Fundamentals and processes

The processes of filtration used for water treatment vary greatly. Filtration covers all processes in which separation into liquid (filtrate) and concentrated substances (retentate) is performed mechanically. The selection of the filtration process or multiple serial process steps is determined by the quality of the raw water and the requirements for the pure water (drinking or process water). The minimum size of the solids to be held back is defined via the separation limit of the filter.

Problem substances

The following, in particular, are problem substances in raw water:

- Sand, solids, impurities causing turbidity and particles, broken out incrustations from pipelines
- Dissolved substances such as iron, manganese and arsenic
- Aggressive carbonic acid
- Pesticides, chlorinated hydrocarbons (CHCs) etc.
- Dissolved salts (sea water)
- Impurities caused by water circulation (e.g. condensate/steam cycle)

Separation limits

This overview shows a rough correlation of the filtration processes and their use depending on the separation limits.

Separation process	**Sieve filtration**	**Fine filtration**	**Particle filtration**	**Micro-filtration (MF)**	**Ultra filtration (UF)**	**Nano-filtration (NF)**	**Reverse osmosis (RO)**
Separation limits	> 500 µm	5 - 500 µm	1 - 10 µm	0.1 - 1 µm	0.01 - 0.1 µm	0.001 - 0.01 µm	< 0.001 µm
Separable materials	grains, sand, fibres	Larger particles, algae	Small particles, germs, bacteria, algae	Smallest particles, germs, bacteria, viruses	Viruses and macro-molecular substances	low molecular-weight substances and Humates	Ions
Method in water technology	Sieving, cyclone, sedimentation, clarification	Fabric filter, cloth filter, disc filter	Multi-layer rapid filter, membrane filtration (MF)	Multi-stage slow filter, membrane filtration (MF)	Membrane filtration (UF)	Membrane filtration (NF)	Reverse osmosis (RO)

Separation limits

Filter systems

We dimension, manufacture, supply and install high-quality and efficient systems for filtration such as

- Cartridge filters, backwash filters
- Gravel filters / multi-stage filters
- Filter systems for deferrisation, demanganisation and arsenic removal
- Deacidification filters
- Activated carbon filters
- Membrane filtration systems (MF, UF, NF, RO) with polymer and ceramic membranes

Fine filtration

When using drinking water from the community water supply, the raw water from kilometres of pipe networks can be contaminated with rust, sand, broken out incrustations and other solids. These solids can be filtered out with cartridge filters.

Cartridge filters

Cartridge filters are not suitable for removing larger quantities of dirt. In case of large quantities of dirt, the agglomeration of solids on the cartridge surface can lead to a rapid increase in the differential pressure. Cartridge filters can be cleaned via back-flushing. When a defined maximum permissible differential pressure is reached, the filters must be flushed. The filter cartridges must be changed when the back-flushing intervals become increasingly shorter. In nanofiltration and reverse osmosis, cartridge filters are normally used as protective filters. In ultrafiltration, automatic backwash filters or disc filters are normally used as protective filters.

Gravel filtration/ multi-stage filtration

In contrast to cartridge filtration, gravel filtration - in particular the multi-layer filtration variant (filter gravel + filter carbons) - represents a deep-bed filtration. With multi-layer filtration, the water passes through various layers of filter material with increasing fineness in the direction of filtration. Dirt is agglomerated in the various layers of the filter depending on its size. Multi-stage filters can take up large amounts of solids and, if properly assembled and operated, can deliver outstanding filtration results.
Gravel filtration or multi-layer filtration, in conjunction with flocculation, is used in particular in the treatment of river water. In these cases, a sedimentation stage or other suitable pre-treatment is to be found upstream of filtration as the initial process step.

Gravel, sand and multi-stage filters must be cleaned regularly by backflushing. Depending on the use, pure water flushing or air/water flushing is carried out.

Deferrisation

Water with higher iron concentration must be treated. Water containing iron is generally reduced- or low-oxygen water in which the iron is usually dissolved in bivalent form. Compressed air or oxygen is introduced into the raw water upstream of the filter and mixed with it for oxidation of the iron. Single-stage or multi-stage filters can be used for deferrisation.

The bivalent iron oxidises with oxygen and forms undissolved iron oxide hydrates, which is held back in the filter bed. The held back iron leads to an increase in the differential pressure in the filter. Back-flushing generally occurs, depending on the throughput. If a defined differential pressure is exceeded, forced flushing can be initiated automatically. Depending on the degree of automation of the deferrisation system, the flushing procedures are fully-automatic, semi-automatic or manual.

For water with elevated humate levels, simple oxidation agents like oxygen from the air are often insufficient. Stronger oxidation agents, such as ozone, hydrogen peroxide or potassium permanganate, are used in such cases.

Demanganisation

Dissolved manganese is usually present in water that also contains iron. The oxidation of manganese is then more difficult, due to the fact, that manganese is oxidised after iron. Besides the chemical and biological demanganisation, catalytic filter materials are primarily used. Demanganisation can occur in one or two filter stages, depending on the manganese content of the raw water.

When ozone is used, demanganisation can in principle occur parallel to deferrisation in a multi-stage filter, because ozone safely and fully oxidises both iron and manganese.

Arsenic removal

In addition to iron and manganese, arsenic is trace substance occurring especially in reduced groundwater. When ozone is used, arsenic removal can occur parallel to deferrisation and demanganisation in a multi-stage filter.

Alternatively, filtration via granulated iron hydroxide (GIH) is possible. In this case however, the water being filtered must be free of solids, iron and manganese. In this process, arsenic agglomerates on the GIH material. Agglomerated arsenic cannot be removed from the filter via back-flushing. The material must therefore be changed or renewed after the calculated service life (2 – 3 years).

Deacidification

Natural spring water and groundwater sometimes contains excessive amounts of carbonic acid, which must be corrected by way of treatment measures.
Filtration via materials containing calcium carbonate (semi-burnt dolomite, marble or Jurassic limestone) causes neutralisation of the free aggressive carbonic acid until a lime-carbonic acid equilibrium is achieved. In this context, the free carbonic acid reacts with calcium carbonate from the filter material. This hardens the water. Deacidification filters must in principle be dimensioned based on a current and representative water analysis. Dolomitic filter materials have a tendency to alkalise excessively is under-loaded. It must be possible to flush deacidification filters with air and water.

Ozone bio-filtration

The natural organic matter (NOM) content is significant if the water is to be used for the drinking water supply. The NOM concentration is recorded analytically as the sum of the dissolved organic carbon (DOC). Water containing humates and with raised DOC levels / colouration should not be used as drinking water without water treatment.

Ozone bio-filtration is an established natural method for treating water containing humates. The method uses the biological mechanisms in the filter bed for reduction of TOC / DOC together with a preceding ozonisation. With ozone acting as a powerful oxidation agent, the organic carbon compounds with a high molecular weight are split, colouration is massively reduced and the concentrations of the compounds with a low molecular weight are increased. Some of the compounds created in this way are biologically available and can be degraded in the downstream (bio-)filtration stage.
This method is especially environmentally friendly as - in contrast to nanofiltration systems or reverse osmosis - almost no substances which are harmful to the environment are created and energy consumption is minimised.

The configuration of an ozone bio-filtration system requires a lot of experience. This is why we cannot specify any general data here.

Membrane filtration

The following processes are grouped together under membrane filtration:

- Microfiltration (MF)
- Ultrafiltration (UF)
- Nanofiltration (NF)
- Reverse osmosis (RO)

Membrane filtration techniques are used for many different applications in water treatment - often combined with traditional processes.

Besides standard racks, we design application-orientated special systems with many different membranes for almost all applications in water treatment.

Nanofiltration system for softening and trace substance removal

Particular emphasis is placed here on ceramic membranes with ozone regeneration.

Ceramic membranes are extremely resistant and impress with significantly higher permeabilities compared with PES membranes. The higher price can be offset by the smaller membrane surfaces that are required.

HydroGroup®/Hydro-Elektrik GmbH • Angelestraße 48/50 • 88214 Ravensburg, Germany • Tel.: +49 751 60 09 0
www.hydrogroup.biz