PRONOMAR – MERUS TECHNOLOGY

Lasting solutions fighting rust, lime scale
and microbiological problems in
water-bearing systems

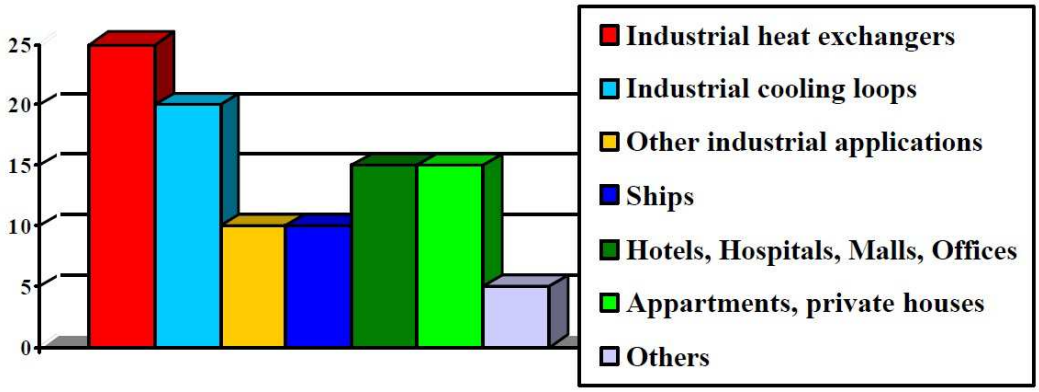
Table of content

1. General information

A description of how Merus devices work and their effect on water and the substances it contains will be given as detailed as possible on the following pages.
A great part of the knowledge and findings have been obtained empirically. Theory itself is largely based on hypothetical models since the effects and phenomenas observed have not been studied in detail to date. This is above all due to the fact that the measurement technology available induces more alterations in water than the devices themselves.

However, with almost 10,000 installations, the findings are so convincing that Merus is able to continuously expand its market position and is now represented in more than 30 countries in all 5 continents. The chart depicts the numerous areas of application where Merus devices are used.

Sales breakdown by applications in percentage

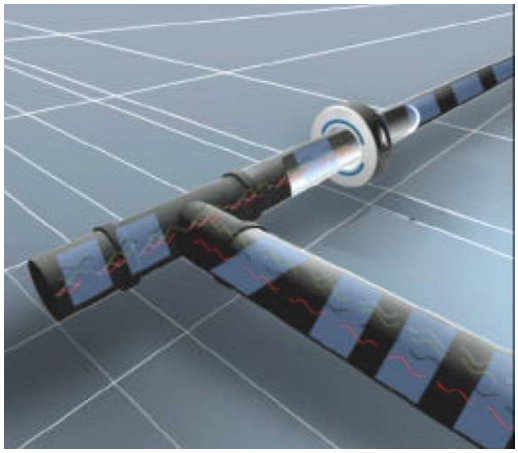


Merus worldwide

1.1. What makes the MERUS rings so unique?

The unique Merus technology differs effectively from the standard methods of water treatment. While, for most part, conventional methods only treat the symptoms, Merus has been working at the root of the problem for more than 10 years. This has been achieved by using water itself effectively against technical problems caused by water, such as rust or lime scale. To a certain extent, Merus has transformed water into its ally.

All conventional technologies on the market, whether chemical or physical, work only at the point of installation. Once the water has passed this point, such conventional methods of treatment can no longer control the water. Either chemicals are added or magnetic fields produced which change or should change the lime scale, the corrosion or the microbiology in water. In the case of physical devices, the changes undergone by lime scale are not stable, but rather they convert to the previous state after a while. Physical methods have, if at all, only an indirect effect on corrosion or microbiology. If chemicals are used, those added degrade quickly. Technically, it is not feasible that the necessary concentration of the substrate spreads uniformly in the whole system. The factors and circumstances described above, together with the sometimes long periods of time the water remains in less used parts of the system, can frequently lead to suboptimal results or even to the failure or malfunctioning of conventional methods .



Precisely when it comes to such problematic applications, two of the most important unique features of Merus oscillation technology achieve the results required.

On the one hand, Merus technology uses the water itself to transport and preserve the active oscillations. These active oscillations spread much more quickly through water than water itself flows. This means that each time water flows through the device, not only is the water at the point of installation supplied with new oscillations but the whole water leg that follows. Especially if temperatures are above 60° C, it is necessary to th at oscillations are reemitted continually in order to prevent lime scale from converting to its previous state as known in the case of physical methods. This explains why, for instance, Merus technology remains fully effective even at temperatures well above 100℃.

On the other hand. the oscillations stay in water for a long time. Even if no water is flowing, the effect on the formation of rust, lime scale and biofilm lasts. This is of a great advantage in particular in the case of microbiological problems because the oscillations can reach the socalled deadlegs and are effective in these biological problem areas.The devices do not require any servicing or maintenance. Trial installations can be carried out easily and quickly by installing the device without having to do any welding to the piping and without entailing any financial risks.

2. Theoretical background

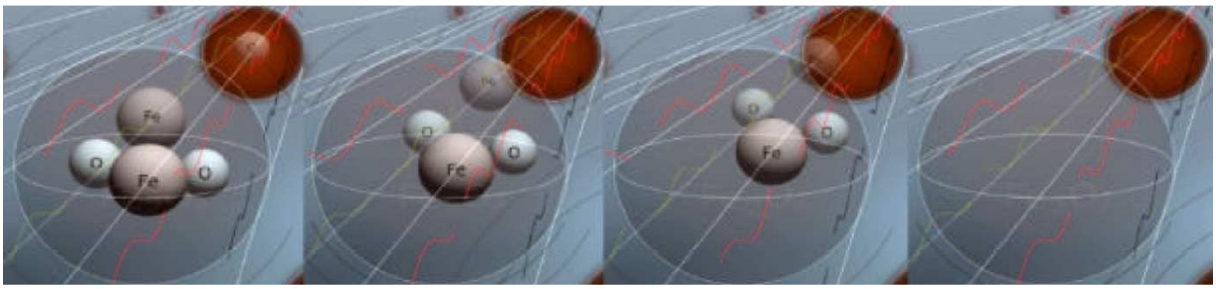
Merus technology works using specifically modulated molecular oscillations or lattice oscillations and is **not** based on using fields created by electric coils or magnets. Due to the fact that this technology has been developed empirically, there is still no in-depth scientific explanation.

Each element, each molecule has its own typical natural molecular oscillation. This natural oscillation is unique and compares well with the human fingerprint. Merus is able to isolate, record and store these oscillations of, for instance, rust.

Based on these original oscillations, Merus develops new active oscillations. The aim is to influence the original oscillation of the element in question through new active oscillations in such a way that ultimately the physical properties of the element or of the molecule are modified in the water. Merus can use and benefit from its work and experience of more than 10 years. Hence, theoretically at least, Merus is able to produce a new active oscillation for each isolated element.

Today, Merus has a database containing a great number of active oscillations, each with a specific task. These active oscillations are recorded on an oscillation carrier in a similar way as writing on a data carrier (CD/DVD). In most cases for cost-benefit reasons, an aluminium alloy is selected as carrier material. This alloy can store an almost unlimited number of active oscillations and emit these in water in a constant and stable form, largely independent of the ambient temperature. The active oscillations are modulated according to the lattice oscillation of aluminium. Due to the ambient warmth, the aluminium lattice oscillates and hence the active oscillations implemented by Merus as well. The oscillations are positioned in the lattice structure in a similar way as a parasite and are thus continually created simultaneously. The active oscillations create a field within the ring, which penetrates all piping material and thus passes into the water.

Due to its bipolar properties, water can absorb, store and spread the active oscillations well through the entire water leg that follows. In the water, the active oscillations interfere with the natural oscillation of rust, lime scale, iron, etc. Owing to this overlapping, the behaviour of the substances, which are released in the water and come in contact with it, is modified. The result is: rust molecules disintegrate in an unstable form and are washed out. Iron no longer reacts to Fe_2O_3, but to Fe_3O_4 (magnetite), which is largely inert to further forms of corrosion. Lime remains dissolved in water longer and crystallises out to a much lesser extent.



3. Overview of applications

a. Corrosion
Merus devices can be used against corrosion in numerous areas of application. In general, it can be said that simple forms of corrosion are reduced or stopped in all water-bearing systems. Corrosion can be stopped effectively using Merus technology and the existing layers of rust can be reduced in thousands of areas of application, ranging from normal piping and pipelines, water-bearing machines, steam generators, cooling facilities and systems to sprinkler systems.

b. Lime scale
Merus is used against lime scale primarily in technical water, in other words in systems in which water is used for transferring and transporting heat. Very good operating experience has been made with temperatures well above 100℃. Merus is used in are as ranging from small dishwashers, machines and tools to huge pipe bundle heat exchangers in the chemicals and heavy industry.

c. Microbiology
Merus has special devices for solving microbiological problems in water. The spectrum of applications ranges from algae in open systems, cooling towers, swimming pools or fountains, and biofilm/ biofouling in complex piping to the removal of legionella in drinking water installations.

d. Sea water and crude oil
These applications are very specialised, and that is why we will not go into further details in this paper. We will be pleased to discuss the possibilities for your application with you.

e. Process water
Merus can also be used in process water, i.e. water that is directly or indirectly a part of the product. In all cases, it should be checked whether or not Merus technology affects the process as well. Some customers have experienced and noticed that the taste and flavour of products (food) have changed slightly. Above all in fermentation processes it is very likely that the taste or flavour may be affected.

More details about use and applications can be found on our website www.pronomar.com

3.1. Corrosion

In general, metals occur in their chemical compounds with oxygen, sulphur, silica or carbonic acid and are extracted by metallurgical processes using energy. This shows that under the existing environmental conditions the elemental state of most metals is not stable and is released again sooner or later. The conversion to the previous state, which is visible as corrosion, occurs mostly on the surface and ultimately lead to the failure of metallic parts and components. In general, this is an electrochemical reaction promoted by bipolar liquids such as water.

Metals have the property to emit electrically charged atoms (ions) into liquids. In their solid state, metal atoms are in an electrically charged state. The cohesion of the lattice and its external electric neutrality are due to the fact that the electrons remain in a so-called electron cloud within the metal lattice. If a piece of naked iron is emerged in water, then it emits a small amount of $Fe2+$ ions in the solution. Seeing that the water and the piece of metal become electrically charged, this reaction would stop soon if it were not for other processes which occur. They lead to a form of corrosion which we know as rusting of iron.

Rusting process of iron in water
As described above, in watery solutions naked iron emits $Fe2+$ ions in the solution. Water consists not only of $H2O$, there are $H3O+$ and $OH-$ ions in it as well, even if in a very low concentration, owing to its own dissociation. The carbon dioxide, which is released in the water, produces a diluted solution of carbonic acid that increases the proportion of $H3O+$ ions.

Released oxygen can still be found in the water. If naked iron becomes wet, oxide film, which has a higher chemical potential than iron, is formed at places where there is a sufficiently high concentration of oxygen. That is to say, galvanic cells are formed between the naked iron and the oxidised spots. Metallic iron emits bivalent ions in the solution, in other words the actual material degradation takes place. In water $Fe2+$ and $OH-$ combine to iron hydroxide which is relatively soluble in water. If there is enough atmospheric oxygen, the $Fe2+$ ions oxidise to $Fe3+$ ions, which, together with the $OH-$ ions, form the virtually insoluble iron oxide hydrate FeO*OH. A further reaction promoted by oxygen is the formation of $Fe2O3$ due to $FeOH2$ and oxygen. This forms a main component of rust.

This form of corrosion is stopped by Merus technology in an effective and lasting way. Any existing films of rust are dissolved and removed.
Forms of corrosion, such as contact corrosion (contact between different metals), stress crack corrosion, trans- or intercrystalline corrosion or grain boundary corrosion, are no longer stopped altogether, but nevertheless reduced considerably, due to the much higher electrochemical forces.

In practice, the service life of pipes, machines and plant components is increased thanks to Merus technology. Less corrosion leads to less roughening of pipe walls, thus reducing considerably the formation of encrustation at places where the flow velocity is lower. A direct consequence is lower pressure loss and maintenance requirements as regards rinsing/cleaning.

Existing layers of rust are dissolved and can be simply washed out. The formation of a magnetite film ensures a lasting and effective protection against new formation of corrosion.

From a commercial aspect, corrosion is one of the key factors which influences the lifetime of metallic components in plants and machines. If corrosion is slowed down or even stopped, the service life of capital equipment is lengthened, and this results in substantial cost savings. For instance, the corrosion in the titanium fire tubes was reduced to such a considerable extent that there was no longer any need to replace them each year as to date, but every three years. Alone the annual hardware costs for this application were reduced by USD 25,000 each year to one third, and this does not even include the cost of production loss and the performance of works.

3.2. Lime scale

Lime scale and other salts in a dissolved form can be found in almost any water. The lime scale contained in water remains dissolved as long as there is sufficient CO2 in the water. If the temperature of the water rises, CO2 gases out and less lime scale stays dissolved in the water. It precipitates, deposits itself on the surfaces and, in the end, clogs the pipes, valves or other components of the system. In order to avoid this problem, water is treated chemically, particularly in critical applications. This relatively cost-intensive method (cost of chemicals and service) is often not financially expedient in the case of applications which use large amounts of water. Therefore, the operator often accepts the consequence of having to descale heat exchangers, cooling towers, etc from time to time.

Merus technology is a very competitively priced alternative. The oscillations emitted by Merus devices into the water modify the structure of lime scale in a lasting and effective way. This means that the lime scale can be bonded much better by water and thus only precipitates at considerably higher temperatures or much higher concentrations.
If the flow in the pipeline or in the machine is strong enough, the lime scale, deposited despite the increased solubility, is carried by the water. If there is no flow or if it is low, the lime is deposited in a soft, slushy consistency (lime sludge). This can, however, be wiped or sprayed away very easily without using chemicals.

There is a record of very good experience based on several hundred heat exchangers used worldwide, which in some cases have a capacity of well over 1,000 m3/h. In most cases when using Merus devices, there is no longer any need to descale the system chemically. In several regions of the world, Merus technology is also being used very successfully in steam generators. The results depend very much on the type of steam generator and cannot be described in general terms.

A further result of the increased solubility of water is that the existing lime scale, for instance in the piping, is dissolved and carried away by the flowing water.

	Ca [mg/l]	CaO [mg/l]	CaCO [mol/m³]
without MERUS	1.0	2.0	0.03
with MERUS	18.0	25.0	0.4 4

Table: Ca content in the water of a smaller closed heating circuit. During the observation period of 2 months, no additional water was filled in and the operating parameters were not changed.

In particular in open circuit cooling systems, the costs spent on the investment can be recouped very quickly thanks to the increase in lime solubility. Due to the higher blowdown limit, great amounts of water can be saved. The potential increases differ from case to case and have to be tested on site. In the case of some applications, a ROI was achieved within a few months.

As far as some special applications are concerned, Merus technology reaches its limits. Each time when the water flow is too weak due to the application to carry the precipitated lime scale, it is deposited for the time being. It hardens if it is not washed away within a few days, particularly in the case of vaporisation, this is not always possible due to the type of construction and production conditions.

3.3. Algae, biofilm, bacteria

Merus has developed special active oscillations for these microbiological problems and provides them, together with the protective effect against rust and lime scale, in so-called bioindustrial devices. The effect is based on two effective mechanisms. On the one hand, there is a direct effect on the microorganisms, and on the other hand, their breeding places, i.e. rust and lime scale, in the system are reduced. Due to the fact that Merus technology is effective in stagnating water and also in so-called deadlegs, microorganisms are also reduced sustainably in difficult zones where conventional methods mostly work inefficiently.

Our customers' experience has shown that over a period of some weeks to a few months algae or bacteria were reduced continually until they either disappeared completely or stabilised at a very low level.

Algae:
Algae can be found in open systems, such as cooling towers, fountains or ponds. Algae proliferate primarily in warmer surroundings. Traditionally, this problem is combated by adding biocides. This is very cost-intensive and is not always the most effective method in every system. Especially as far as fountains in public parks are concerned, the use of chemicals entails incurring high financial costs. Merus can give examples of many fountain and open circuit cooling systems where the use of chemicals is no longer necessary and less time is needed to clean the systems, and thus reducing the costs considerably.

Biofilm:
In some systems, fouling is formed due to microorganisms. It is debatable where they come from, but it can be assumed that they are mostly brought in from outside. Once they are present, the microorganisms proliferate and often spread throughout the whole system. A sludgy film on the pipe walls is evidence of their existence. Flocculent particles continually peel off from this film or covering. These particles are then carried by water and can lead to serious problems in narrow passages or in machines. Some of these life forms in the biofilm promote corrosion. These microorganisms secrete substances which are very aggressive and promote corrosion in the piping. Proliferation takes places through very resistant spores which are deposited in the biofilm or in other fouling. In the case of chemical and thermal remediation, it is for most part not possible to kill all spores and, therefore, the old problems reappear shortly after the remediation. By applying Merus technology permanently, effective results have been obtained in installations in which no long-term solution was achieved using conventional methods.

The active oscillation of the devices used by Merus in these cases are similar to those used against algae. Over the last few years, Merus has succeeded in removing biofilm from entire cooling circuits and waste water treatment plants.

Legionella:
Water suppliers provide water free of microbiological contamination. Nonetheless, time and again there are reports in the press of legionella being found in large quantities in individual buildings. The new Drinking Water Ordinance prescribes that public buildings, such as schools, hospitals or homes for elderly, have to be inspected at least once a year to see whether there is any microbiological contamination. The criteria for hospitals are very strict and, as a consequence, the operators scrutinise this water.

Legionella in drinking water only pose a true danger if they are breathed in together with water vapour, in other words when taking a shower or a bath. Only a few forms of legionella are hazardous to health and infect the lungs.

The law prescribes value limits for legionella. If these limits are exceeded and depending on the degree of contamination, respective measures are prescribed, which could even mean closing the hospital.

Over the last few years, Merus has solved this problem completely in numerous domestic water systems of hospitals, swimming pools, hotels or homes for elderly by using special devices. One or several devices are used depending on the size and complexity of the water system.

The previously described special features of Merus technology, namely being effective in stagnant water and the oscillations being able to penetrate in deadlegs as well, are of particular importance when it comes to solving this problem of legionella. Especially the deadlegs pose great problems for conventional methods, such as thermal remediation. It is almost impossible to thermally remediate parts where no water flows, as found in particular in old complex water systems, because it is not guaranteed that the required high temperature can reach the end of the piping.

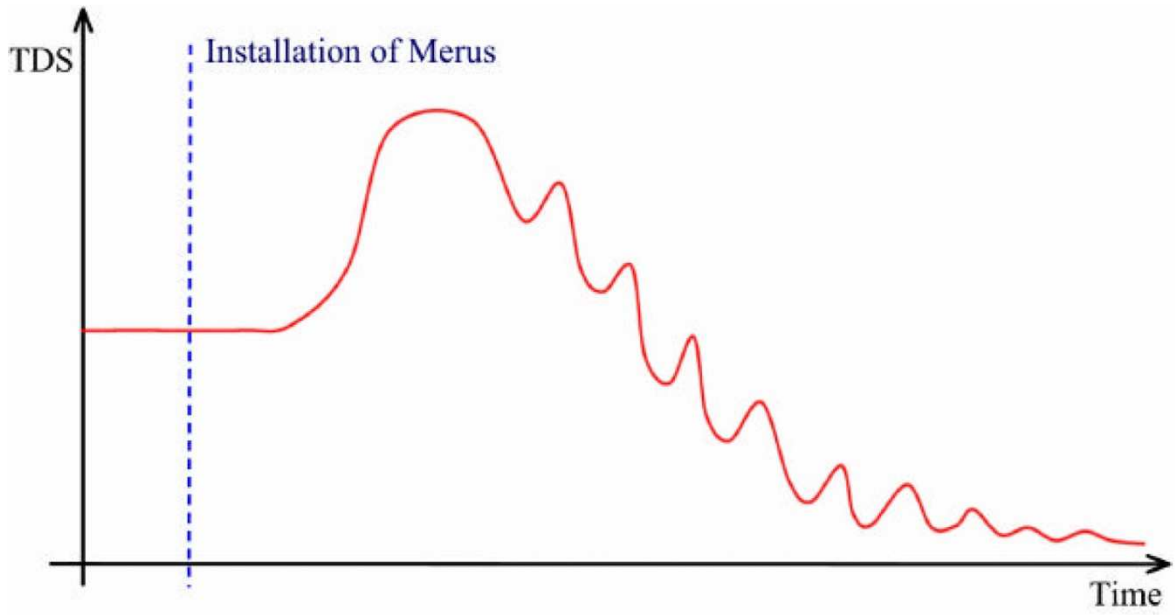
Merus devices used against legionella are not sold individually on account of the complexity of this problem. The problem is solved as a part of a project. Merus guarantees that the bacterial count is reduced to a certain number for a certain period of time. In exchange, Merus receives the count so that, if need be, additional devices can be installed or placed in different positions. Frequently, these solutions are very complex and require careful planning and execution. We would be pleased to advise you and answer any questions regarding this matter.

4. Monitoring of the function

4.1. Measuring method

When using Merus technology, water is not or only insignificantly modified. Hence, the effectiveness cannot be evaluated using simple analytic methods (e.g. hardness testing). Therefore, indirect measuring methods have to be used, in other words the effects on the system are observed. Depending on the application, specific methods are required, We would be pleased to discuss these methods with you and develop them.

a. Corrosion
As far as corrosion in piping or in machines is concerned, it is relatively easy to measure the percentage of iron contained in water. If there is historical data, it can be easily observed how the percentage of iron in water first increases considerably after installing Merus technology and then decreases, ultimately falling below the initial value. Water samples can be taken from any part of the piping system. In the case of steam generators, the best place to take a sample is the blowdown pipe. The total dissolved substance (TDS) is also a good indication to test the function.



It goes without saying that Merus technology only reduces the iron in water which exits due corrosion in water. The total percentage of iron or the TDS cannot fall below the value of feed water.

b. Heatexchangers

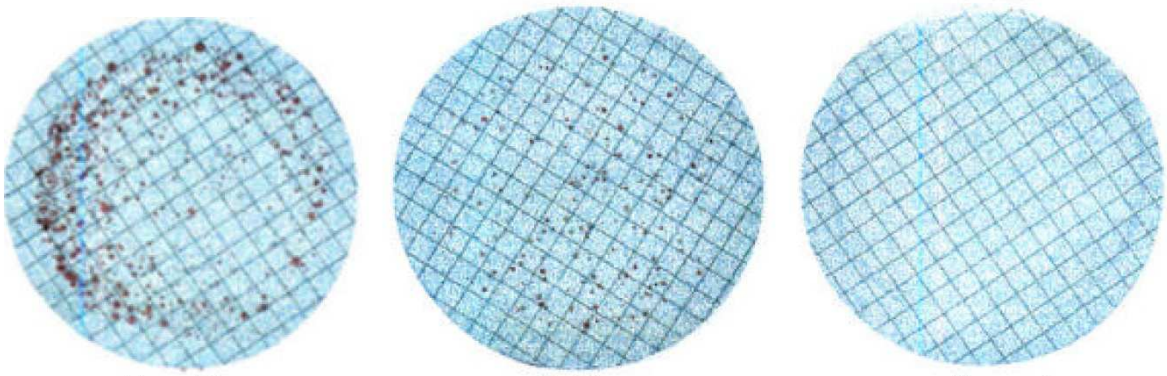
The most common application. The higher the precipitation or fouling in heat exchangers is, the higher the pressure loss (? P) will be from inlet to outlet. If Merus technology is installed in a fouled heat exchanger, it can be observed that the pressure difference no longer rises and even falls again, reaching the value that a new or a recently cleaned heat exchanger would have. At a constant volume flow, the difference in temperature between inlet and outlet provides information on the interior of the heat exchanger. The more precipitation or fouling there is, less heat will be transferred. If the circuit is controlled by volume flow, the effect can be ascertained by monitoring the volume flows. Ultimately, the increase in the exchanger's efficiency shows how Merus functions.

	primary circuit [litre]	secondary circuit [litre]
target value	10.8	14.8
before installing Merus	9.0	4.5
after installing Merus	10.8	13.0

Volume of a heat exchanger in litres before and some weeks after installing Merus

c. Bacteria

Microorganism can be easily proved by bacterial count. In most cases, a reduction of about 80% is noticeable within a few weeks. For a short time, higher values may be measured due to the bursting of existing nests. Depending on the type of organisms, the bacterial count ultimately stabilises at a very low level or even at zero.



without Merus with Merus sterile sample

4.2. General conditions

Merus technology can be used in any piping material, even in mixed-metal systems. The place of installation should be largely free of electromagnetic pollution since the devices may be discharged due to the constant influence of an electric field (>=50 V/m). Furthermore, the devices should be installed in such a way that they are protected from splash water so as to avoid surface corrosion.
Electric fields also have an impact on treated water. If the piping runs through or along strong electric fields, the oscillations in the water are overlapped. Should this be the case and depending on the size of the system and the components, it might be necessary to install several devices, distributing them in the system. However, several devices in a leg are seldom necessary thanks to the constant recharging of the entire water leg when water flows through the device.

Each device is able to treat a certain volume flow. Different types as regards diameter and capacity are available for different requirements. In a few cases, several devices may have to be installed in a series. We will be pleased to advise you regarding the right position for the devices and the number needed. In addition to the problem itself, issues such as volume flows, water circulation, the length of the system, electric load, and open or closed circulation should be taken into account when choosing the devices.