Design of an Effective Ozone Pool Treatment System Using Sidestream Application

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Successful ozone application in a pool is highly dependent on efficient mass transfer of ozone into the water stream and proper reaction/contact time. A successful system treats pool water with ozone levels high enough to be effective against the toughest contaminants while remaining safe for operators and pool patrons. Sidestream ozonation when sized properly has been found to allow for high ozone doses (capable of very high bacteria kill rates) while maintaining human exposure levels well below acceptable levels.

Ozone is dispersed into water in two main ways. The first is the traditional method of diffusion under pressure by use of a dispersion element such as a porous stone or perforated pipe. This is relatively inefficient but may be enhanced by use of static mixers or high vertical 'bubble columns'. Another method is injection through a venturi injector. This type of injector achieves high dissolution rates through the violent mixing that occurs at and just downstream of the throat of the venturi. The venturi injector is capable of achieving greater than 97% dissolution of the ozone when operated in accordance with the manufacturers recommendations. Another benefit of the venturi injector is the ability to keep the ozone system under vacuum. Vacuum operation is safer than pressure because of the reduced risk of human exposure to high ozone concentrations.

Installing the venturi in a sidestream which handles 15 to 25% of the system flow (see Figure 1) gives the system greater design and operational flexibility over main flow installation. Much higher dosage rates (ppm ozone in water) can be applied to the sidestream without the need to install ozone removing equipment downstream. Thus higher oxidation rates can be achieved more economically. Ozone is mixed in the sidestream water flow which is then retained in a reaction tank to allow for greater contact time. The treated water is next mixed back into the main stream and returns to the pool. By calculating ozone dose on the main stream flow (see Equation 1), but applying the ozone on the sidestream, water is treated with a 'super dose' of ozone elevating the concentration as much as five times the design value. During retention in the reaction tank ozone is quickly used up in oxidation reactions. This super dosed water then mixes back with the main stream and is diluted. Oxidation reactions continue to occur and dissolved ozone is reduced to minimal levels before returning to the pool.

Total GPM • 0.227 • dose rate = Grams per hour
(Equation 1)

Sizing flow rates, ozone dosage and tank sizes can be based on the CT (product of Concentration and contact Time) concept as put forth by the US EPA (see Table 1). Inactivation rates for various micro-organisms have been developed and assigned CT values. Drinking water standards are generally accepted at a CT value of 1.6 or greater. Using a CT of 1.6 a practical sidestream ozone system is outlined in Example 1.

An ozone dose calculated on the main stream of 0.4 ppm (mg/l) with a reaction time of four minutes and applied as outlined above has been found through experience to be optimal for most commercial pools. However, consideration should be given to factors such as high temperature, high bather loads, abnormally high environmental contamination levels, and min-

Proceedings of the 1st Annual Chemistry Symposium
National Spa and Pool Institute – November 1996
Pages 11–13

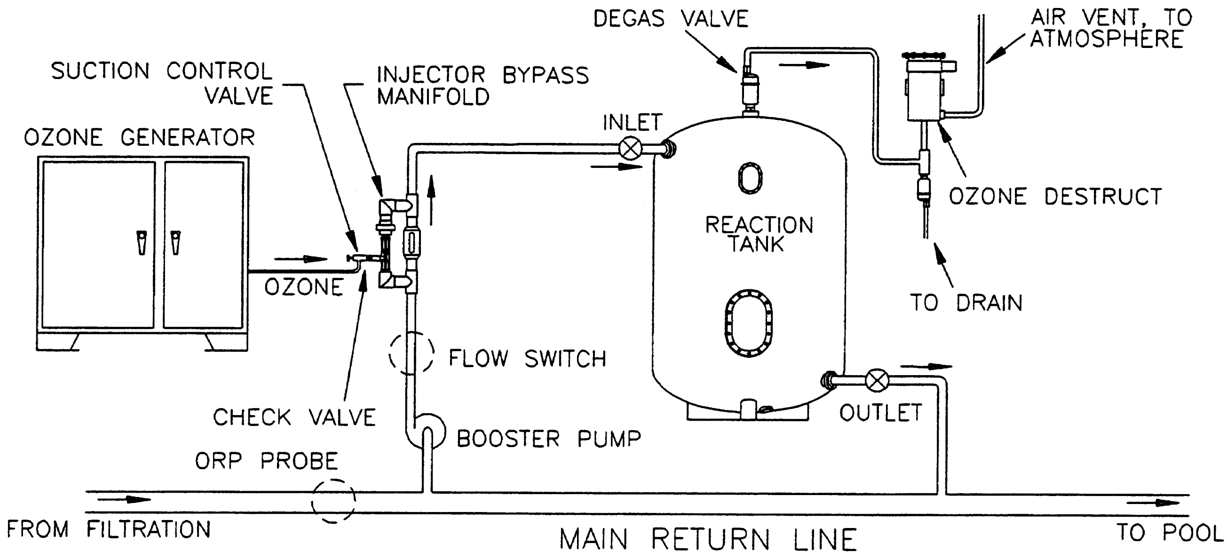

Figure 1 — Sidestream ozone system

	Disinfectant			
Microorganism	Free Chlorine (pH 6 to 7)	Preformed Chloramine (pH 8 to 9)	Chloride Dioxide (pH 6 to 7)	Ozone (pH 6 to 7)
E. coli	0.034-0.05	95-180	0.4-0.75	0.02
Polio 1	1.1-2.5	770-3740	0.2-6.7	0.1-0.2
Rotavirus	0.01-0.05	3810-6480	0.2-2.1	0.006-0.06
Phage f2	0.08-0.18	—	—	—
***G. lamblia* cysts**	47->150	—	—	0.5-0.6
***G. muris* cysts**	30-630	1400	7.2-18.5	1.8-2.0

Source: Hoff (1987)

Table 1 – CT values (mg • min/l) for 99% Inactivation of Microorganisms with Disinfectants at 5°C

6 Hour turnover:	**555** GPM main flow rate
Ozone Dose:	555 (GPM) x 0.4 (mg/l) x 0.227 = **50.4** g/hr
25% Sidestream:	555 (GPM) x 0.25 = **140** GPM sidestream flow
Reaction Tank:	140 (GPM) x 4 (min) = **560** Gal reaction tank
Injector (Mazzei sizing chart):	**#1584** @ 30 psi inlet
Booster Pump:	30 psi @ 140 GPM ~ **3** Hp

Example 1 – 200,000 gallon commercial pool

eral laden makeup water when calculating dosages and flow rates. Table 2 summarizes ozone dose values and their corresponding expected reduction in chemical use (over a non-ozonated pool of similar design).

Ozone Dose mg/l (ppm)	Contact Time (CT) In Minutes	Approximate % Reduction in Halogen
1.0	4.0	>85%
0.8	4.0	80%
0.4	4.0	70%
0.2	4.0	65%

Table 2 – Ozone dosage

A properly designed sidestream ozone system can deliver exceptional oxidation performance with efficient mass transfer of high ozone doses while maintaining a safe environment for operators and swimmers.

Case Study:

DEL Industries received NSF approval for meeting the criteria of less than 0.1 ppm ozone residual in the pool water at a dose level of 1 mg/L (ppm) ozone on two commercial pools. This approval was obtained by passing a stringent 3,000 hour life test. Dissolved ozone levels at the point of return to the pool were monitored daily for 125 consecutive days. Sensitive monitoring equipment capable of detection of 0.001 to 100 ppm was used.

References

Hoff, J. C. (1987) "Strengths and Weaknesses of Using CT Values to Evaluate Disinfection Practices" *Proceedings from the AWWA Seminar "Assuarance of Adequate Disinfection"* J.A.W.W.A. Denver CO pp. 49–65.