ZK)

The operating hours of the compressor indicate whether the compressor must be maintained.

“Utilisation %” (only for type plus) indicates the ratio as to how many treatment cycles have actually been performed. A standard system performs 4 cycles per day = 100 % (2 cycles for **Eclean**). The display, first and foremost, provides a plausibility check to determine whether the function “Underload detection” has been properly configured.

5.2.3 Readout with SD card (only KLplus)

The rubber stopper at the front of the controls must be removed and an SD card inserted in the empty slot in order to perform a readout. The user switches to the item “SD card” in the service menu and confirms with Set in order to start data transmission. “SD card OK” appears as soon as the data has been transmitted in full. The user can now exit the service menu by pressing Esc multiple times and then remove the SD card.

The card slot in the controls is to be carefully closed again in order to prevent any intrusion of moisture.

The software GRAF@kom transmits the data readout from the SD card to a PC in fully formatted Excel tables. These tables can be further processed, saved and printed, e.g. as an annex to the maintenance report.

Manual data readout

Readout via SD card

5.2.4 Functional check

As a check, all consumers are briefly activated and deactivated in sequential order in the menu “Manual mode”. The controls display an electric malfunction as an impairment. Proper functionality of the components inside the treatment tank should be visually checked. The treatment cycle is stopped in the background when switching to the menu “Manual mode”.

The treatment cycle starts again when the user exits the menu “Manual mode” with “Esc”. **Exception:** The cycle does not continue, but is cancelled for KL controls in the settling phase. The controls automatically switch to a cycle pause, which prevents insufficiently settled water from accidentally being pumped out in the subsequent outflow phase.

NOTICES:
- For the older controls ZK and ZK plus, an examination of the 9-V battery is concurrently performed in the background.
- Alternatively, the function “Execute functional test” can be activated in the service menu for manually switching valves 1-4. The controls automatically activate and deactivate valves 1-4 for a few seconds after a waiting time of 2 minutes.
- Caution when removing the outflow sample! For the functional test of valve 3, the outflow lifter usually carries contaminated or insufficiently settled water from the SBR chamber to the integrated sampling. Sampling for laboratory examinations is then no longer possible. Therefore, always perform the sampling BEFORE the functional check.
- For systems with P-precipitation, a check is performed to determine whether the dosage pump works, all connections are connected directly and precipitation agent is dripping into the SBR basin.

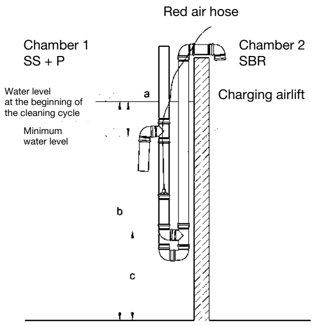
5.2.5 Checking the filling-level measurement

The measurement should be tested with each maintenance performance if the system is being operated with active filling-level measurement. This is possible in manual mode. The measured value is displayed after about 25 seconds. A subsequent measurement must be performed manually with the folder ruler for comparison purposes. Deviations should not exceed +/-3 cm. Greater deviations can occur for *Eclean* systems due to leakage in the measurement line or wear of the membrane aerator. This can be visualised by integrating a manometer between the controls and the air diffusers and repeating the measurement.

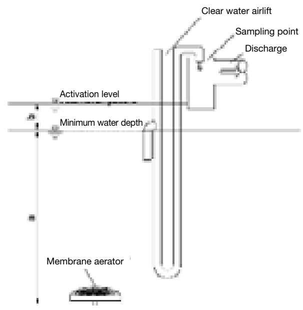
- **Tight:** The needle slightly oscillates for a few seconds after stopping the compressor and rests on a value that roughly matches the water depth. (1 m = 0.1 bar = 100 m bar)
- **Leaky:** The needle consistently drops to zero after the compressor stops.
- **Membrane wear:** The manometer shows a value that is clearly above the water column + 50 mbar.
  Example: Water depth is actually 1.20 m (= 0.12 bar = 120 mbar). The manometer should indicate approx. 170 mbar.

Measurement with the manometer

All connections must be checked and carefully tightened in case of leakage, which includes hose clamps and nozzles with threads. The measurement is to be performed again to determine tightness. Finally, the filling-level measurement must be recalibrated as for the initial commissioning.



Filling-level measurement via loading lifter for Epro



Filling-level measurement via aerator for *Eclean*

NOTICE:

- For Epro systems, the filling level is measured via the loading lifter (valve 1, red hose) in "pretreatment" (first chamber). The value measured with the manometer is always lower than the water depth measured with the folding ruler since the insufflation point at the lifter is not at the bottom of the container, but always slightly higher.

NOTICE:

- For **Eclean** systems, the filling level is measured via the membrane aerator (valve 1, blue hose) in the reactor chamber. The water column (aerator always on the bottom) plus approx. 50 mbar opening pressure must be overcome in order for the air to escape. Thus, the needle of the manometer is expected to approximately stop at the water column (in mbar) + 50 mbar. Membrane aerators age slowly, and opening pressure slowly increases over the years.

5.2.6 Configuring optimal operating values

Controls are configured ex-factory according to utilisation (EW figure) and the cleaning class printed on the type plate. For safety reasons, consistent, maximum utilisation of the system is assumed. Control configurations can be adjusted to the actual conditions on site. We recommend performing adjustments of this kind only after a safe start-up phase, e.g. within the context of the first maintenance measure. Significantly lower runtimes can usually be achieved. Down-regulating should occur in small steps and is to be documented in the logbook or maintenance report so that the change is comprehensible when performing the next maintenance measure.

Adjustment of the EW number or cleaning class

The currently configured control table, e.g. Epro 8 EW C" is displayed in the menu "Display settings". Another table can be selected and activated in the service menu by pressing Set.

NOTICES:

- The newly selected table is initially displayed in the menu "Display settings" if the old cycle has ended or was cancelled with the function "Cycle restart".
- The annex provides an overview of all control tables. A maximum of 25 tables can be stored in the controls. Tables can be prompted via the SD card for special applications. Please consult Epro on this matter.

Adjustment of aeration times

The cycle setting "Aeration ON T6" and "Aeration OFF T7" can be changed in the service menu under the function "Configuring cycle times" in order to reduce oxygen input during the aeration phase.

NOTICES:

- Always confirm a change of cycle times with Set. Changed cycle times are only displayed in the menu "Display settings" if the old cycle has ended or was cancelled with the function "Restart cycle".
- KLbasic and KLplus show the currently configured aeration duration in hours per day with T18. Changes to aeration times can be easily comprehended here.
- For Epro: Do not change the "Aeration phase T 5". Extending this phase may exceed the maximum permissible total cycle time, which results in the loss of the subsequent cycle (the controls switch to "Cycle pause") and a reduction of the actual total aeration duration. For *Eclean* systems of outflow class C, the aeration phase can be increased up to 100 min without exceeding the cycle time.

Cycle	Function	ACTUAL status	Decrease	Increase	Maximum
T 5	Aeration phase [min]	250	250	250	250
T 6	Aeration ON [min]	4	3	5	250
T 7	Aeration OFF [min]	6	7	5	0

Example: Configuring aeration for the Epro treatment system

Configuring the number of cleaning cycles

The number of cleaning cycles can be reduced from 4 to 2 cycles per day for consistently strongly underloaded Epro systems (e.g. only 1 person in the house). This is most easily achieved by increasing the cycle time "Settling phase T8" from the standard setting "90 min" to "100 min". As a consequence, the max. permissible total cycle time is exceeded, and only every second cycle is executed. The system operates in "Cycle pause" between these cycles. This does not apply to Eclean systems. Aeration times can be reduced in case of underloading.

Configuring the sludge return time

The duration of the sludge return can be reduced or increased via T12, which is performed in minute increments for ZK and ZKplus. For KLbasic and KLplus, this can be configured in second increments. The sludge return time should be changed by a maximum of 1 minute or 60 seconds. Pretreatment is usually full in case activated sludge content is extremely high for Epro.

Configuring the underload function

The underload function (only for ZKplus and KLplus) is primarily intended as an energy-saving measure. The filling-level height, which triggers the treatment cycle can be configured in the service menu under "Configuring the filling-level measurement". "Utilisation" in the menu "Operating hours counter meter" indicates the actual ratio of cleaning cycles to pause cycles.

Configuration options

- Reduce "Filling level start from: xxx cm" if: displayed utilisation is low, but filling levels in the tank are high; outflow quality is unsatisfactory.
- Increase "Filling level start from: xxx cm" if: displayed utilisation is high, but filling levels in the tank are low; outflow quality is good.

5.2.7 Programming GRAF

Cycle time	Explanation	Valve		4 EW C	4 EW N	4 EW D
T 1	Loading	1	[min]	6	6	6
T 2	Deni phase		[min]	0	0	30
T 3		Off	[min]	0	0	9
T 4		On 2	[sec]	0	0	30
T 5	Aeration phase		[min]	250	250	220
T 6		On 2	[min]	4	5	6
T 7		Off	[min]	6	5	4
T 8	Settling phase		[min]	90	90	90
T 9	Outflow phase		[min]	6	6	6
T 10		On 3	[min]	6	6	6
T 11		Off	[min]	0	0	0
T 12	Sludge return	4	[sec]	60	60	60
T 13	Cycle pause	Off	[min]	15	15	15
T 14	Cycle pause	On 2	[min]	2	2	2
T 15	Vacation	On 2	[min]	2	2	2
T 16	Vacation	Off	[min]	15	15	15
T 17	Cycle duration		[min]	353	353	353
T 18	Aeration duration		[h/d]	6,7	8,3	8,8
T 19	Runtime per day		[h/d]	7,5	9,2	9,7
	Number cycles		[pcs.]	4	4	4
	Start time 01		[Time of day]	01:30	01:30	01:30
	Start time 02		[Time of day]	07:30	07:30	07:30
	Start time 03		[Time of day]	13:30	13:30	13:30
	Start time 04		[Time of day]	19:30	19:30	19:30

NOTICES:
- Tables according to EW/outflow class
- T4 and T12 can be in [min] rather than [sec] for older controls.
- The cycle duration T17 must be less than 360 min if the system is operated with 4 cycles per day.
- The controls automatically “fill” the difference between actual cycle duration and 360 min in the cycle pause.

5.2.8 Programming Epro

Cycle time	Explanation	Valve		2V 4C	2V 4N	2V 4D	3V 4C	3V 4N	3V 4D
T 1	(Loading)	1	[min]	0	0	0	0	0	0
T 2	Deni phase		[min]	0	0	90	0	0	90
T 3		Off	[min]	0	0	18	0	0	18
T 4		On 1	[sec]	0	0	60	0	0	60
T 5	Aeration phase		[min]	480	480	480	480	480	480
T 6		On 1	[min]	4	5	5	4	5	5
T 7		Off	[min]	6	5	5	6	5	6
T 8	Settling phase		[min]	120	120	120	120	120	120
T 9	Outflow phase		[min]	10	10	10	10	10	10
T 10		On 2	[min]	10	10	10	10	10	10
T 11		Off	[min]	0	0	0	0	0	0
T 12	Sludge return	3	[sec]	0	0	0	120	120	120
T 13	Cycle pause	Off	[min]	15	15	15	15	15	15
T 14	Cycle pause	On 1	[min]	2	2	2	2	2	2
T 15	Vacation	On 1	[min]	2	2	2	2	2	2
T 16	Vacation	Off	[min]	15	15	15	15	15	15
T 17	Cycle duration		[min]	610	610	700	612	612	702
T 18	Aeration duration		[h/d]	6.4	8.0	8.0	6.4	8.0	8.0
T 19	Runtime per day		[h/d]	6.7	8.3	8.3	6.8	8.4	8.4
	Number cycles		[pcs.]	2	2	2	2	2	2
	Start time 01		[Time of day]	07:00	07:00	07:00	07:00	07:00	07:00
	Start time 02		[Time of day]	19:00	19:00	19:00	19:00	19:00	19:00

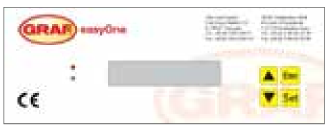
NOTICES:
- Tables according to EW/outflow class/number valves (2V or 3V)
- Assignment of values different than for Epro, a different programme is loaded ex-factory.
- Max. cycle duration 720 min

5.2.9 Programming GRAF Eclean

Cycle time	Explanation	Valve			4 EW	4 EW D	5 EW	5 EW D	7 EW	7 EW D
T 1	Deni phase			[min]	0	90	0	90	0	90
T 2		Off		[min]	0	18	0	18	0	18
T 3		On	1	[sec]	0	60	0	60	0	60
T 4	Aeration phase			[min]	480	480	480	480	480	480
T 5		On	1	[min]	6	6	6	6	6	6
T 6		Off		[min]	4	4	4	4	4	4
T 7	Settling phase			[min]	120	120	120	120	120	120
T 8	Extraction phase	On	2	[min]	11	11	12	12	14	14
T 9	Cycle pause	off		[min]	30	30	30	30	30	30
T 10	Cycle pause	On	1	[min]	9	9	9	9	9	9
T 11	Cycle duration			[min]	611	701	612	702	614	704
T 12	Aeration duration			[h/d]	9.60	9.60	9.60	9.60	9.60	9.60
T 13	Runtime per day			[h/d]	9.97	10.12	10.00	10.16	10.07	10.22
	Number cycles			[pcs.]	2	2	2	2	2	2
	Start time 01			[Time of day]	7:00	7:00	7:00	7:00	7:00	07:00
	Start time 02			[Time of day]	19:00	19:00	19:00	19:00	19:00	19:00

NOTICES:

- Tables according to EW/outflow class
- Table shows the outflow with software 10-315-12. For previous versions, aeration times and allocation on/off for T2/3 and T 10/11 partially deviated.
- Eclean tables have somewhat higher aeration times ex-factory since these systems are mostly operated with filling-level measurements in order to ensure a higher basic supply.



5.3 Compressor

Maintenance work and intervals depend on the compressor type.

5.3.1 Piston compressor "NITTO"

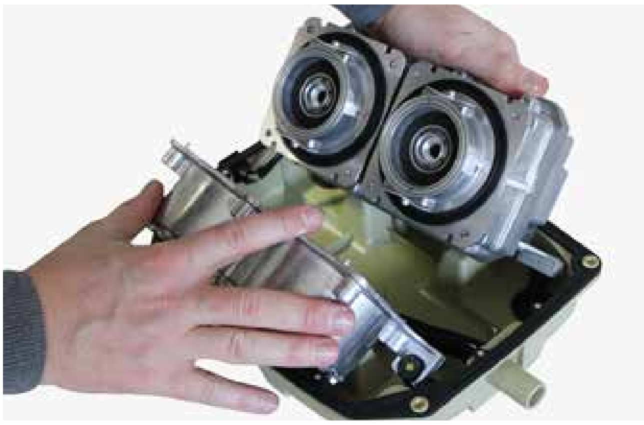
Detailed instructions regarding operation and maintenance as well as drawings are stated in the logbook.

We recommend the following maintenance measures:
- Checking the air filter during EVERY maintenance performance
- Exchanging the piston set after 25000 operating hours

NOTICES:
- Air-delivery performance can decrease if the compressor is operated beyond 25000 operating hours, requiring compensation by increasing aeration times. The piston set must be immediately exchanged if ringing or knocking sounds are audible; otherwise the device may be destroyed irreparably.
- A video on compressor maintenance can be requested from us free of charge.

Unscrewing the cover for NITTO compressors

Checking the air filter


Open casing for piston exchange


Pistons

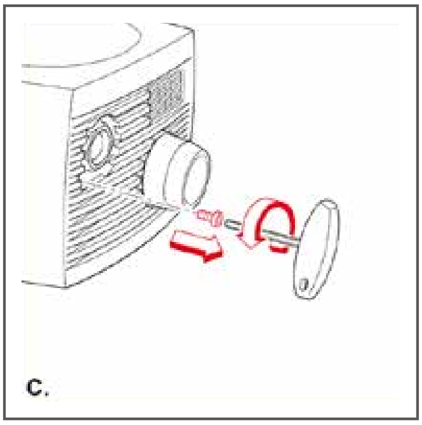
5.3.2 Rotary-slide compressor “BECKER” or “RIETSCHLE”

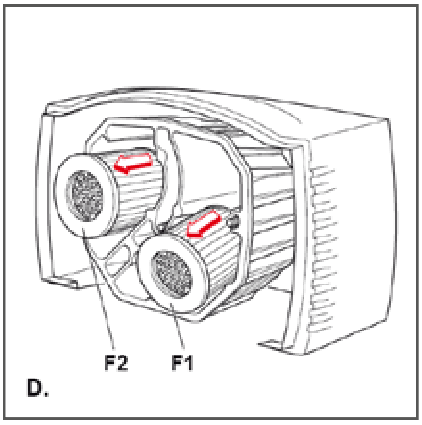
Detailed instructions on operation and maintenance as well as drawings are available in the logbook.

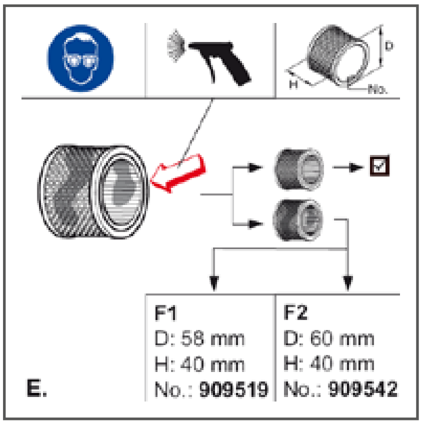
We recommend the following maintenance measures:

- Checking the air filter during EVERY maintenance performance, at least semiannually
- Omitted for small series BECKER DT 4.4 - 4.8
- It is imperative to blow out contaminated air filters or replace these.

NOTICE:
A clogged air filter leads to reduced air delivery and overheating of the device.







Checking the air filter

- Checking the slider width at least every 3000 op. hrs.

  → The permissible minimum width of the respective model is stated in the manufacturer’s specifications (see logbook) or printed directly on the device.

  → The measured slider width is to be noted in the maintenance protocol in order to comprehend wear and find a replacement slider in good time.

- Checking the starting capacitor at least every 5000 op. hrs.

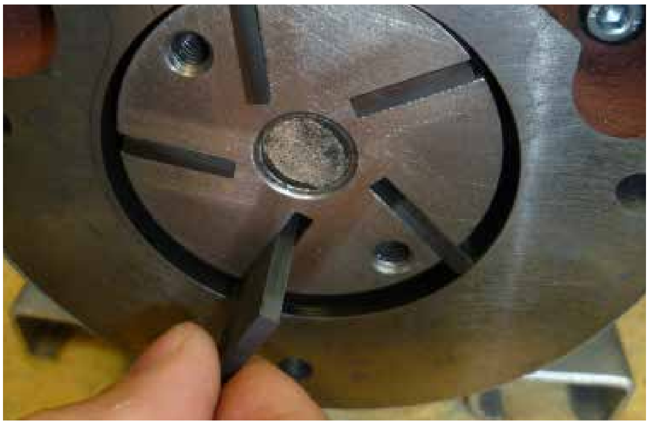
  → Disconnect the capacitor

  → Use a multimeter (with capacity measurement) with crocodile clamp for the measurement. A terminal is to be used for measurement lines with probe tips (see image). Measurements directly at the terminal board falsify the measurement result as well as using fingers to press the probe tips to the stranded wires of the capacitor.

  → The target value in mF is printed on the type label of the compressor

NOTICE: Deceeding the minimum slider width can result in cancellation of the remaining sliders and blocking of the rotor.

NOTICE: When activated, the starting capacitor causes the compressor to run in the correct direction. A worn (too weak) capacitor can cause the compressor to run in the wrong direction (suction instead of pressing) or cause the compressor to not work at all.



Checking the slider on the rotary-slide compressor

Measurement of the capacitor capacity for the rotary-slide compressor

5.3.3 Membrane compressor HIBLOW

Compressors of the series XP and HP are also used for the treatment system easy*One*.

Membrane compressor HIBLOW XP

Membrane compressor HIBLOW HP

We recommend the following maintenance measures:

- Checking the air filter during EVERY maintenance performance
- Exchanging the membrane set after approx. 9000 operating hours or after membrane breakage

Checking the filter XP:

Removing and cleaning the filter cover

Removing gasket and filter, cleaning or exchanging the filter

Exchanging the membrane unit XP:

Unscrew the top casing part and remove.
Pry it open with a screwdriver in case it is firmly attached.

Remove the rubber cover. The safety switch is visible underneath. The white switch is off-centre, and the contact is interrupted in case of membrane breakage.

Remove the sound-damper mat. Release the plug from the fastening and decouple it.

Remove the pump block from the lower casing part. Carefully remove the rubber buffers.

5. Machine-technology maintenance

Press the safety pin on one side all the way to the stop in the pump block. This keeps the anchor in a central position.

Unscrew the membrane block on the side where the safety pin is located. Remove the pressure chamber.

Unscrew the membrane and remove it together with the white ring.

Insert the new membrane and new ring, and fasten it again. Screw on the new pressure chamber. Then repeat steps 5-8 on the other side. Reassemble the compressor again. The safety switch must be in the central position.

Checking the filter HP:

Remove the cover.

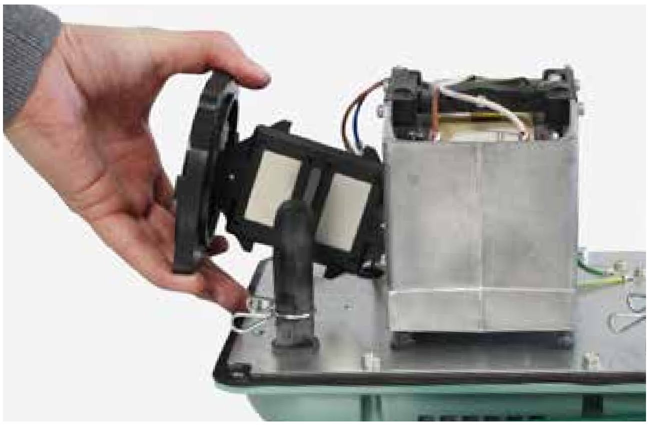
Remove, clean or exchange the filter.

Exchange membrane unit HP:

Remove the top casing part, sound-damper mat and inner casing cover one after the other.

Loosen the L-shaped pressure connections.
Unscrew and remove the pressure chambers on both sides

Unscrew and remove the membrane from the axle on one side



Remove the other membrane including the axle. Loosen the second membrane.

Exchange both membranes and seal rings. Assemble everything again.

Insert the new safety pin. Just as for HP compressors,
newer models have a safety switch rather than a pin.

NOTICES:
Various Internet videos illustrate compressor maintenance.

5.4 Valves and air diffusers

KLARO valves are extremely low-maintenance. Older air diffuses work with magnetic valves (230 V AC, currentless and closed), newer systems with stepper-motor technology (24 V DC, currentless in end position). Stepper-motor valves open and close gently. They are virtually silent and maintenance-free.

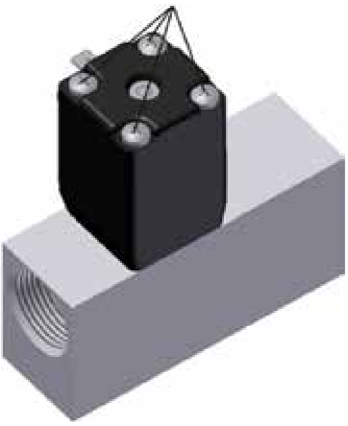
A functional check is generally performed for each maintenance procedure, and each valve is checked for switching and tightness.

Our recommendation for:

- **Magnetic valves + rotary-slide compressor:** Regularly clean the air diffuser on the inside. Unscrew individual valves consecutively, and blow out the interior space with compressed air. Then assemble the unit again. The status of the gaskets or membranes (¾" and larger for larger systems/magnetic valves) is also checked at this time. Brittle or torn membranes must be exchanged.

- **Stepper-motor valves + piston or membrane compressors:** A routine inspection or cleaning of the interior space is generally not required.

NOTICE: The coils for air diffusers with cube-shaped coils are the same for all series; however, the interior anchors may be different.



Cube-shaped magnetic coils

Different anchors

Magnetic diffusers with internal membrane for large-scale systems

Air diffusers with stepper-motor valves

6.1 Assessment of cleaning performance

Simple, basic principles for biological wastewater cleaning are stated in the following: Microorganisms (activated sludge) ingest contaminants and use up oxygen. Sufficient oxygen must be supplied in order to ensure good cleaning performance so that enough activated sludge can build up to consume the existing contaminant load.

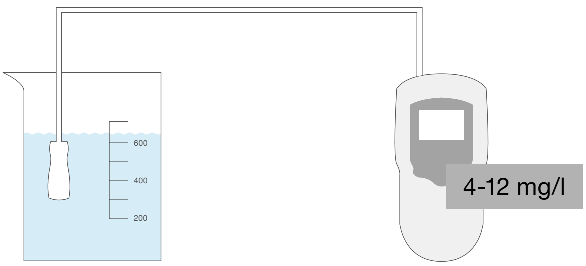
- **A large contaminant load $\xrightarrow{\text{requires}}$ lots of activated sludge and oxygen.**
- **A small contaminant load $\xrightarrow{\text{requires}}$ little activated sludge and little oxygen.**

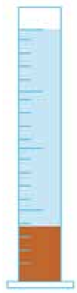
Our most important guiding parameters, namely oxygen in the outflow and activated-sludge content in the SBR basin already give us a good indication of the situation on-site. These parameters indicate the following:

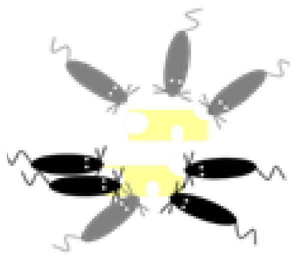
- **Is activated sludge present?**
- **Is oxygen present?**
- **Is oxygen being consumed?**

Three typical situations can be differentiated:

a) Good water quality





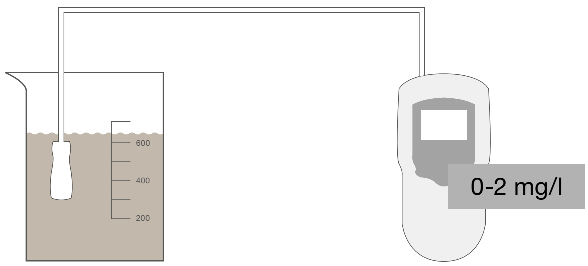


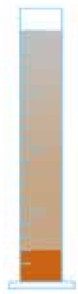
Outflow sample	O_2 measurement	SV_{30}	Diagnosis
Good water quality	Sufficient oxygen present	Sufficient activated sludge present	“Sparse food supply, many eaters”

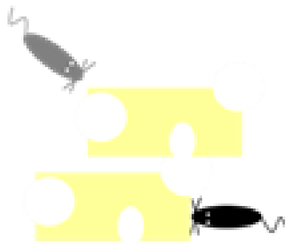
CONCLUSION: Oxygen is left over at the end of the process, and sufficient activated sludge has formed according to “food supply”, which is the basis for good water quality.

b) Poor water quality (cleaning performance), impairment due to oxygen deficiency

Outflow sample	O_2 measurement	SV_{30}	Diagnosis







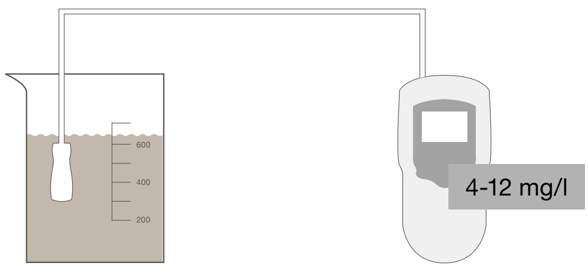
Poor water quality	Oxygen deficiency	Activated-sludge deficiency	"Lots of food, few eaters"

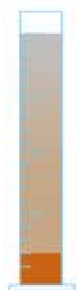
CONCLUSION:
Sufficient activated sludge cannot grow because the oxygen supply is not sufficient. Contaminants cannot be degraded sufficiently.

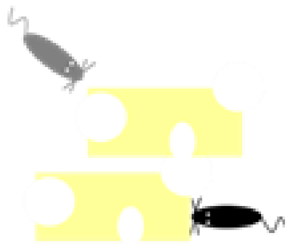
Possible causes and measures:
- Technical problem (hose kinked, filter clogged, ...) → Rectify
- Too much contamination → Increase oxygen

c) Poor water quality, impairment due to inhibition:

Outflow sample	O_2 measurement	SV_{30}	Diagnosis







Poor water quality	Sufficient oxygen present	Activated-sludge deficiency	"Lots of food, few eaters"

CONCLUSION:
Activated sludge cannot grow although oxygen and contaminants are present.

Possible causes and measures:
- Faulty inflows, impairing substances (cleaning agents, ...) → Clarify with operator

6.2 Foam, floating sludge, oily film

In most cases, foam formation does not impact the outflow. The quality of the outflow is only impacted when foam flakes enter into the sample container or directly into the outflow.

Three types of foam can occur in the SBR basin:

Protein foam

- Light grey or beige, dirty foam
- Piles up
- Immediately disintegrates upon contact

Protein foam frequently occurs during the start-up phase. Foam formation can be extremely strong and fill out the entire container, even overflowing from the shaft cover. This is not an operational impairment, but shows that the biology is in the build-up stage. The foam regresses on its own after a few days.

Strong foam formation during the start-up phase

Surfactant foam, "detergent foam"

- White foam
- Piles up
- Compact, stable, does not disintegrate upon contact
- Shines in rainbow colours

This foam is created when detergent residue is contained in the wastewater and aerated in the SBR basin.

The foam itself is not a problem, but surfactants can impair the biology. Large foam mountains indicate a high intrusion of detergents into the treatment system and a possible impact on the biology due to surfactants. Consultation with the operator is required on how to prevent this occurrence (→ Inhibition due to surfactants, see page 48).

White, stable detergent foam

Extreme foam formation while cover is open

6.3 Foam layer, floating layer, oily film

- Grey or brown, bubbly, viscous, compact layer, sometimes also just as oily film
- Covers the entire surface of the SBR basin and sampling
- Does not pile up
- Does not disintegrate upon contact, cannot be destroyed with spray water

This impairment is similar to bulking-sludge formation. The causes and countermeasures are the same as for bulking sludge.

Oily film in sampling

6.4 Bulking sludge

For the SV_{30} test, light brown and very voluminous sludge flakes appear that do not settle easily when bulking sludge is present. Bulking sludge does not necessarily mean that the water quality of the outflow is poor. Most often, a small, but very clear water zone exists at the top. The problem is that sludge discharge can easily occur when extracting clear water if flakes have not settled sufficiently.

Bulking sludge is caused by various filamentous bacteria. Filamentous bacteria can be caused by various factors:

Wastewater-related causes:

- Lack of nutrients (nitrogen/phosphorous)
- Putrid wastewater (hydrogen sulphide H_2S)
- Soft water, low acid capacity
- Extreme pH values
- Complexing agents (dishwasher tabs, …)
- Disinfecting cleaning agents

Operational causes:

- Lack of oxygen, aeration times insufficient

Oily film in sampling

System-related causes:

- Long sludge-storage times/fouling (for Epro)
- Poor mixing

Countermeasures are only necessary when sludge output occurs.

There are various measures for combating the excessive formation of bulking-sludge:

- Increasing oxygen input, deactivating underload detection
- Deactivating sludge return (for Epro)

Natural causes:

- Temperature changes during the transition fall/winter and spring/summer; filamentous bacteria can handle these changes better/are less sensitive.

- Addition of hydrated lime to add weight to the activated sludge
- Preventing rot by increasing the water inflow or reducing the pretreatment volume
- External nutrient supply in case nutrient deficiency is detected in the system's inflow

6.5 Sludge floatation, "wild deni"

Activated sludge flotation may occur due to the accumulation of gas bubbles along sludge flakes. This phenomenon is rare for SBR systems and can only be observed, if at all, during long rest phases. Rising nitrogen bubbles (N_2) attach themselves to filamentous sludge flakes and cause these to drift to the surface. Whether intentionally or not, nitrogen is produced in the denitrification process. Gas bubbles in the sludge layer can often be seen with the naked eye. At first glance, the system looks terrible, but excellent water quality often exists underneath the floating layer (carefully push aside with a shovel) or in the sampling.

Often the floating layer disappears during the next aeration phase.

Countermeasures are only required when sludge output occurs. However, this is almost impossible due to the construction of lifters and sampling devices by Epro.

Options:

- Increasing oxygen input so that deni does not occur
- Increasing the sludge return in order to reduce the sludge volume (for Epro)

"Wild deni" in Epro-SBR basin, crystal-clear water in sampling

Floating activated sludge for easy*One*

6.6 Suspended sludge and flake disintegration

The cleaning performance of small-scale treatment systems greatly depends on the efficiency of separating solids/liquids during the sedimentation phase in the biological stage. Performance is only good when activated sludge flakes can form in an unimpeded manner. Sufficient oxygen is required. The pH value can fall below 6.5 due to the degradation process in case of low acid capacity (ANC < 1.5 mmol/l). Flake formation of activated sludge is impacted in this milieu. Increased salt concentrations in the inflow can also be responsible for poor sedimentation of activated sludge flakes. Salt can, e.g., be released through backwashing from water treatment systems.

Another frequent cause of suspended sludge is the usage of cleaning agents and contained surfactants.

The following occurs when too many surfactants are present:

- Grease and contaminants are dissolved, and the organic load is increased.
- Faecal sludge in pretreatment dissolves, and a floating sludge cover does not form.
- Oxygen input in the biological stage is reduced (oxygen content decreases).
- Activated sludge flakes disintegrate, and important filtering bacteria die off.
- Turbidities can no longer be filtered out.
- Filtered substances (SS) and the COD value increase.

Strong opacity after settlement, only some of the activated sludge settles while the rest remains suspended.

Typical indications for the presence of surfactants:

- Severe foam formation (see page 45)
- Opaque clear-water overhang that does not clear after additional aeration
- None or very little activated sludge-flake formation.
- For the most part, no floating-sludge layer in pretreatment

Possible causes:

- Oxygen deficiency
- Low water hardness in the catchment area of the small-scale treatment system
- Increased salt concentration in the inflow to the small-scale treatment system
- Increased nitrogen content in the inflow to the small-scale treatment system
- Full sludge storage and thus overloading of the biological stage with faecal sludge
- Intrusion of impairing substances such as complexing agents (in detergent tabs) and preservatives (e.g. Benzisothiazolinone)
- Cleaning agents

6.7 Inhibition and poisoning

Inhibition generally refers to the prevention of biological degradation processes and thus the halting of cleaning performance. More specifically, enzyme activity, and thus the metabolism of organisms is inhibited. Enzyme inhibition is differentiated according to reversible and irreversible inhibition. In reversible inhibition, enzymes are only temporarily inactive or their activity is temporarily reduced since enzymes are not damaged in reversible inhibition. Reversible inhibition can occur relatively quickly due to insufficient aeration. However, in irreversible inhibition, inhibitors and enzymes enter into a permanent compound so that enzymes remain permanently non-functional.

Bacteria can also be killed off with disinfectant, which is generally referred to as poisoning. However, this occurs only rarely.

The difference between the inhibiting and killing effect mainly depends on amounts and concentrations.

Inhibition and poisoning are predominantly caused by cleaning agents and chemicals in household wastewater.

These problematic substances include chlorine cleaner, paints, varnishes, brush cleaner, disinfectant, flea shampoo for dogs, herbicides from spray containers, anti-fungal shampoos for horses, slurry, etc.

The inhibiting effects of medication are being controversially discussed.

Characteristics of poisoning:

- Opaque water, high oxygen content, little activated sludge
- Strong, often caustic chemical odours

Measures

- Consultation with the operator, impairing substances must not enter the wastewater.
- Empty and start anew

Poor water quality, strong opacity, little activated sludge, but lots of oxygen: inhibition likely

NOTICE:
The pit does not have to be emptied entirely. The biology usually recovers. However, the quickest way to achieve change is to empty the system and inoculate it with activated sludge. A renewed dying-off of the introduced sludge indicates that inhibition is still present.

6.8 Poor outflow values

Poor cleaning performance and thus possible exceedance of threshold values indicate that the small-scale treatment system is not working properly or that something is wrong with the inflowing wastewater. A properly planned, regularly maintained and not overloaded small-scale treatment system usually demonstrates a very stable cleaning behaviour.

A functional impairment is to be expected if the measured values are not in the usual fluctuation range or above expected values. A need for action exists in case threshold values are exceeded.

The measurement value is to be initially checked for plausibility prior to making operational or structural changes. The sampling execution is to be examined initially if increased measurement values are detected in the outflow of the small-scale treatment system.

The following causes must be excluded for random sampling:

- The sampling container contains cleaning-agent residuals or a different sample.
- Presence of too many solids in the sample, resulting in falsification due to contamination of the integrated sampling container, scoop or sample cup
- Confusion due to missing, insufficient or faulty designation of the sampling cup

NOTICE:

- Scraping along the bottom and the walls of the tank is to be avoided while immersing and removing the scoop from the tank.
- A second measurement is to be performed in case of implausible results. The cause of the occurred functional impairment is to be determined if the measured, increased outflow value is plausible and overloading of the treatment system has not occurred. Increased measurement values can have more than one cause.

6.8.1 Increased sedimentable and filterable substances (SS_{120} and SS)

Outflow values of SS_{120} < 0.3 ml/l and SS < 10 mg/l are detected in sufficiently dimensioned treatment systems and unimpaired bioreactors. Increased solid output usually only occurs when SS_{120} > 1 ml/l and SS > 30 mg/l are exceeded in the outflow.

Most common causes for increased SS_{120} values:

- Full pretreatment/sludge storage (for GRADsystem)

Increased solid content in the bioreactor

→ SV_{30} > 400 ml/l for Epro system

→ SV_{30} >700 ml/l for **Eclean** system

- Bulking-sludge formation
- Flake disintegration
- Hydraulic overloading

Observation	Cause	Remedy
Increased values SS_{120}, SS	Increased solid content in the bioreactor	**For Epro system:** Gradually increase excess sludge extraction. **For *Eclean system:*** Increase aeration or initiate sludge removal.
	Full pretreatment	Initiate pretreatment disposal.
	Flake disintegration	Subsequently regulate the pH value with lime, soda or caustic soda. Check inflow for inhibitors (disinfectants, medication, food remains, waste from renovations: paint, paste, etc.).
	Hydraulic overloading	Check inflow amounts. Check installation parts and electrical parts (control cabinet).
	Bulking-sludge formation	Increase oxygen input.

6.8.2 Increased COD or BOD_5 value

In new treatment systems, the activated sludge that is necessary for biological cleaning generally only forms after some time. A full cleaning performance cannot be ensured until this has taken place.

Moreover, an increased COD or BOD_5 value in the outflow can be attributed to particulate and dissolved substances. Thus, 1 mg/l of solids have a COD value of 0.8 - 1.6 mg/l depending on the organic share.

There are various possible causes – just as for an increased FS value.

Most frequent causes:

- Increased solid content/organic overloading
- Bulking-sludge formation
- Flake disintegration
- Hydraulic overloading
- Faulty or insufficient aeration
- Inhibition of the biology

Increased solid content in the bioreactor can reduce the effect of sedimentation. Clear water can no longer separate sufficiently from sludge flakes, and sludge output occurs. Solid output can be countered very effectively with increased excess sludge extraction. However, excess-sludge extraction should only be increased in steps.

A poorly sedimentable and easily floatable sludge structure (bulking sludge) can also lead to increased COD or BOD_5 values. Bulking sludge refers to the increased growth of filamentous microorganisms. In contrast to flake-forming microorganisms, filamentous organisms have poorer sedimentation properties and are extracted from the treatment system with clear water. In most cases, bulking-sludge formation is due to insufficient oxygen supply or insufficient mixing of the bioreactor.

Oxygen-limited conditions promote the growth of filamentous agents. Thus, the oxygen supply should be checked and possibly increased. In addition to filamentous microorganisms, the increased disintegration of sludge flakes can also lead to increased sludge output and thus to increased values in the outflow.

Flake disintegration is usually caused by the following:
Destruction of the frame substance of sludge flakes due to a low or high pH value in the bioreactor
- Inhibitors in the treatment system inflow
- Salt in the treatment system inflow

Thus, the pH value must always be determined. A pH value below 6.5 or over 9.0 usually leads to flake disintegration and inhibition of the cleaning performance. As many chemical auxiliary agents (alkalies) as necessary are to be introduced to the bioreactor for as long as necessary until the pH value stabilises in the range of 6.6 - 8.0. The addition of lime is to be recommended due to cost considerations.

Hydraulic overloading may cause increased solid input from pretreatment to the bioreactor and lead to overloading. Additionally, full pretreatment increases the solid input in the bioreactor.

Sludge removal should be initiated if necessary.
- High COD, low BOD_5: Wastewater contains a high degree of hardly degradable or non-degradable substances such as strong cleaning agents, toilet disinfectant blocks, etc.
- Humin substances can be contained in swampy water and lead to increased COD, which is often indicated by a red-brown water colouration. Humin substances are not pollutants, but ecologically harmless

Observation	Cause	Remedy
Increased COD or BOD_5 value	Increased solid content in the bioreactor	Gradually increase excess sludge extraction.
	Bulking-sludge formation	Increase oxygen input.
	Flake disintegration	Subsequently regulate the pH value with lime, soda or caustic soda. Check inflow for inhibitors (disinfectants, medication, food remains, waste from renovations: paint, paste, etc.)
	Hydraulic overloading	Check inflow amounts. Check installation parts and electrical parts (control cabinet).
	Faulty or insufficient aeration	Check aeration intervals and possibly reconfigure.
	Full pretreatment	Initiate pretreatment disposal.
	High degree of hardly or non-degradable substances.	Clarify problematic substances with the operator.
	Humin substances	–
	Overloading (load), e.g. fats, fat separator	

6.8.3 Increased ammonium value (NO_4-N)

Anorganic nitrogen compound ammonium (NH_4^+) in the raw wastewater is oxidised to nitrite (NO_2^-) and then to nitrate (NO_3^-) in treatment systems with additional nitrification. The change requires lots of oxygen. Ammonium nitrogen (NH_4-N) is used for measuring the nitrogen balance and as a threshold-value indication. A reduced performance capability of the activated sludge as well as insufficient aeration are usually the causes for increased ammonium content. It must be taken into account that the nitrification performance depends on the temperature in the bioreactor. The nitrification performance is inhibited if the water temperature in the bioreactor drops below 10 °C

As a first step, the oxygen content should be checked in order to rectify the nitrification impairment. Insufficient oxygen content is present if the oxygen content in the outflow is less than 2 mg/l. The aeration status, the condition of air hoses and air filters and the control settings should be checked. The pH value is another critical parameter, which should fall between 6.5 and 8.0. Suitable measures are to be initiated to stabilise the pH value if the measured value is above or below the threshold range.

Increased ammonium loads in the inflow can also lead to increased ammonium values in the outflow. For the Epro system, a sample from pretreatment can be tested (test strip, quick-test, laboratory). Inflow concentrations of approx. 70 mg/l NH_4N are generally assumed. Causes must be investigated in consultation with the operator if values are much higher. As another optimisation option, Zeolith can also be added to the activation basin as it adsorbs ammonium and stabilises degradation. We recommend a consultation with GRAF technicians in regard to this matter.

NOTICE: Increased NH_4-N values in the outflow at water temperatures below 10 °C are not a functional impairment. This also applies to previous temperature fluctuations even when current water temperatures in the area are greater than 12 °C.

Observation	Cause	Remedy
Increased NO_4-N value	Insufficient oxygen input (< 2.0 mg/l in sampling)	Increase aeration.
	Aerobic sludge age insufficient	Temporarily deactivate the sludge return.
	Water temperature below 10 °C	–
	pH value too low (< 6.5)	Subsequently regulate the pH value with lime, soda or caustic soda.
	pH value too high (< 8,5)	Increase oxygen input.
	Nitrogen load in the inflow too high	Reduce the sludge return. Add Zeolith to the bioreactor.

6.8.4 Increased nitrite value (NO_2-N)

Nitrite is both an intermediary product for the oxidation of ammonium to nitrate as well as for the reduction of nitrate to nitrogen. Nitrite nitrogen (NO_2-N) is only at < 1.5 mg/l if the nitrification/denitrification process is functioning properly.

Nitrification is not functioning optimally if nitrite and ammonium are high while nitrate values are low. The aeration duration should be increased during the nitrification phase. Lower temperatures (< 12 °C) could be another cause as these inactivate nitrifying agents. Bacteria that are responsible for converting ammonium to nitrite grow more quickly when temperatures rise while bacteria that convert nitrite to nitrate grow more slowly. This results in increased nitrite content. Nitrite degradation stabilises at consistently warm temperatures.

Incomplete denitrification most likely exists if ammonium is low while nitrite and nitrate values are high. Improvement options (see → Increased nitrate value).

Observation	Cause	Remedy
Elevated NO_2-N and low NO_3-N	Insufficient oxygen input (< 2.0 mg/l in sampling)	Increased aeration
	Water temperature below 10 °C	Stabilises independently
Increased NO_3-N and increased NO_2-N	Oxygen input too high during denitrification	Extend denitrification phase and reduce aeration.

6.8.5 Increased nitrate value (NO_3-N)

Nitrate is converted to molecular nitrogen (N_2) via nitrite in low-oxygen phases during denitrification. Most bacteria in the activated sludge are capable of this. Sufficient organic carbon as well as nitrate are required for effective denitrification. A high concentration of ammonium or nitrate in the outflow indicates insufficient nitrogen degradation.

Effective denitrification requires a large volume of activated sludge that is capable of consuming dissolved oxygen during the phases without aeration (settlement + extraction + deni phase). Excess sludge extraction should be shortened so that more sludge remains in the basin if the activated sludge volume is low. For the Epro system, it may even be useful to strive for more than the usual 400 ml/l of activated sludge. Oxygen input is critically important for the denitrification performance. Aeration should be reduced if the oxygen content is too high at the end of the settling phase or the consumption potential of existing activated sludge is too low. We recommend extending the total time of the denitrification phase while concurrently reducing the duration of the aeration phase.

Example Epro system:
Increase the deni phase T02 from 30 min to 60 min. Reduce the aeration phase T05 from 220 min to 190 min. On/Off cycling T06/T07 can also be adjusted if required.

Observation	Cause	Remedy
Increased NO_3-N value	Increased oxygen input during the denitrification phase	Extension of the deni phase
	Insufficient nitrification	Increase nitrification performance by increasing the oxygen content in the aeration phase.
	Contact time too short	Extend mixing duration.
	Too little activated sludge	Shorten excess sludge extraction or deactivate temporarily.
	Water temperature below 10°C	–

6.8.6 Increased N_{tot} value

Total nitrogen (N_{tot}) is a total parameter and indicates the total of organic and anorganic nitrogen compounds. The share of organic nitrogen is negligibly low in wastewater. Therefore, the total parameter N_{inorg} is usually used instead of N_{tot}. This refers to the total of ammonical-, nitrite- and nitrate nitrogen. All three individual parameters must be checked if the total nitrogen is to be optimised (see page 53-55).

6.8.7 Increased P_{tot} value

Approximately 50% of phosphates contained in raw wastewater are degraded through biological wastewater treatment. Chemical precipitation is required to reduce this value even further. Still contained dissolved phosphates are converted to an undissolved form by precipitation agents; these phosphates then sink to the bottom together with the activated sludge. Polyaluminium chloride solution is mainly used as the precipitation agent. The P_{total} value in the outflow mostly depends on the P-load in the inflow and the dosage of precipitation agent. The dosage can be adjusted within the context of maintenance.

Possible causes for increased P_{tot} values in the outflow:

- Precipitation-agent canister empty
- Underdosing of precipitation agent
- Defective dosage pump or hose
- Leaky dosage line/Suction takes in air/Pressure side leaks.
- Impairment of the chemical intake/hose clogged
- Dosage in wrong chamber (correct: SBR)
- Impact load/Inflow load fluctuation

The flow rate of the dosage pumps depends on the diameter of the hose and the rotational speed of the rotor. The easiest way to adjust the dosage is via the runtime in the service menu of the controls. A different hose can also be used. The rotational speed can also be adjusted via potentiometers for larger dosage pumps.

The dosing begins with the start of the aeration phase. For some controls, the runtime can be configured in seconds, for others, in minutes. The pump runtime has no impact on other cycle times or the cycle duration.

The canister is often empty or the suction hose is not immersed in the liquid or a leaky screw connection or clogging of the line exists if the operating dosage pump does not deliver precipitation agent.

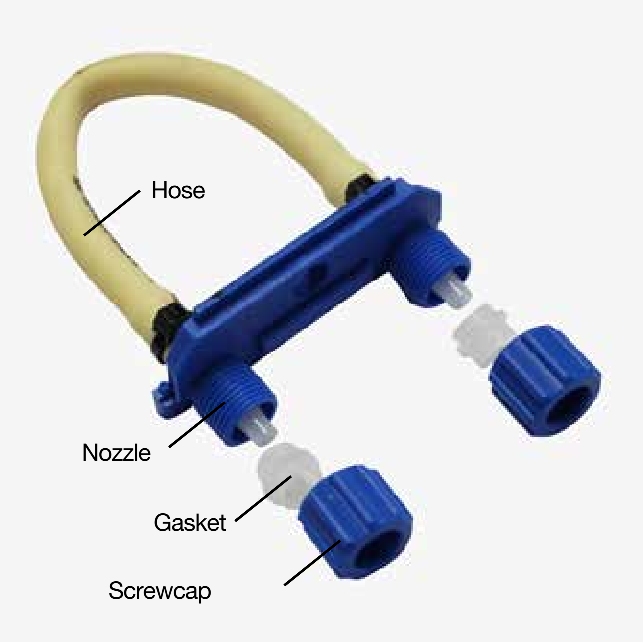
NOTICES:

- Blockages or incrustations of lines are especially tricky. The quality (and purity) of the precipitation agent may fluctuate. Sometimes the precipitation agent contains small solid particles. We, therefore, recommend suctioning via a so-called toe filter in order to prevent blockages. All lines should also be rinsed with warm water every 2 years in order to dissolve incrustations.

Hoses within the pumps are wear parts and must be replaced from time to time. The faster a pump runs, the greater the wear.

- Always check the diameter when exchanging hoses!
- Food remains often cause increased P-loads in the inflow.

Observation	Cause	Remedy
Increased P_{tot}-value	Empty precipitation-agent canister	Fill-up or exchange the empty canister.
	Underdosing of precipitation agent	Increasing or extending the dosage amount/duration
	Defective dosage pump or hose	Replacement
	Leaky dosage line	Find leak and rectify.
	Impairment of the chemical intake due to blockages (incrustations, crystallisation)	Rectify blockage, install toe filter, rinse lines with warm water.
	Dosage in wrong chamber	Dosage in SBR chamber
	External impact loads with phosphorous compounds	Avoid input of food remains.



Hose kit


Dosage pump

6.8.8 Increased/Reduced pH value

An increased or reduced pH value can most often be attributed to external factors, but may also be caused by the process.

A pH value of more than 8.5 verifies the intrusion of alkaline substances (cleaning agent for removing grease and oil). The risk for bacteria and thus for insufficient cleaning performance of the treatment system rises with the amount, duration and lye concentration of intruding substances. The wastewater in the treatment system has a certain buffering effect so that alkalies are neutralised for the most part and biological damage does not occur. However, bacteria in the bioreactor can be inhibited or destroyed if the pH value increases to over 9.0 due to introduced alkalies. Additionally, excessively high pH values in connection with higher wastewater temperatures can lead to the formation of ammonium (NH_3-).

Ammonium has a strong inhibiting effect on nitrification. Only measures can be introduced that limit the potential consequences for the cleaning performance if alkalies are already in the activation process (bioreactor).

Recommended measures in case of increased pH values:

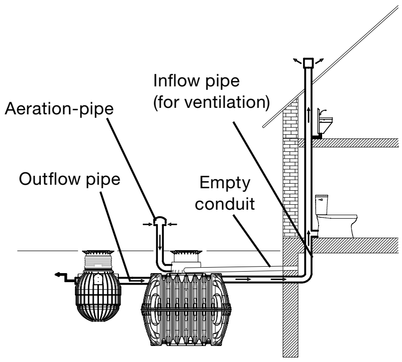
- Intensification of aeration (maximum possible oxygen input)
- Dosage of iron or aluminium salts (PAC) in order to neutralise alkalies
- Tracking the pH value in the further process

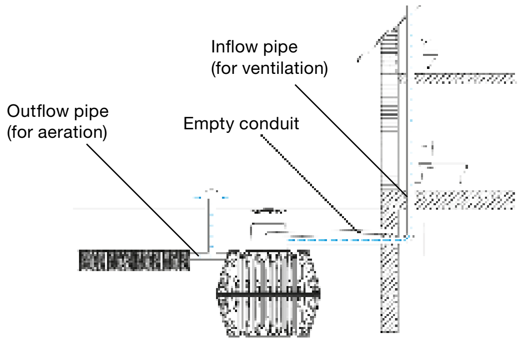
The deceedance of the pH value of 6.5 can be attributed to the presence of acidic substances. The risk for the cleaning performance rises with increased amounts and the increased acid capacity of the substance. An inhibition or destruction (flake disintegration) of the biology cannot be excluded when acidic substances are introduced to the bioreactor. An increased risk of corrosion also exists for installed parts. Organic acids are produced in case of a process-related pH value reduction with increased oxygen content due to nitrifying microorganisms – if present. The pH value can drop below 7.0 if the wastewater does not have a sufficient acid capacity (buffer capacity).

Observation	Cause	Remedy
Increased pH value	• Introduction of alkaline substances	• Intensification of aeration • Dosage of iron and aluminium salts (PAC)
Reduced pH value	• Introduction of acidic substances • Increased nitrification • Low water hardness • Low acid capacity	• Dosage of alkaline neutralising agents (hydrated lime, soda, caustic soda) • Activation of denitrification

6.9 Odours

Odours can arise when operating a small-scale treatment system, which most often occurs in anaerobic milieus (= no dissolved oxygen in the water) as e.g. in pretreatment. Ammonium (NH_3), hydrogen sulphide (H_2S) and organic acids, etc. can form. For fully aerated systems without pretreatment, as e.g. Eclean, this is almost impossible if the system is properly operated since anaerobic milieus do not exist. Thus, the risk of odours is much lower.





Rotten-eggs odour

The rotten-eggs odour is often caused by increased inflow of sulphurous substances. Deposits in the pipes of the treatment system lead to the formation of hydrogen sulphide (H_2S).

Ammonium odour

Ammonium odour can be caused by the increased inflow of ammonium compounds. The oxygen consumption is higher in the bioreactor in addition to increased outflow values. The inflow is to be examined for potential sources of ammonium-containing wastewater (slurry, etc.), and oxygen in the outflow is to be checked.

6.9.1 Restricting odour pathways

Odours in the house?

- In the room with the control cabinet?
  → Exit pipe not properly sealed
- In the room with a drain (sink, floor drain, …)? → Siphon has run dry, and the odour seal no longer works. Problems with the house installation, not the small-scale treatment system

Odours in the house, balcony, patio, ...?

- Odours emanate from the shaft cover. Indication of poor roof ventilation
- Odours are not properly vented through the roof ventilation or the roof ventilation is not properly installed.
- Weak roof ventilation → Improve ventilation.
- System too close to the house, odours emanate through covers.

When does it smell?

- **Summer or winter?**
  → Stronger outgassing in the summer? Low O_2 supply in the summer?)
- **On the weekend? Laundry day?**
  → Overloading? pH shift?)
- **In certain weather? When muggy or before storms**
  → Natural phenomenon
- **During events?**
  → Big party, visitors → Overloading?

Maintenance Report

☐ Epro ☐ Eclean

Location (address): ______________________________

Maintenance Company: ____________ Date of maintenance: ____________

Operator's name: ____________ Start-up date of the plant: ____________

Telephone number: ____________ Size of the plant (PE): ____________

Order number: ____________ Actual PE connection: ____________

Commercial wastewater is also discharged into the plant? ☐ No

☐ Restaurant with kitchen ☐ Restaurant without kitchen ☐ Office

☐ Grease separator on site ☐ Emptying from grease separator necessary ☐ Others

1. Visual inspection (current condition of the plant):

The plant is accessible	☐ Yes	☐ No	____________
Manhole cover is stable and secure	☐ Yes	☐ No	____________
Components in good conditions	☐ Yes	☐ No	____________
Normal water level	☐ Yes	☐ No	____________
Aeration chamber free from floating sludge	☐ Yes	☐ No	____________
No foam formation	☐ Yes	☐ No	____________
No grease depositions	☐ Yes	☐ No	____________
Good ventilation	☐ Yes	☐ No	____________
No corrosion damage	☐ Yes	☐ No	____________
Dividing wall on place and in good conditions	☐ Yes	☐ No	____________

Notes: ______________________________

2. Effluent analyses (sampling):

Sampling point:	☐ Sampler container		☐ SBR-chamber		
Sample transport:	☐ Cooled (4°C)		☐ Frozen		
Odor:	☐ None	☐ Weak	☐ Strong	☐ Foul	☐ Earthy
Color:	☐ None	☐ Yellowish	☐ Brownish	☐ Greyish	☐ Strong color
Turbidity:	☐ Clear	☐ Cloudy			
Suspended mater:	☐ None	☐ Few	☐ Many		

On-site measurements:

Oxygen (should be 4 – 8/Min. 2): ________ mg/l

Temperature of water: ________ °C

pH value: ________

Conductivity: ________ µS/cm

Laboratory analyses:

BOD_5: ________ mg/l COD: ________mg/l

SS: ________ mg/l NH_4-N: ________ mg/l

$N_{inorg.}$: ________ mg/l P_{tot}: ________ mg/l

SS_{120}: ________ ml/l _____: ________ _____

3. SB-Reactor: SV30

☐ Undiluted (KLARO): ___________ ml/l	☐ Diluted (KLARO *One*): ___________ ml/l
> 400 ml/l → Increase sludge recirculation T12	Dilution = 330 ml activated sludge + 670 ml treated effluent *One* > 700 ml/l → Sludge removal, increase aeration SV30 = ___________ ml/l **x 3** = ___________ ml/l

Aeration: ☐ Intense, circulation clearly visible ☐ Fine bubbles ☐ Weak, no circulation

4. Pretreatment/sludge storage + buffer (KLARO):

Water level: _________ cm Actual sludge height: __________ cm Floating sludge height: ____________ cm

Max. possible sludge height: ________ cm Sludge level: __________% ☐Sludge removal required (when > 70 %)

5. Maintenance of the technical equipment:

Air filters: ☐ Cleaned ☐ Replaced

Controller: ☐ Checked for errors ☐ Errors read-out with SD card

Operation hours: Compressor: _______ h UV lamp: _________ h Dosing pump _________ h

Valve 1: _______ h Valve 2: _______ h Valve 3: _______ h Valve 4: _______ h

Function control: ☐ Measuring of water level ☐ Cooling fan ☐ UV ☐ Valve1 ☐ Valve 2

☐ Dosing pump ☐ Power failure alarm ☐ Valve 3 ☐ Valve 4

Compressor: ☐ Compressor all right ☐ Filter checked/replaced

☐ Pistons ___________	☐ Pistons replaced
☐ Membrane ___________	☐ Membrane replaced
☐ Rotary vanes ___________	☐ Condenser all right ☐ Vanes checked/replaced ☐ Vanes width: _____ mm

6. Additional remarks:

☐ Operating manual is available ☐ Maintenance registered in the operating manual

☐ Programming was changed: ____

☐ Problems have been fixed: ____

7. To be done by the operator:

☐ It is requested to pay attention to the non-dischargeable substances (see operating/maintenance manual)

☐ If the plant is overloaded, the operator must ensure that the plant can discharge

☐ The operator must arrange the sludge removal from the sludge storage

Wastewater parameters	Explanation	Usual threshold values	Typical inflow and outflow concentrations	
			Raw wastewater	Epro/Eclean outflow values
SS [mg/l] Filterable substances	• Measure of the total of undissolved wastewater ingredients that are removed via filtration • Undissolved substances constitute approx. 1/3 of the contamination in raw wastewater.	30 – 75	200 – 700	5 – 15
SS_{120} [ml/l] Sedimentable substances	• Measure of the total of sedimentable wastewater ingredients within 120 min • Sedimentable substances constitute approx. 1/4 of the total wastewater ingredients.	–	1 – 20	< 0.1 – 0.3
BOD_5 [mg/l] Biochemical oxygen requirement	• Measure of the total of biologically degradable wastewater ingredients • BOD_5 indicates how much oxygen is required for the biological degradation of organic substances within a time period of 5 days.	20 – 40	150 – 500	5 – 9
COD [mg/l] Chemical Oxygen Requirement	• Measure of the total of all organic wastewater ingredients including hardly degradable substances • COD indicates how much oxygen is required for the complete oxidation of organic wastewater ingredients. • Characteristic variables for the degree of contamination	90 – 150	300 – 1.000	39 – 48
N_{tot} [mg/l] Total nitrogen	• Measure of the efficiency of nitrogen decomposition (nitrification and denitrification) • Total of organic and anorganic nitrogen in wastewater	25 – 50	25 – 100	16 – 20
NH_4-N [mg/l] Nitrogen ammonium	• Measure of the oxidative degradation of nitrogen compounds via nitrifying bacteria (nitrification) • Nitrogen share in wastewater in the form of ammonium	10 – 20	22 – 80	0.8 – 7

Wastewater parameters	Explanation	Usual threshold values	Typical inflow and outflow concentrations	
			Raw wastewater	KLARO/*One* outflow values
O_2 [mg/l] Oxygen concentration	• Measure of the concentration of dissolved oxygen in wastewater • Oxygen is essential for aerobic wastewater treatments. • Water contamination (wastewater) results in strong oxygen consumption. • The oxygen concentration of raw wastewater is zero.	–	0	≥ 2
P_{tot}[mg/l] Total phosphorous	• Measure of the phosphorous-compound load in raw wastewater • For the most part, the elimination of **P_{tot}** is performed via P-precipitation.	1 – 5	5 – 20	0.4 – 3
pH value [-]	• Measurement for the hydrogen concentration and thus for the acid capacity of wastewater • The lower the pH value, the more acidic the wastewater. • The efficiency of degrading bacteria depends on the pH value (optimum: 6.5 - 8.0)	–	7.2 – 8.2	6.5 – 8.0

9.1 This does NOT belong in wastewater treatment systems

- Nylon stockings
- Textiles
- Nappies
- Tampons/ Pads
- Condoms
- Band-aids
- Medication
- Packaging
- Cat litter
- Razor blades
- Sand/Ash
- Cigarette butts
- Food remains
- Coffee grounds
- Tea bags
- Frying oil/ Frying grease
- Cleaning cloth/Sponge
- Backwash water from softening systems
- Condensate from heating
- Concrete wastewater
- Cotton swabs
- Moist toilet paper
- Toilet disinfectant blocks
- Machine oil
- Aggressive cleaning agents
- Disinfectants
- Colouring agent/Thinner
- Paint/Lacquer

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