In the May, 2010 Issue of Tech Talk Ron George posted an article called “Pressure Situation”. Unfortunately, several statements in that article are, in my opinion, either incorrect or highly misleading. I have structured my response by quoting Ron George’s paragraphs and then followed by my specific responses.

Ron George

“They discovered low-pressure technology that was successful for drinking water did not work as effectively in pools. That led UV-lamp manufacturers to develop medium-pressure lamp (MP) technology. The recreational pool market for UV systems then quickly became successful.”

“Several significant factors in pool applications make LP lamp technology unsuitable for disinfection and the destruction of chloramines. They are as follows:

> The wavelength emitted by LP lamps is narrow — 254 nm. This radiation is capable of destroying monochloramine, which would be effective if the water were being treated in its entirety in one single pass.”

“That is not the case. Therefore, trichloramine and dichloramine, which are far less healthy, are produced from the monochloramine still in the untreated water. Once the tri and di appear, LP cannot effectively destroy them because di and tri compounds absorb UV light at 297nm and 345nm, according to research from Purdue University.”

Jim Bolton

The statements in the above three paragraphs are either not true or highly misleading. In fact, according to the paper by Li and Blatchley (Ling, J; Blatchley III, E R, “UV photodegradation of inorganic chloramines”, Envir. Sci. Technol. 2009, **43(1)**, 60–65.), monochloramine and trichloramine have almost the same molar absorption coefficient (388 and 367 M^{-1} cm^{-1}, respectively) at 254 nm. Only dichloramine has a lower value (142 M^{-1} cm^{-1}). But the rate of degradation is proportional to the product of the fraction of UV light absorbed (related to the molar absorption coefficient and the concentration) and the quantum yield. The quantum yields for the photodegradation of mono- di- and trichloramine are 0.62, 1.80 and 1.85, respectively. Thus dichloramine will degrade at about the same rate as monochloramine and trichloramine will degrade about three times faster than monochloramine at 254 nm.

Ron George

“The temperature of pool water is normally around 80 to 85 degrees; spas are in the 95 to 104 degree range. Low-pressure lamps have a relatively low surface temperature; therefore, the influence of water temperature is significant. The optimal water temperature for LP lamps is 68 degrees Fahrenheit (20 degrees Celsius). At temperatures above that, the UV output drops off significantly.”

Jim Bolton

This is not true – the optimal surface temperature for a low pressure UV lamp is 40 °C. Low pressure high output lamps operate at a surface temperature of about 100 °C.

Ron George

"Medium-pressure lamps operate at a much higher temperature and can operate effectively in a much greater temperature range with no effect on the UV output, according to Dr. James Bolton of Bolton Photosciences Inc. in Edmonton Canada."

Jim Bolton

This statement is true; however, medium pressure UV lamps have about half the germicidal efficiency as that of low pressure and low pressure high output lamps.

Ron George

"Low-pressure lamps are vulnerable to photorepair when an organism is exposed to sunlight for a short period of time, approximately 30 to 180 minutes."

"What does this mean? In swimming pools, the water passes through the UV chamber after filtration and returns to the pool during the turnover cycle. At this time, the DNA that was broken down by LP lamps can repair itself. We are, in effect, showing that we are "destroying" the parasite when it passes through the UV chamber; it is, however, reappearing in the pool water only to be reactivated again. This is a cycle that repeats itself."

"However, studies have shown medium-pressure lamps break down the DNA and do not allow photorepair, according to a study published in the journal Applied and Environmental Microbiology by researchers J.L. Zimmer and R.M. Slawson."

Jim Bolton

The evidence for the statements in the above three paragraphs is not clear in the literature. For example, Guo et al. (Guo, M; Hu, H; Bolton, J R; Gamal El-Din, M, "Comparison of low- and medium pressure ultraviolet lamps: Photoreactivation of *Eschericia coli* and total coliforms in secondary effluents of municipal wastewater treatment plants", Water Res. 2009, **43**, 815–812.) found no difference in photoreactivation between low- and medium pressure UV lamps for the same germicidal UV dose.

Ron George

"Medium-pressure lamps break down organics, assisting in water clarity. Low-pressure lamps will not, according the U.S. Environmental Protection Agency."

Jim Bolton

This statement is highly misleading. What matters in photolysis reactions is the product of the fraction of UV light absorbed (related to the molar absorption coefficient and the concentration) at a given wavelength and the quantum yield at that wavelength. So a comparison between a low pressure and a medium pressure UV source requires extensive calculations. The answer may be one way or the other depending on the photolysis system.

Ron George

"Low-pressure systems use multiple lamps to achieve enough intensity to treat the water. This creates several issues. Typically, several lamps are monitored by a single sensor to be able to verify the proper dose and intensity is being applied. One can only be sure that the flow nearest the closest lamp is effectively being disinfected. Second, if one of several lamps has failed, do you replace them all? How do you monitor the lamp hours? Do you number each one and keep a record of each?"

Jim Bolton

In drinking water UV reactors with multiple UV lamps, the system is 'validated' by biodosimetry. There is a requirement for periodic monitoring of the system to make sure that the quartz sleeves are not fouled. Also UV lamps must be replaced after a certain lifetime. Very large municipal UV drinking water systems have been installed (over 100 MGD) and there have been few if any problems in their operation.

Ron George

"Multiple lamps with LP technology mean more maintenance issues. Most LP manufacturers do not provide automatic wiper systems to keep the quartz clean; they are simply not practical with multi-lamp LP systems. This then requires manual cleaning, which is very time-consuming. Again, when one or more lamps fail, do you replace them all?"

Jim Bolton

This is simply not true. There are hundreds or even thousands of UV systems in operation today that have multiple low pressure or low pressure high output lamps and do have effective automatic cleaning systems. Many have been in operation for years with very few, if any, problems.

Ron George

"Research is an important tool in developing new products and testing existing products to meet the requirements of our industry. But it is important to review the results objectively rather than use those parts of the study to advance one's interests."

"For example, several manufacturers have cited a recent study on the "Impact of Chlorine and Monochloramine on Ultraviolet Light Disinfection," from Duke University/University of North Carolina. They extract data from this study, trying to claim that LP technology is more effective than MP technology."

"The problem with the extrapolation is that they fail to cite the conclusion arrived at or the conditions under which the study was conducted. The study involves dosing from 300 mJ/cm^2 to 1500 mJ/cm^2 to find out if UV will degrade chlorine and monochloramine. The UV dose range for chloramine destruction and disinfection is from 40 mJ/cm^2 to 60 mJ/cm^2 in swimming pools."

"The study concluded: "Chlorine and monochloramine in water decay steadily when

exposed to monochromatic (LP) and polychromatic (MP) UV light. However, total decay of chlorine and monochloramine are relatively small in the UV dose range that is generally applied for disinfection (15-130 mJ/cm^2)."

"The assumption that MP lamps burn more chlorine than LP lamps and thus are not as effective is simply misguided."

Jim Bolton

The statements in the above five paragraphs are confusing and misleading. One has to realize that any photolysis process will require a UV dose for 90% degradation that is 10 – 50 times that for 90% inactivation of bacteria or viruses. The reason is that for a photolysis process, the quantum yield is of the order of unity or less. However, in the inactivation of bacteria and viruses, there is a multiplication mechanism. Only about 100 thymine base pairs in a DNA chain of over 1 million bases need to be 'dimerized' to achieve total inactivation of the microorganism. Thus alteration of only about 0.01% of the bases leads to an inactivation (inability to replicate) or the microorganism. This is why the inactivation of microorganisms is so much more effective than direct photolysis processes.

In my opinion, the following conclusions can be made:

1. There should be little difference between low pressure (LP) and medium pressure (MP) UV as regards UV disinfection for the same germicidal UV dose.

2. There may be little difference between low pressure (LP) and medium pressure (MP) UV as regards the level of photoreactivation following UV disinfection at the same germicidal UV dose.

3. Since monochloramine has a peak absorbance near 254 nm, it may be that LP UV could be more effective than MP UV, but further investigation is required. Certainly LP UV should be at least as effective as MP UV in degrading monochloramine.

4. The UV doses for the photochemical degradation of chlorine or chloramines will be at least 10 times higher than the UV doses required for UV disinfection.

Remember, our LP lamp put out 35% more 254nm than MP…….Roy