The use of UV for destruction of combined chlorine

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Major reasons of formation of combined chlorine

Combined chlorine, also known as chloramines, is the result of a chemical reaction between the desired and needed disinfection product chlorine and other organic compounds in the swimming pool. These organic materials are often compounds which enter the pool via the actual swimmers: skin material, hair and ureum. These compounds are potentially ideal to create in a reaction with chlorine this combined chlorine. In addition to this compound level brought in the pool by swimmers, one often sees that non cleaned filters increase this organic load. Especially when filters are not maintained properly and frequently, one often sees that during cleaning or backwashing of these filters organic compounds remain floating and are not taken out of the filter. This can even result in a biological contamination of the water. Another important factor of having a high organic load in the water might come from an undersized water treatment system. A system can be designed to meet optimum values but when it is under dimensioned it will never achieve these ideal values.

The use of medium pressure UV tubes

We have chosen the word “medium pressure UV” here and not the more general term “UV” because of the unique character medium pressure tubes have. UV tubes are recognised for their ability to disinfect water by emitting light at 253,7nm. These tubes, known as low pressure tubes, are traditionally used in UV disinfection installations worldwide for disinfection of drinking water, waste water and industrial process waters. If these type of UV tubes would be used in swimming pool installations they would not be able to contribute to a lower combined chlorine level since the wavelength they emit have no impact on these. In order to destroy combined chlorine one needs to trigger a reaction that takes place at an optimum emission of 280nm wavelength. Although we realise that the desired spectrum for destruction of organic compounds is much more complex than described here we feel this practical study is not ideal to go into full depth

History of medium pressure technology in swimming pools

Norway, Denmark and Great Britain have a leading position in the use of medium pressure UV systems applied in swimming pools for chloramine destruction. Due to the high maximum accepted level of combined chlorine measured in the outlet of the swimming pool (Great Britain uses a level of 1.0 mg/l) one was able to establish a fast reduction of chloramines in the pool by installing these specific UV units. In other parts of Europe the use of medium pressure UV systems was introduced in 1992 till 1997. Early adapters took on the concept of medium pressure UV systems and optimised the installation on the basis of try and error tests. An important parameter was to design a system that would reduce the costs per m^3 of water and to meet the maximum allowed concentration of combined chlorine. Germany introduced a norm to be met by the swimming pool industry, the DIN 19643. This norm indicates all critical values and states that the maximum amount of combined chlorine must not exceed the 0.2mg/l.

Obviously the norm is implemented to ensure that the actual filter process used in swimming pools is designed to meet these stringent values but with the use of medium pressure UV technology one is able to optimise the results long term; even when the filters are reaching saturation and / or one deals with more swimmers than the daily average. It offers security and flexibility.
Experience has shown that medium pressure UV disinfection units are able to control the combined chlorine levels even when an installed active carbon or sand filter is about to be saturated.

Installation

Installation of the medium pressure UV unit is always after the filtration and before chlorine dosing. (see figure 1) This way the water running through the UV system is cleaned from larger organic particles. These large organic particles do not only have a negative effect on the chloramine destruction process but may also foul the quartz sleeves. These quarts sleeves surround the actual UV tubes. To prevent additional fouling an in situe cleaning mechanism is recommended. This cleaning mechanism comes in two different executions, a hand operated cleaning mechanism and an automatic cleaning mechanism. With such a cleaning mechanism one no longer needs to clean the UV unit chemically. An additional advantage of such a built in cleaning mechanism over alternative cleaning methods is that one does not have to switch the unit off.

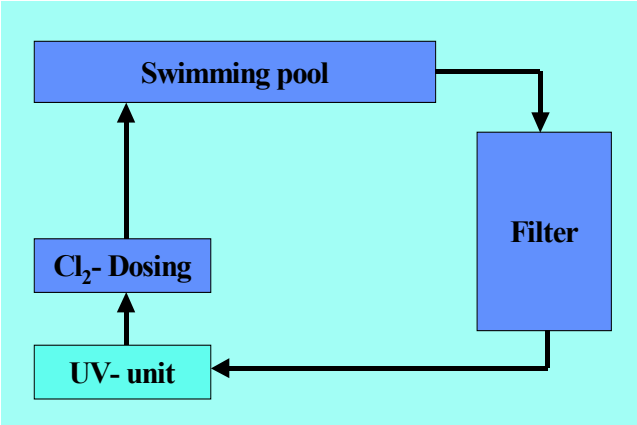

Figure 1

Application study

In a 25 meter long swimming pool protection takes place by a sand filter. An average flow is between 120 and 140m3/hour and the combined chlorine levels found exceed the allowed maximum level and occasionally even touch the 0,5mg/l. In a test that took please in a timeframe of 2,5 months all values on combined chlorine, before and after installation of the UV unit were monitored, as well as the amount of swimmers per day and the fresh water intake. In the figure 2 given below the amount of swimmers per day are visualised. Also the combined chlorine level is shown.

The actual measurements were done manually by the personnel on site and monitored on line. The figure clearly shows that, prior to the start up of the UV unit, the combined chlorine levels exceed the 0,2mg/l
Mind you that these values were based on the relatively smaller amount of swimmers. During the cause of the tests the amount of swimmers increased and have an effect on the actual results of these tests. At a continuous amount of

Swimmers, on the same level as before the UV unit was installed, the combined chlorine level would have been lower than the values found here. After the UV unit was switched on it took approximately 5 days before the desired combined chlorine level of 0,2 was achieved in the pool. In the following 10 days the combined chlorine level continued to drop steadily. After this period it remained more or less stable on this level. The service personnel was used to compensate the too high values with increasing the fresh water intake by means of backwash of the filters. Before the installation of the UV unit a typical interval for backwashing these filters was 3 times a week. After the UV was installed they reduced this to two times per week. Savings out of this was 1/3 of the water. At the end of the tests (day 48 onwards) the UV unit was switched up to a higher UV-C power level to investigate the relation between the incoming UV power and the chloramine destruction potential.

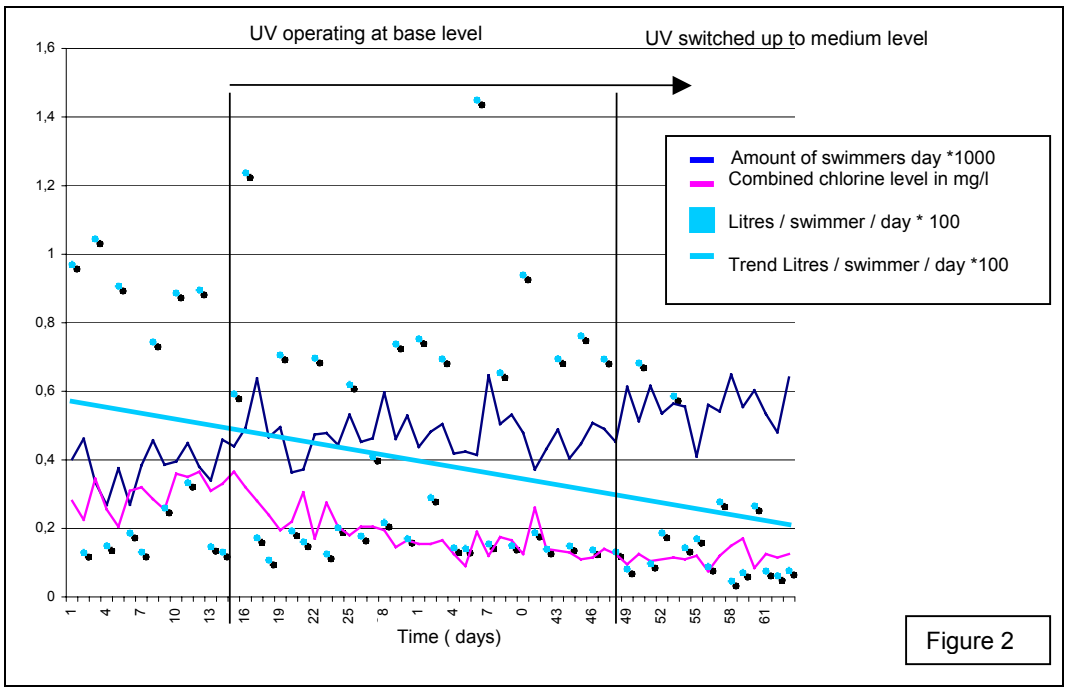

Figure 2

The final results were shown in figure 3. The combined chlorine level could be reduced from 0,3 down to 0,17 mg/l even at these higher amount of swimmers. This is a reduction of 43% on the combined chlorine level. The amount of fresh water needed per swimmer per day was reduced from 49,4 litre down to 37,7 litre which is a saving of 24%. This value of 37,7 litres per day also reaches the, acc DIN 19643, the needed limit 30 litres of fresh water per swimmer per day. The absolute amount of water needed before and after UV per day remained almost constant.

This is due to the fact that the amount of swimmers was increased dramatically throughout the test period.

Average combined chlorine (mg/l) per day	Average swimmers per day	Average freshwater in m³ per day	Average litres per swimmer per day	Remarks
0,30	383	19	49,4	Before UV
0,17	521	18	37,7	After UV
-43%	36%	-4%	-24%	Difference in (%)

Figure 3

What about Trihalomethanes (THM)

With the satisfied results achieved with the medium pressure UV unit, also the question was raised as to if and how the UV medium pressure tubes would influence the THM level. This question is answered below:
Before the UV unit was installed the operator had instructed a local laboratory to investigate the actual THM level in the pool. The measurements showed that the THM value in the pool was between the 32 and 44 µg/l. This is more than the actual DIN 19643 norm accepts, since the maximum allowed concentration is 20 µg/l
Two weeks after the UV unit was started a concentration of 30 µg/l was measured and 23 µg/l direct after the UV unit. In the four months after installation of the UV unit the THM value gradually dropped to 21µg/l. This needs to be seen in direct relation with the reduced amount of fresh water that contained humic components, an important pre cursor to create THM compounds. These humic compounds that enter with the fresh water react with free active chlorine and form these THM. Direct in front of the UV and after the UV units tests were conducted and showed that the levels was 18 µg/l in front and 16 µg/l directly after the UV system. Pending on the actual level of humic compounds in the intake water one can expect a reduction. In this case the reduction found was close to 33%

Costs around the UV unit

Because of the huge savings in water, an advantage we clearly saw at all units sold, it is possible to have a relatively fast pay back time on the investment in the UV unit made. A typical payback time we have found is between one and three years, pending on the actual process design and other specific parameters. In the above mentioned case we were able to generate a water saving of 11,7 litres per swimmer per day. Here we found that the system, with an initial sales price of Euro 9.000 pays itself back in approximately 2 years. (see figure 4) What we have not taken into account here is the costs for heating up the water which often involves 20 to 30% of the total consumed annual energy. On the other hand this UV system costs approximately Euro 2,000 on spares and maintenance.

The outcome of these two variables will still offer an additional saving on top of the already mentioned pay back time of two years.

Cost calculation	
Swimmers per year	172987
Water savings per swimmer in litres	11,7
Cost for 1 m^3 of water	3,66
Costs savings in Euro	7407,65
Annual costs to operate the unit in Euro	2727,90
Total nett savings in Euro	**4679,75**

Figure 4

Conclusion

The use of UV disinfection in swimming pools for destruction of combined chlorine has been tested and proven to be a cost effective and successful solution. In addition to the above mentioned facts it offers following advantages:

- A more healthy pool environment
- Lesser waste water disposal
- Lesser backwashing of filters, which can be time-consuming
- A second disinfection technology that offers microbial control on those (few) micro organisms that are difficult to control with chlorine

UV is simply to operate and perfectly safe to use. Wallace and Tiernan have a leading position worldwide in selling chlorination systems and pool equipment technology. With the recent expansion of a new generation of UV equipment products we now offer a total concept to the swimming pool industry. There is a direct relation between chlorination of the water and the actual destruction of chloramines. Sizing the UV system incorrectly will have an impact on the free chlorine level in the pool or could result in a too low chloramine destruction level. Being able to offer these two disciplines, Wallace & Tiernan is in a unique position to take responsibility for both these processes carefully steering away from the scenario that product supplier A, who delivered the chlorine disinfection equipment holds product supplier B, who supplied chloramine destruction equipment responsible. And vica versa.