EUROPEAN UNION OF SWIMMINGPOOL AND SPA ASSOCIATIONS

# TECHNICAL PAPER – Water Treatment

There has to be an international understanding of certain words when producing any paper such as this. The word “REGULATION” means that there is a national law and is associated with the word “MUST”. The word “RECOMMENDED” means that there is no legal requirement but this is the EUSA suggested best way of working and is associated with the word “SHOULD”.

## 1. Introduction

This paper deals with water treatment for private and public pools (natural swimming pools are excluded) In addition to the papers *circulation systems* and *filtration systems* this paper deals with the water itself – mainly water disinfection, pH-regulation and water balance.
The water may affect the skin or eyes of bathers, disturb the flocculation, affect the filtration process and also the materials e.g. piping work.
Therefore additional water treatment facilities are necessary to obtain a certain water quality.

Different steps have to be considered

- Flocculation
- Disinfection
- pH-adjustment
- Water-balance
- Dilution
- Water monitoring
- Cleaning

Other technologies might be also possible, but have to be approved first.

## 2. Flocculation

Pollutants in the pool water can vary in a wide range. They can be classified either in particle size or in consistence. The bigger a particle is, the better it can be removed in the filter. Small particles on the other hand can go through the filter. Therefore a flocculent has to be used to increase small particles in size.
Flocculants destabilize the electric charges of particles to succeed the repulsions forces. Hence the particles are increased in size to be removed in the filter.
Especially metal ions, colloidal pollutants and microorganisms can be efficiently removed out of the pool water cycle.
It is important to know, that some kind of microorganisms (e.g. cryptosporidia) are even resistant to disinfectants. The only way to get rid of them, is the combination of flocculation and filtration. From these reasons a flocculent is recommended to be used in public pools.
The compatibility of flocculants with different types of filter media has to be checked (i.e. cartridge filters or diatomaceous earth filters).

When using a flocculent, make sure, that the concentration of the active substance (aluminium or iron) is known. Otherwise a proper setting of the dosing pump is not possible. Overdosing or inefficient flocculation may occur.
When using other qualified flocculants, other settings and operating conditions must be considered.
It is recommended that the injection-point is positioned after the filter pump and before the filter vessel. However there must be sufficient pipework before the filter to ensure the proper mixing of the flocculant and the water. This can be for example an extension of the pipe diameter at this point and a longer pipe length before reaching the filter.

Note: flocculation should only be applied in combination with medium- and slow rate filtration and also with a certain height of the filter bed.

## 3. Disinfection

Disinfection means: removing the source of transferable diseases

**To assure this definition the disinfectant has to fulfil following requirements**

1. Mode of action: fungicide, algaecide, bactericide and against viruses
2. Consistent disinfection
3. High kill off rate
4. Easy and fast measuring method of disinfectant content
5. No harm to bathers in adequate concentrations

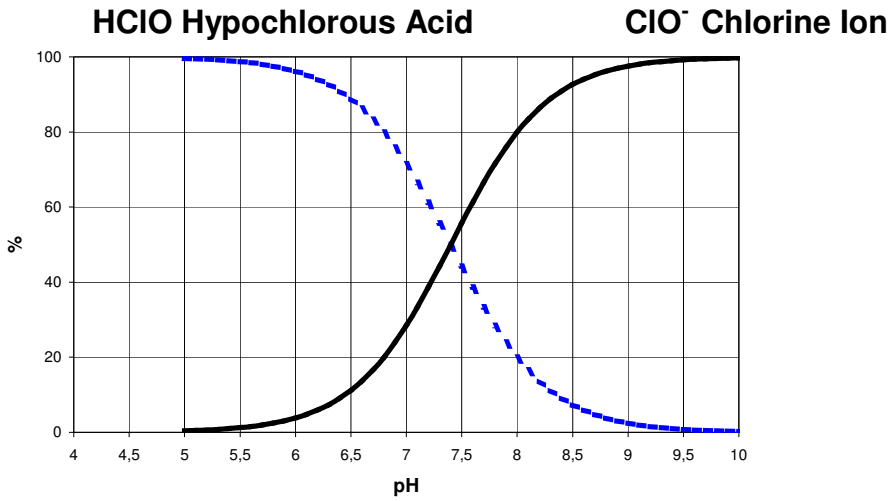
These requirements are fulfilled so far only by chlorine disinfectants.
Other disinfectants might be possible. But they have to be tested and approved to meet theses requirements.
When using UV, ozone or other treatment methods, always free residual chlorine has to be present.

The disinfection with chlorine derivates is based on the production of hypochlorous acid – which is the effective agent (free chlorine).

The chemical reaction equation in case of dosing pure chlorine:

| | | | | | | |
|---|---|---|---|---|---|---|
| $Cl_2$ | + | $H_2O$ | ⇔ | **HClO** | + | HCl |
| (Chlorine | | water | | Hypochlorous acid | | hydrochloric acid) |
| | | **HClO** | ⇔ | $H^+$ | + | $ClO^-$ |
| | | Hypochlorous acid | | hydrogen ion | | hypochlorite ion |

The effectiveness of Hypochlorous acid is strongly dependent on the pH in the water. Since it is an acid, the disinfection is more effective at a lower pH, which is also shown on the picture below.
Hypochlorous acid has the highest concentration at low pH-values.




Picture: Dependency of disinfection efficiency vs. pH

## Chlorine disinfectants

**A. Sodium-Hypochlorite (EN 901)**
Sodium-Hypochlorite is a liquid product. The content of free chlorine is approx. 12 – 13 %. Other contents are mainly sodium hydroxide, salt and water. The pH is approx. 12.
Using Sodium-Hypochlorite means a higher demand in acid for pH-correction.

**B. Calcium Hypochlorite (EN 900)**
Calcium Hypochlorite is a solid chlorine product, usually granular. Calcium Hypochlorite contains calcium and reacts with the water making it more alkaline. Above that due to calcium solid cristalls can also block the injection unit.
Calcium Hypochlorite has to be dissolved in water before dosing into the pool water.

**C. Chlorine Gas (EN 937)**
It is pure chlorine delivered in pressure gas bottles. The effectiveness of chlorine gas is very high since no by-products are present. On the other hand, the handling, storage and dosing needs more effort, attention and safety requirements. For storage and the dosing equipment a separate, with safety systems equipped room is necessary.

**D. Chlorine produced on site through electrolysis**

This can be achieved either by producing a diluted sodium hypochlorite solution (approx. 3%) or by production of chlorine gas which is immediately fed into the pool water cycle (without storage or accumulation).
The capacity of the electrolysis unit must meet the maximum expected demand of free chlorine in the pool. Unwanted hydrogen is also produced and has to bled out of the building.

**E. Organic chlorine Products**

Solid or liquid chlorine products are decreasing in concentration with time, temperature and light. To reduce this effect, stabilizing organic based agents are added.
But these organic compounds can affect the quality of measuring and above that, lead to higher concentrations of organic by-products in the pool water.

**General information for use of chlorine disinfectants**

For all disinfection methods the national health and safety regulations have to be observed. A risk assessment has to be carried out as well.
I.e. safety precautions, personal safety equipment, ventilation in plant room, collecting container, chlorine gas sensors, etc.

The **ideal level of free chlorine** has to be chosen due to pool load, type of pool and water temperature. National regulations have to be observed.

The reaction of free chlorine with ammonia (which is the main part of urine and sweat) results in a reaction by product – **chloramines** or **combined chlorine**.
Since the amount of chloramines is a measure of the swimming pool pollution it is helpful to measure the content of **combined chlorine** for evaluation of the pool water condition.

Too high concentrations of chloramines are also responsible for eye irritations and the chlorine odour in swimming halls.

To avoid this, it is recommended to keep the level of combined chlorine
below 0.2 mg/l. Otherwise the technology of the pool water treatment facilities and the operating conditions of the pool has to be checked and adjusted.

**4. pH-value and pH-adjusting**

The pH-value is a degree of acidity, alkalinity or neutrality. The pH-value has a range from 0 (acid) – 7 (neutral) –14 (alkaline).
Adjustment of pH in the pool water is essential due to different aspects.

- efficiency of disinfection (see picture)
- efficiency of flocculation
- human skin / eye tolerance
- corrosion of metals

If pH is high (alkaline reaction) > 7

efficiency of disinfection decreases
flocculation can not take place
precipitation of salts in filter or pipework
human skin / eye irritation

If pH is low (acid reaction) < 7

efficiency of disinfection increases
flocculation will be delayed or impossible
pollutants in the filter can be washed out
human skin / eye irritation
corrosion of metals

The pH-value is recommended to be kept in a small range to meet the demands

**pH range in pool water: 6,8 – 7,6**

For adjusting the pH in the pool water, only approved and suitable chemicals should be used. Be aware to consider the concentrations of pH-dosing chemicals. High concentrations can cause overdosing and unsteady pH-values.
If using pH-indicators, be aware that the range can be very small. For example when using phenol red, the ph-range varies between 6,5 (yellow) and 8,2 (red).
That means in case of low pH-values the indicator stays yellow whether the pH is 6.5 or 5.0 !

## 5. Water hardness

Different salts in water mainly bound to calcium and magnesium cause hardness in the water. The visual effect can be often seen as lime scaling in pools.
The water hardness can be divided into hardness based on carbonate salts (alkalinity) and hardness based on other salts mainly chlorides and sulphates.
Water with high alkalinity is able to equalize certain pH-changes due to their carbonate ions (buffer capacity) and therefore are less sensible to over dosage of pH-chemicals.

In case of soft waters with low carbonate hardness, sodium bi-carbonate ($NaHCO_3$) or sodium carbonate ($Na_2CO_3$) should be applied to increase the hardness.
Both chemicals are also able to increase the pH and can therefore be used as pH-increasing chemical as well.

## 6. Water balance

Due to different tap waters, pool types, temperatures and water treatment facilities, the water balance or water equilibrium can vary. Balance means, that neither the water have an aggressive reaction due to carbon dioxide nor precipitation occurs. Precipitation should be avoided, since salts could be scaled and block the filters.
Because of dosing disinfectants, flocculants and pH-chemicals, the pool water is always – at least a little – aggressive. To explain what could happen if pH- or hardness changes, the Langelier-Index could be helpful.

The Langelier-Index (LI) can be calculated dependent on water temperature, pH, total hardness and alkalinity as follows:

**Langelier equation**

| Langelier-Index (LI) = pH – [9.3 + Temperature Factor (TF) + Total Dissolved Solid Factor (TDSF) - Hardness Factor (HF) - Alkalinity Factor (AF)] |
|---|

**Table with factors for Langelier equation**

| Temperature | | Total Hardness | | Alkalinity | | TDS | |
|---|---|---|---|---|---|---|---|
| °C | TF | mg/L ($CaCO_3$) | HF | mg/L ($CaCO_3$) | AF | mg/l | TDSF |
| 0 | 2,6 | 5 | 0,3 | 5 | 0,7 | 100 | 0.1 |
| 3 | 2,5 | 25 | 1,0 | 25 | 1,4 | 200 | 0,13 |
| 8 | 2,4 | 50 | 1,3 | 50 | 1,7 | 500 | 0,17 |
| 12 | 2,34 | 75 | 1,5 | 75 | 1,9 | 1000 | 0,2 |
| 16 | 2,26 | 100 | 1,6 | 100 | 2,0 | 1500 | 0,22 |
| 19 | 2,2 | 150 | 1,8 | 150 | 2,2 | 2000 | 0,23 |
| 24 | 2,1 | 200 | 1,9 | 200 | 2,3 | 2500 | 0,24 |
| 29 | 2,0 | 300 | 2,1 | 300 | 2,5 | 5000 | 0,27 |
| 34 | 1,9 | 400 | 2,2 | 400 | 2,6 | 10000 | 0,3 |
| 41 | 1,8 | 800 | 2,5 | 800 | 2,9 | 15000 | 0,32 |
| 53 | 1,6 | 1000 | 2,6 | 1000 | 3,0 | 25000 | 0,34 |

**Evaluation of Langelier-Index**

| L I | Water Condition |
|---|---|
| -0,6 and less | tends to corrosion |
| -0,5 to -0,2 | reasonable equilibrium, |
| -0,1 to +0,1 | ideal equilibrium |
| +0,1 to +0,5 | reasonable equilibrium, |
| > +0,6 | tends to precipitation |

## 7. Dilution

This can be also considered as a treatment process in the pool water cycle. There are many pollutants which cannot be removed by flocculation and filtration. For example salts like chlorides, sulphates and nitrates. The level of these salts indicate the pool loading and also the age of pool water.
By adding a certain amount of fresh water, the salt level can be kept low permanently. The amount of fresh water depends on the pool load. It is recommended to replace pool water through fresh water at least 20-30 L / bather / day. To assure the right amount of dilution it is also recommended to install a water counter. For domestic pools the dilution could be less due to a small bathing load.

Note: The fresh water which has to be added through loss due to of filter backwashing can be included in the above dilution.

## 8. Water monitoring

High quality of the pool water has to be achieved and maintained all the time. For a fast response in case of poor pool water quality or overdosing the pool water has to be checked permanently.
Reliable parameters are the level of free chlorine to get the level of disinfection capacity, the level of combined chlorine with respect to pool water pollution, the redox-value to get a ratio of disinfection capacity to pollutants and finally pH.
All four parameters together allow a safe rating of the pool water quality.

For public pools an automatic measuring and control system should be used. Above that it is recommended to install a data recording system (i.e. hard disk or printer) for evidence to the public health authorities.
A manual control of free chlorine and pH has to be carried out daily to check the sensors.

## 9. Cleaning

Despite of all applied techniques, there are certain manual works necessary to keep the pool water in a good condition.
Cleaning means the combination of brushing – to separate persistent dirt, vacuum cleaning, using a detergent or disinfectant for further separation and inactivating, abide a certain reaction time of disinfectant, rinse with fresh water

**Pool**
Many pollutants in the water settle to the pool floor. These pollutants can cause bacterial growth. The cleaning process is based on brushing and vacuum cleaning. Only the usage of brushes allows a separation of dirt or bio-films from the pool ground.

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| The pool should be cleaned at least once a week. Outdoor pools may have to be cleaned at least twice a week. |

After a time tenacious stains or bio-films on pool walls or high concentrations of salts or unwanted reaction by-products can occur.

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| Dependent on the pool type is recommended to change the water completely and clean / disinfect the pool regularly depending on water condition such as hygenic condition, clearness, visibility, odour, debris, staines. |

Note: for emptying the pool the building company or pool company has to be consulted. Also regulations for draining the water have to be observed.

**Overflow channel**
Overflow channels have to be brushed and flushed to avoid staining or the growth of algae. The grilles have to be cleaned as well; especially on the underside where the growth of algae is also possible.
When cleaning and flushing the channel, make sure that the water cannot flow into the balance tank. A separate pipe and valve is recommended to be installed to drain the cleaning water.

**Balance tank**

The behaviour of balance tanks are simply like sedimentation tanks. Therefore debris on the bottom can occur. A balance tank should have a drain valve at the lowest point, to clean and flush completely.

Note: access to balance tanks and cleaning have to be carried out under National health and safety regulations.

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| Balance tanks have to be checked regularly. A build up of debris and staining will mean the tank has to be cleaned regularly as well. |

**Pool surrounds**

Barefoot areas and relaxing areas have to be considered in the cleaning process as well. No cleaning water may flow into the pool or pool water cycle. A sufficient number of separate drains in the pool surrounding is recommended to drain the cleaning water.

In case of skimmer pools, the dirt and cleaning agents have to be rinsed carefully to a drain in the pool surrounding.