Hydrotech Chemical Cleaning

Manual

by VEOLIA Water Technologies

HYDROTECH

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Manual

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Introduction

The purpose of this instruction is to provide a detailed overview of when and how to perform chemical cleaning of Hydrotech filters. The document can be used as an encyclopedia, where the user, by the help of the table of contents, will find which sections to read when looking for answers to chemical cleaning related questions.

The document includes a short background describing how the filters work and how to determine when chemical cleaning is needed. The instruction also covers general health and safety aspects, the recommended chemicals to use and the estimated chemical consumptions for the drum and disc filters. The instruction also comprises different ways of performing chemical cleaning, manually or automatically, how to evaluate the performance of the chemical cleaning and a list of relevant documents for further reading.

Contents

1. Background

The drum filter and the disc filter are based on the same principle. Water flows by gravity into a central drum, supporting vertically mounted discs (disc filter, Figure 1) or covered by filter panels (drum filter, Figure 2). During filtration, solids larger than the pore openings of the filter cloth are caught on the filter panels. As the solids layer on the panels increases, the water flux through the filtration media decreases, which (at a constant inlet flow) causes the water level inside the central drum to rise.

When the water level reaches a level sensor, mounted at a certain critical head loss level, the backwash is initiated. The backwash pump is activated and the drum starts to rotate, to transport the solids retained from the water up to the backwash nozzles. The nozzles spray the filter cloth from the outside with clean water, at up to 8 bar, and the solids fall into a solids collection trough, from which they can be discharged.

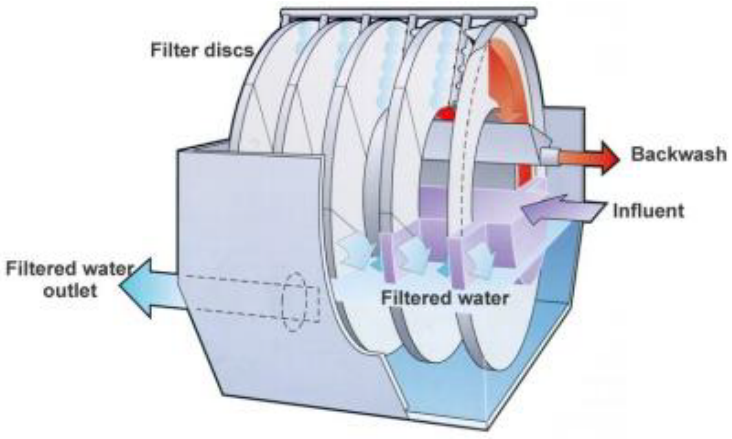

Figure 1. The disc filter filtration principle.

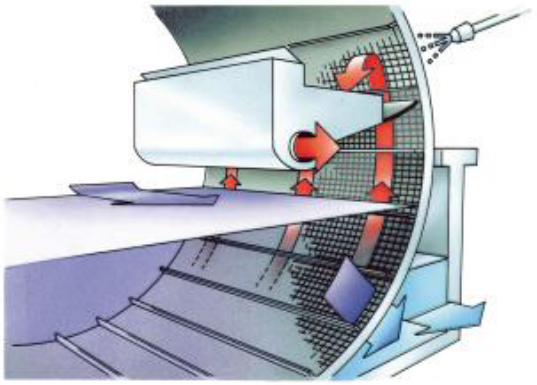

Figure 2. The drum filter filtration principle.

Once the water level inside the drum decreases, the backwash pump and the rotation of the drum stops. The filtration continues, without interruption, throughout the whole backwash cycle. In the best-case scenario, the filter installations will operate for several months without any noticeable reduction of the hydraulic capacity thanks to the regular backwash. There is however, a risk of the hydraulic capacity decreasing due to either clogging or fouling or a combination of both.

Clogging occurs when particles are blocking the pore openings of the filter media, whilst fouling can be either reversible i.e. physically removed by the standard backwash or by high-pressure cleaning, or irreversible, which will require chemical cleaning. The fouling of the filter cloth is usually caused by both inorganic and organic foulants, where inorganic fouling is most often associated with chemical precipitation, when coagulant is used in the treatment process to remove e.g. phosphorus. Meanwhile, accumulation of biological material on the filter panels is typically seen in connection with applications with very active biomass (e.g. biofilm processes) and/or during long periods of very low loading e.g. at night. For long periods of low loading, it is recommended to introduce a forced backwash once an hour and to implement a longer overrun on the backwash timer.

Fouling can in many cases be prevented by performing regular high-pressure cleaning (at max 80 bar), e.g. once a week or every second week, either by using the optional built-in high-pressure cleaning equipment or by cleaning the filters manually. If manual high-pressure cleaning is done, the high-pressure nozzles should not be closer than 10 cm to the filter media, in order to avoid tearing it. When the standard backwash and the high-pressure cleaning cannot remove the foulants, chemical cleaning of the filter media is required to recover the filtration capacity, see Figure 3.

Figure 3. A disc filter panel from an installation with iron based coagulant dosing, before (left) and after (right) chemical cleaning.

2. Frequency

How often chemical cleaning is needed depends on the pore sizes of the filter cloth, any chemical dosing upstream the filter and the water characteristics of each installation. In some cases, it is rarely needed, while in others it might be needed every week. It is recommended to check if chemical cleaning is needed every 3-4 weeks by using the test-tube set-up described below, and to adjust the chemical cleaning interval accordingly.

In general, for smaller pore openings such as 10 µm, chemical cleaning is needed more often than for larger openings such as 40 µm. When chemical precipitation is used in the water treatment process the chemical cleaning frequency might increase. For more information regarding the chemical cleaning frequency, see examples from full-scale installations in Appendix I.

Determining if chemical cleaning is needed can be done by comparing the operation hours, the sludge flow, the power consumption or the frequency of the backwash cycles for similar conditions over time. If the backwash frequency[1], hours of operation or power consumption for a similar load and the same backwash pressure increases over time, it means that the backwash is not succeeding in keeping the panels clean anymore, and that the capacity of the filter is decreasing. A decrease in the sludge flow over time can also serve as an indication that the filter media is suffering from clogging and/or fouling.

Another way of determining if chemical cleaning is necessary is to use a test-tube with an insert (see Figure 4) to relate the hydraulic capacity of the filter media to that of a new filter cloth, see the user manual in Appendix IV.

Figure 4. Test tube and insert for measuring long-term fouling of the filter media.

[1] Calculated as the backwash time divided by the time of the whole backwash cycle, i.e. the backwash time plus the static time when the filter is not backwashing.

3. Material

3.1 Health and safety

Read the labels, and safety data sheets (SDS) of the cleaning chemicals prior to use. Always wear gloves and all required personal protective equipment (PPE) as indicated on the SDS.

Local regulations for work with hazardous chemicals must be observed. For information regarding handling, storage, transport and disposal of the cleaning chemicals, see the SDS of each chemical used.

A workplace risk assessment should be done before starting the chemical cleaning. For an example of a risk assessment, see Appendix II.

3.2 Chemicals

The chemicals required for chemical cleaning will depend on the type and the extent of fouling. Before chemical cleaning is performed, the most effective chemical or combination of chemicals must be determined. In addition, the required concentration and necessary contact time of the chemicals should be evaluated. In some cases, it may be necessary to repeat the cleaning procedure a number of times or to use two different chemicals in succession. Higher concentrations than necessary should be avoided and the contact times stipulated below should not be exceeded.

To determine what chemicals should be used for chemical cleaning, a test-tube with an insert can be used to compare the hydraulic capacity before and after cleaning a clogged panel with the chemical that is being evaluated. For more detailed instructions see the user manual *Determination of clogging degree of filter media* in Appendix IV.

The recommended products for chemical cleaning are:

- Dilute hydrochloric acid (HCl, 3-5%)
- Dilute sodium hypochlorite (NaClO, 0,5-1,5%)

Generally, if chemical cleaning is performed regularly according to site-specific maintenance schedules, a 3-5% HCl solution (v/v) and 0,5-1,5% NaClO (v/v) is sufficient. However, if the filter panels have been completely blinded, concentrations of up to 15% HCl and 4% NaClO respectively can be used.

If needed, the product Hydrex 4921 (10% w/w), dilute phosphoric acid (H_3PO_4, <10%) or dilute nitric acid (HNO_3, <10%) can be used as a replacement of HCl. Hydrogen peroxide (H_2O_2, <15% v/v), dilute sodium hydroxide (NaOH, 5%) or sodium percarbonate ($2Na_2CO_3 \cdot 3H_2O_2$, 5%) can be proposed as a substitute for NaClO. There are also commercial (acid) products, which include

surfactants and inhibitors, available that can be used for chemical cleaning, for example Benco Extra/Duge supplied by FR Kemi ApS, Denmark. Dilute solutions of phosphoric acid or nitric acid can also be an alternative.

Do not use basic solutions at high pH, such as potassium hydroxide (KOH) and sodium hydroxide (NaOH), at high concentrations as this might damage the structural integrity of the filter cloth. Other solutions to avoid are listed in Table 1 below. Please contact Hydrotech for assistance in evaluating if any of the chemicals listed could be used for cleaning without damaging the filter media.

IMPORTANT NOTE!
Do not mix hydrochloric acid and sodium hypochlorite, as poisonous chlorine gas will form.

Table 1. The chemical compatibility of the polyester cloth with different chemicals. The resistance of the filter media is limited for the chemicals on the left, and the filter media is strongly attacked by the chemicals on the right.[2]

Limited resistance		**Strongly attacking**
Hydrofluoric acid	Fluorine	Sulphuric acid
Nitric acid	Sodium hypochlorite	Potassium hydroxide
Aqua regia	Iodine solution	Sodium hydroxide
Salicylic acid	Carbon bisulfide	Sodium chlorite
Sodium carbonate	Diethylene glycol	Propylene glycol
Peracetic acid	Ethylene glycol	Phenol
Bromine	Acetaldehyde[3]	
Potassium chlorite	Cresol	
Chlorine	Nitrobenzene	

3.3 Chemical consumption

Tables with the chemical consumption for the different drum and disc filter versions and models can be found in Appendix III. The chemical consumption per cleaning cycle presented for the different

[2] All information is derived from published data of the fiber manufacturers. Generally, it reflects the resistance at 20°C (68°F) of concentrated or saturated solutions. Rating, sample preparation, exposure time, load and other relevant factors vary between materials. Consequently, this information should be used as a guide only. Prior to any application, users are strongly advised to determine the accuracy, safety and suitability of this information by laboratory and field tests. For more information please contact Hydrotech.
[3] In water.

filter models in the tables should be seen as a general estimation, which is likely to differ depending on the specific conditions for each site, the cleaning frequency, the settings and the cleaning chemicals used. Hydrotech strongly recommends that the chemical cleaning settings, frequency, etc. are adapted to the conditions of each site.

4. Execution

The cleaning procedure includes the following steps:

1. A backwash (and high-pressure cleaning, if available) is done to physically remove contaminants
2. The backwash water is allowed to drain from the filter panels
3. The chemical working solution is sprayed onto the panels
4. A certain contact time is allowed for the chemical reaction to take place
5. A backwash is done to wash the chemicals off the filter panels

While it is possible to clean the filter media manually with chemicals, Hydrotech strongly recommends using the Hydrotech Cleaning Trolley (HCT). The HCT is fully automated after it has been filled with the chemical and connected to the filter and the control cabinet. The control system ensures optimized cleaning and automatically rinses the filter after the chemical cleaning is finished.

If the panels are extremely fouled, due to e.g. issues with the chemical precipitation (over-/underdosing of coagulant and/or polymer), an option is to remove all of the panels, wash them with high-pressure equipment and let them soak in chemicals.

Note that it is recommended to close the inlet to the filter during the chemical cleaning to avoid by-pass, as the filter will not be backwashing during the cleaning cycle.

4.1 High-pressure cleaning system (option)

If the filters have been equipped with the optional high-pressure cleaning system[4] (HPC, see Figure 5 and Figure 6), it can be operated using the buttons on the control cabinet (see Figure 7 for an example). For detailed instructions, see the filter manuals.

Figure 5. The optional high-pressure cleaning system for disc filters.

[4] Not available as an option for the HPF series.

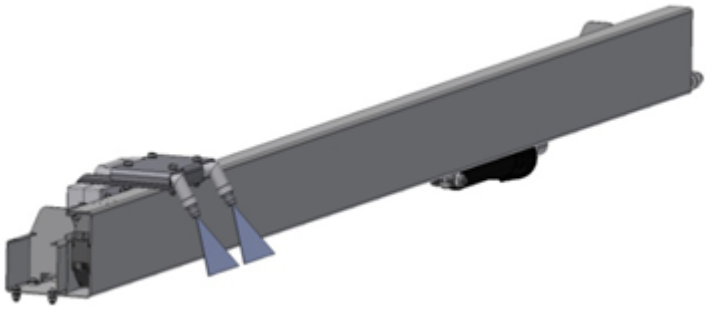

Figure 6. The optional high-pressure cleaning system for drum filters.

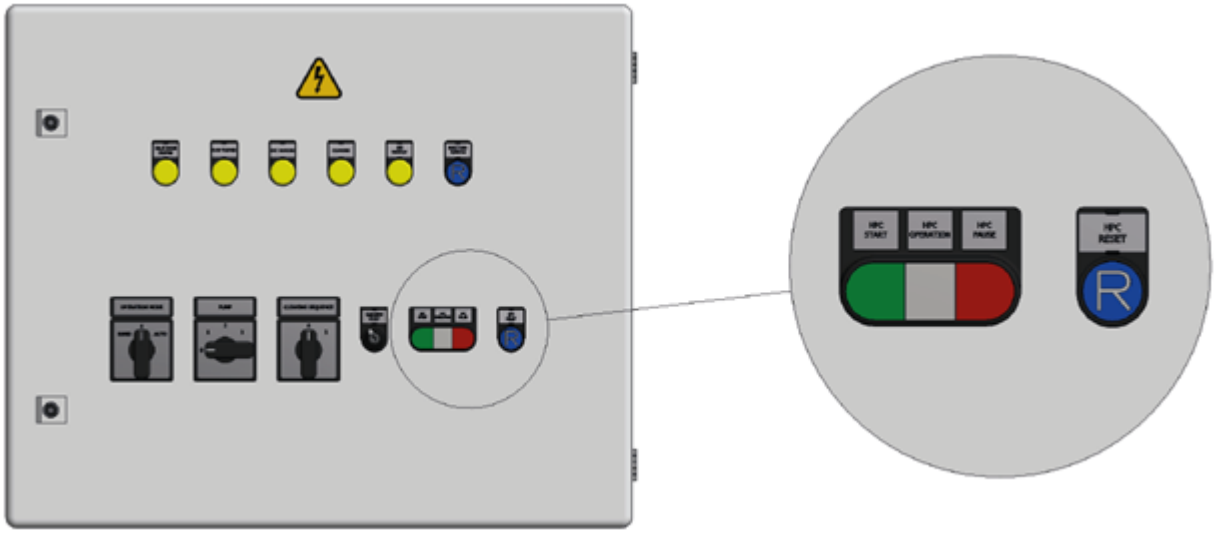

Figure 7. Control cabinet for a filter with the high-pressure cleaning system integrated.

The high-pressure cleaning should be set to operate at a pressure of 80 bar. The time it takes to complete a cleaning cycle depends on the filter model. During the cleaning cycle, the filter will rotate continuously, while the high-pressure equipment cleans one filter segment at a time.

Manual high-pressure cleaning can also be performed but, for disc filters, it requires a pressure washer lance with an angled nozzle to fit in the space between the filter panels. The pressure washer lance must be used at a distance greater than 10 cm from the filter panels.

If the fat, oil and grease concentration in the water is high and causes the filter media to clog, hot water (<60°C) can be used for the high-pressure cleaning.

4.2 Manual chemical cleaning

Note that the procedure for chemical cleaning outlined below is an example only. The actual procedure, i.e. the chemicals, concentrations and number of repetitions needed, must be

determined for each installation depending on the type and extent of clogging before starting. The chemicals are preferably applied to the filter panels using a portable pressure spray bottle or similar (see Figure 8).

A. Backwash the filter continuously for 5 minutes at maximum pressure (7.5 bar or higher[5]). Alternatively, high-pressure wash the filter panels at a maximum of 80 bar, as described above.
B. Allow the filter panels to drain 1 minute.
C. Spray hydrochloric acid (or an equivalent cleaning product) on the filter panels that are visible and leave it for a contact time of 5-10 minutes.
D. Backwash the filter at maximum pressure (7.5 bar or higher[5]) for 5 minutes, to wash the hydrochloric acid off the filter panels.
E. Rotate the filter to expose untreated panels and allow the panels to drain for 1 minute.

Repeat steps C to E until all of the filter panels have been cleaned.

Figure 8. Portable pressure spray bottle used for application of cleaning chemicals on the filter media.

Safety note: Before starting with the following steps, make sure that the hydrochloric acid is not mixed with the sodium hypochlorite, to prevent toxic chlorine gas from forming.

A. Spray sodium hypochlorite (or an equivalent cleaning product) on the visible filter panels and leave it for a contact time of 5-10 minutes.
B. Backwash the filter at the maximum pressure (7.5 bar or higher[5]) for 5 minutes, to wash the sodium hypochlorite off the filter panels.
C. Rotate the filter to expose untreated panels and allow the panels to drain for 1 minute.

Repeat steps F to H until all of the filter panels have been cleaned.

[5] The maximum backwash pressure depends on the filter model. It can be found in the technical specifications for each filter model.

4.3 Chemical spray bar

The filters can be equipped with chemical ramps[6] (see Figure 9 and Figure 10) with spray nozzles, to enable automatic chemical cleaning of the filter panels by connecting the optional Hydrotech Cleaning Trolley. Hydrotech recommends having one spray bar per cleaning chemical.

The chemical spray bar can also be used for manual cleaning. The chemicals are then injected by using a dosing pump or ejector and e.g. technical water as motive water. The type and size of ejector needed depends on the filter model and the flows required to obtain the correct concentrations of the cleaning chemicals.

Figure 9. Chemical spray bar with nozzles for disc filters.

Figure 10. Chemical spray bar with nozzles for drum filters.

Before starting the chemical cleaning the spray bar, nozzles, spray pattern, and spray angle should be checked with pressurized tap water to ensure there are no leaks or clogged nozzles, which can significantly reduce the cleaning efficiency. If clogged nozzles are a recurring issue, due to e.g. biological growth in the filter, exchanging the nozzles for blinded nozzles can be considered when the chemical spray bar is not in use.

The spray pattern can be modified, if necessary, by replacing the standard spray nozzles with a larger model. Using larger nozzles, however, will have an effect on the chemical consumption.

[6] The HSF1700 series and the drum filters are not, as a standard, equipped with chemical ramps.

4.4 Hydrotech Cleaning Trolley (option)

The Hydrotech Cleaning Trolley (*HCT*), see Figure 11, can either be used with the automatic settings in the control cabinet or manually, as described in section 4.6. Before starting the chemical cleaning, the HCT manual in Appendix V should have been read carefully and the equipment should have been installed correctly.

The HCT has three connections:

- A 10 m power cable (3 x 400V), to be connected to the filter unit
- A 10 m signal cable, to be connected to the control cabinet
- A hose for the chemicals, to be connected to the spray bar of the filter unit

Figure 11. The Hydrotech Cleaning Trolley (HCT).

The HCT can be stored separately from the filter units, indoors, to protect it from frost and direct sunlight. When a chemical cleaning is needed, the HCT can be moved into position close to the filter unit and connected, as described in the manual.

4.5 Automatic chemical cleaning with HCT, and PFC control cabinet

The automatic chemical cleaning procedure is fully automated once the HCT has been filled with the cleaning chemical to be used, connected to the filter and control cabinet and the operation of the filter is changed to cleaning mode. For the automatic chemical cleaning to start, the operator has to press the buttons manually. Consequently, the chemical cleaning requires someone to be on site to make sure that it is safe to start the chemical cleaning. The procedure for chemical cleaning is as follows.

To avoid by-pass, during the chemical cleaning when the filter is not backwashing, it is recommended to close the inlet to the filter.

A. Fill the container with the chemical to be used.
B. Connect the HCT to the filter and the control cabinet.
C. Change to the cleaning mode in the control cabinet.

The system will start the cleaning, by spraying the chemical onto the filter panels following a sequence, which will allow the filter panels to be soaked in chemicals. When all the panels have been sprayed and left soaking, the backwash cycle will start to rinse the panels. The cleaning procedure is fully automated, and takes approximately 20 minutes.

If several chemicals are needed for the chemical cleaning, replace the chemical container and restart the procedure. If both hydrochloric acid and sodium hypochlorite have to be used, great care should be taken to avoid mixing the two, as it can produce toxic chlorine gas. The safer, faster and easier option is to use two separate cleaning trolleys, instead of using the same trolley.

If the same cleaning trolley has to be used, the chemical cleaning procedure with hydrochloric acid is performed (see the HCT operation manual). The residual hydrochloric acid is then pumped out of the tank and the whole system is thoroughly washed with an excess of water. After this is done, the sodium hypochlorite solution is pumped into the tank and the chemical cleaning procedure is repeated.

D. When the panels are clean, disconnect the HCT from the filter unit and the control cabinet.
E. Change to the standard operation mode in the control cabinet.

4.5.1 Chemical cleaning settings

Several different parameters can be adjusted to optimize the chemical cleaning, depending on the conditions of the specific site. When the HCT is used the factory settings are recommended, but for permanent chemical cleaning installations, the chemical cleaning system is more likely to require adjustments. Factors that can influence the choice of settings are, for example, the time required to

build pressure in the chemical pipe and time delays in the control system, as well as the type and development of the fouling.

The parameters that need to be checked, and if necessary adjusted, are:

- Number of cleaning cycles
- Drum start delay
- Drum dispensing time
- Drum dispensing speed
- Chemical pump stop delay
- Soaking time
- Index steps
- Rinsing time

For more information, see the operation manuals and functional descriptions for the filters.

4.5.2 Chemical cleaning sequence

1. The chemical pump starts.
2. After a set time, the *drum start delay*, when the pressure in the chemical spray bar has built up and the spray pattern is right, the filter drum starts to rotate at the set *drum dispersing speed* (normally 10-20 Hz).
3. The drum rotates for a set time, the *drum dispersing time*, during which 2-3 segments are sprayed with the cleaning chemicals.
4. When the drum dispersing time has elapsed, a stop signal is sent to the drum motor, which ramps down the rotation of the drum. Due to the time it will take to slow down and stop the filter drum, a *chemical pump stop delay* is used, in order to make sure the chemicals are evenly applied to all of the filter segments.
5. After the chemical pump and the drum has stopped, the segments sprayed with cleaning chemicals will soak during a *soaking time* of, usually, 300-600 s.
6. After the soaking time, the whole cleaning sequence (steps 1-5 above) is repeated on the other segments, until all of the filter segments have been cleaned. The number of repetitions will depend on the filter model. As an example, a disc filter from the HSF2600-series has 14 segments and requires a minimum of 5 *index steps* to clean the whole filter discs. It is recommended, however, to clean the filter in 6-8 index steps to ensure that the filter segments are completely covered by cleaning chemicals. For other filter models and placements of the chemical spray bar, other settings might be needed.
7. When all of the filter segments have been sprayed and left soaking with cleaning chemicals, the chemical cleaning sequence is finished by backwashing of the filter for a *rinsing time* of approximately 5 minutes, to remove the cleaning chemicals from the filter media.

It is strongly recommended during commissioning of the filters that all of the above settings are evaluated, by using tap water, and if necessary adjusted. This should be done by having

manometers installed on the chemical spray bar and the filter lid kept open, to be able to inspect the performance.

The key is to verify the spray pattern from the chemical nozzles (spray pressure >3 bar) before the filter starts to rotate, that the filter stops before the treated segments enter the water, that the treated segments are left soaking long enough and that the cleaning of the filter segments overlap to avoid untreated sections.

4.6 Manual chemical cleaning with HCT, without PFC control cabinet

A. Backwash the filter continuously for 5 minutes at maximum pressure (7.5 bar or higher[7]) and allow the filter panels to drain for 1 minute.
B. Rotate the drum at 10-20 Hz by changing the settings in the control panel.
C. Spray hydrochloric acid at 3 bar for 12 seconds (with the drum rotating at 10-20 Hz) using the chemical spray bar.
D. Stop the drum rotation and let the chemical soak for 3 minutes.
E. Repeat steps B-D 5 times until the whole surface has been covered with acid.
F. Backwash for 5 minutes and allow the filter panels to drain for 1 minute.
G. Repeat the above steps with sodium hypochlorite, if necessary.

N.B. Make sure to **never** mix hydrochloric acid and sodium hypochlorite to prevent poisonous chlorine gas from forming.

[7] The maximum backwash pressure depends on the filter model. It can be found in the technical specifications for each filter model.

5. Performance evaluation

To evaluate the efficiency of the chemical cleaning use a test-tube with insert, as described in the user manual in Appendix IV. The time it takes for 1 L of tap water to pass a used filter panel should be compared to the corresponding time of a new filter panel. If there is a substantial difference in time, repeating part of or the whole chemical cleaning sequence should be considered.

Short summary of Hydrotech chemical cleaning

Different types of clogging

Biological clogging

Organic clogging, most likely to occur on filters with periodically low backwash frequency, in filter installations downstream biological treatment processes or in primary treatment installations.
Best cleaned with: Sodium hypochlorite (NaClO)

Chemical clogging

Inorganic clogging, most likely to occur on filters after phosphorous removal stage (where metal coagulants are dosed)
Best cleaned with: Hydrochloric acid (HCl)

Fats, oils and grease

Most likely to occur on filters in installations with high fat content in the incoming water.
Best cleaned with: Hot water (up to 60°C)

Chemical cleaning options

WARNING: Do NOT mix sodium hypochlorite and hydrochloric acid. It will create toxic chlorine gas!

$$NaClO + 2HCl \rightarrow NaCl + H_2O + Cl_2$$

Hydrochloric acid (HCl)

Used for: Clogging caused by chemical precipitation
Concentration: Dilute in water to a 3-5% HCl concentration (v/v) (max < 15%)
How to use: Spray on the filter panels. Let it react for 5-10 minutes, and then rinse the panel thoroughly

Sodium hypochlorite (NaClO)

Used for: Biological clogging
Concentration: Dilute with water to a 0,5-1,5% NaClO concentration (v/v), depending on how severe the clogging is (max < 4%)
How to use: Spray on the filter panels. Let it react for 5-10 minutes, and then rinse the panel thoroughly

High-pressure cleaning options

High-pressure cleaning (80 bar)

Used for: Filters with biological growth, for filters in primary treatment and when the filters are severely clogged.
Pressure: < 80 bar
How to use: Clean the filter with a high-pressure cleaning system with angled nozzles. Preferably, use the Hydrotech automatic high-pressure cleaning system.

Hot water cleaning (60 °C, < 80 bar)

Used for: For clogging caused by fats, oils and grease
Temperature: < 60°C
Pressure: < 80 bar
How to use: Spray the panels with hot water using an angled nozzle

Note:
For severely clogged filter panels it might be required to do several consecutive cleanings or use multiple types of cleaning methods.
It is often effective to do a high-pressure cleaning of the filter panels before and/or after the chemical cleanings.

Appendices

Resourcing the world

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