Purpose

The purpose of this whitepaper is to provide specific information to the public pool and spa community about the Model Aquatic Health Code’s (MAHC) emerging best practice guidelines for safe and effective pool water disinfection. Our focus is on the recommended secondary disinfection options, with detailed information on the ozone system requirements. Secondary disinfection will be required for higher risk venues like therapy and wading pools, and is recommended for other public swimming venues.

Simply put, the MAHC mandate is to improve the water quality in public aquatics facilities. When the initial conference that kicked off the MAHC development was convened, it was concerned with the outbreaks of Cryptosporidium parvum (crypto) in aquatic facilities across the nation, and with the unevenness of the public health standards that dealt with it. A specific issue was the fact that traditional chlorine-based disinfection treatments did not effectively cope with crypto.
About the Model Aquatic Health Code

The Centers for Disease Control and Prevention (CDC) has sponsored a 5-year long effort to devise a model code to address the issues of Recreational Water Illnesses (RWIs) in disinfected public swimming and bathing venues, with initial financial support from the National Swimming Pool Foundation. The aim is to develop best practice standards to guide and support the various state and local public health regulations.

This effort, still ongoing, has resulted in the emerging Model Aquatic Health Code (MAHC) which will include best practice standards for training, design and construction, operation and maintenance, and policies and management. The MAHC is founded on the best researched information available, and is being created through the work of a Steering Committee chaired by Douglas Sackett of the New York State Department of Health, and a set of 12 Technical Committees addressing specific issues ranging from Disinfection and Water Quality to Recirculation Systems & Filtration.

After 5 years of work, the MAHC team is beginning to roll out proposed guidelines in various modules for public comment. We do not have a firm timeline for when these will be revised into final versions, but the outlines are becoming clear for several of the Technical Committee components. The information we present here is based on current versions of those standards for the Disinfection and Water Quality Technical Committee, and while there may be further changes to them, we are confident the bulk of the material here is a good guide to best practices that will comply with MAHC standards.

About DEL and the MAHC – Full Disclosure

DEL Ozone’s Beth Hamil is a member of the MAHC’s Disinfection and Water Quality Technical Committee, and is the main source for the information in this whitepaper (our expert advisor and source of materials). Beth’s background in pool ozone disinfection systems goes back to 1985, when she led DEL’s successful effort to develop the first NSF-listed ozone system for commercial pools and spas under Standard 50. She has been continuously engaged in this effort since.

We have made every effort to make the information in this whitepaper accurate and objective. It focuses at a detailed level on ozone systems because that is DEL’s expertise. We have installed dozens of effective small, medium and large-scale ozone disinfection systems in pools, water parks, water treatments, spray pads, and splash pools worldwide. The contribution of ozone disinfection systems to public health and safety is indisputable, whether you choose a DEL system or another vendor.
Why Should You Comply with MAHC?

The Model Aquatic Health Code is not a regulation. At this moment, there are no enforcement rules associated with it in any jurisdiction. The influence of the Code will be felt through its adoption by state and/or local public health organizations, and by professional organizations at all levels. At some point, some or all of the Code may become an enforceable part of regulations in specific jurisdictions, but whether that happens or not, it does provide best practice standards for professionals to follow.

Why should they?

**We see two major reasons to adopt the guidelines in the Code:**

First, it is the right thing to do on behalf of your swimmers and bathers. Improving disinfection will reduce RWIs and increase the pleasure of swimming to encourage more people to make swimming their preferred form of exercise.

Second, even if the Code is never adopted as regulation or law, it can become an accepted best practice that will create liabilities for owners and operators who do not follow the guidelines.

We think both of these are compelling reasons. The MAHC was conceived as a means to address growing problems with RWIs, and these kinds of problems continue to crop up in news reports from around the world. Traditional chlorine-based disinfection routines have not been sufficient to keep these outbreaks in check. The most important aspect from a public health point of view is simply that we cannot continue to recommend swimming as the perfect lifelong exercise if that means exposure to either acute or chronic illnesses, and the information coming out almost daily suggests that it does mean that.

The liability issue seems to be getting even more play these days than the health issue. As Gareth Hedges of The Redwoods Group puts it in his presentation for the Aquatics International virtual conference on MAHC, *reasonable care* is a recognized legal criterion where the owner or operator knows or should have known about specific practices. These industry customs can become the basis for legal actions based on a breach of the standard of care – negligence or a breach of duty.

Hedges recommends a comprehensive Risk Management approach that would include taking steps to meet the best practices, make them part of your organizational culture, and be seen to be doing so. Every public aquatics owner or operator will have to adopt these standards in the most effective way for their operation, but whatever they do should be documented and systematic.

Our take on this is that the liability imposed by the guidelines is independent of whether your jurisdiction makes all or part of the Code a regulation, or even a suggestion. Your obligation as an aquatics professional is what is at stake, wherever you are located.
Emerging Issues with Chlorine

Most aquatics professionals are well aware of the mounting evidence that chlorine disinfection routines (which may include a number of chemicals and water treatments) are insufficient to ensure public health. In fact, one of the goals of the MAHC committees is to find disinfection options that are safe and effective against Cryptosporidium parvum, which chlorine is not within a reasonable timeframe.

Solid research information is now available to link chlorine and its byproducts to human disease states. For many years, the linkages between chloramines and swimmer’s asthma or other diseases were expected and believed by many, but conclusive scientific evidence was lacking. We cannot provide an exhaustive review of that research here, but a couple recent findings illustrate the trends in the data.

**Chlorine and genotoxicity:** Last September, CREAL (Centre for Research in Environmental Epidemiology) got our attention with the news release statement “Swimming in chlorinated indoor pools can cause genotoxic effects [DNS damage] and respiratory effects.” This alarming comment was based on studies of disinfection byproducts reported in the journal Environmental Health Perspectives, authored by an international consortium of scientists. These studies correlated the inhaled byproducts with biomarkers that might be associated with changes in cell tissues that might lead to cancer.

**Chlorine and asthma:** Disinfection byproducts of chlorine, especially nitrogen trichloride, have been implicated in swimmer’s asthma for years, especially in children. Recent research on the topic is summarized in the About.com post Chlorinated Swimming Pools Can Cause Asthma in Swimmers. The results are increasingly conclusive that chlorine byproducts can induce this disease.

The common recommendation in these studies is to reduce the use of chlorine. The overriding purpose is to keep swimming as an exercise of choice. The public health implications of over-reliance on chlorine are becoming quite clear.

**Disinfection Treatment Recommendations**

The MAHC guidelines emphasize the safety and effectiveness of disinfection treatments. It recognizes that no single disinfection treatment can stand alone, and recommends approaches that can be tailored to the specific type of facility and bather load. It is important to emphasize that the Technical Committee has required objective research evidence on the safety and effectiveness of alternative treatment methods, and embeds these requirements for 3rd party testing and validation into the guidelines.

The guidelines make recommendations for primary, secondary and supplementary disinfection. We take this summary from Jim Dingman’s presentation for the Aquatics International virtual conference. Mr. Dingman is the Chair of the MAHC Disinfection and Water Quality Technical Committee.

**Primary Disinfection:** This primary level of disinfection is intended to kill common pathogens (bacteria) and will be required for all aquatics venues. The acceptable primary disinfectants will be the traditional chemicals, chlorine and bromine. Chemicals not accepted as primary disinfectants include polyhexamethylene biguanide (PHMB), chlorine dioxide (ClO2), and hydrogen peroxide (H2O2).
Secondary Disinfection:  Secondary disinfection is intended to kill chlorine-resistant organisms like Cryptosporidium. These are required for higher risk aquatic facilities, including therapy pools, wading pools, spray pads and other venues where diaper-aged children might congregate. They are recommended for other venues.

The Technical Committee recommends either of two systems: Ozone or UV light

Supplemental Disinfection: These systems for the additional treatment of the water are not required in any aquatic facility. The Committee recommends ozone, UV and copper or silver ionization as acceptable treatments at this level. It does not accept ultraviolet light with hydrogen peroxide at this (or any) treatment level because this combination is not registered with the EPA for recreational water application.

Secondary Disinfection: UV Light versus Ozone

The two recommended secondary treatment options are both known to kill Cryptosporidium parvum. Currently, UV is somewhat more widely used in commercial aquatic facilities than ozone, though both of them have a substantial installed base and track records. Beyond killing crypto, however, ozone has important differences with UV that aquatics facility designers and operators are beginning to learn about.

The mechanisms of the two systems are quite different. UV lights are enclosed in chambers through which water is pumped. When the water is in the chamber, certain spectrum frequencies of the light kill or inactivate contaminants in the water, including crypto. The UV is only effective when the water is in the chamber, and to the extent the water is cloudy, the lights are dimmed, or the lights are dimming, it loses effectiveness.

By contrast, ozone is generated continuously and introduced into a side stream of the circulation system under vacuum. It instantly oxidizes pathogens (it kills crypto almost on contact), organics, chloramines, and some metallic substances regardless of the turbidity of the water. Read about ozone on our website to learn more about how it works, its benefits, and ozone technology.

Ozone is an oxidizer – UV is not. It is hard to overstate the importance of this distinction. Because ozone is one of the most powerful oxidizers in nature (200 times more powerful than chlorine by volume), it provides a wide spectrum disinfectant that goes far beyond UV in effectiveness. For example, whereas UV will not affect biofilm or Fulvic Acid, both of them are destroyed by oxidation in the presence of ozone.

Ozone controls measure water quality – UV does not. Ozone dose is measured by an ORP (oxidation reduction potential) monitor / controller that indicates the degree of disinfection/oxidation potential in the water. UV dose is measured only by output in the light chamber, regardless of actual water cleanliness. This control is important in knowing about and reacting to changes in water chemistry and contamination.

Capital costs are comparable for ozone vs. UV. Long-term operating costs for ozone are low because the systems are highly reliable and they permit a reduction in the use of chemicals. Both UV and ozone incur energy charges for electrical power used.

Visit DEL’s Ozone vs. UV page to see a detailed comparison.
MAHC Technical Requirements for Ozone Disinfection

The requirements in the current draft for ozone disinfection systems may undergo some further changes, but we believe the information here is very likely to be in the final versions of the guidelines.

We would like to note that all new DEL Ozone Aquatics systems currently meet these requirements. DEL systems now in place either already meet them or can do so, in most cases quite easily.

General Requirements for Secondary Disinfection Systems

- Secondary disinfection systems must be certified to ANSI/NSF Standard 50. DEL systems meet this requirement.
- System disinfection performance must be validated by 3rd party testing. DEL systems are tested and validated by 3rd party agencies.
- Secondary disinfection systems must provide a 3 log (99.9%) reduction in Cryptosporidium parvum. DEL systems exceed this standard when properly installed.
- Secondary disinfection systems are required for therapy pools and aquatic play facilities that may attract large numbers of diaper-aged children.

Specific Requirements for Ozone Secondary Disinfection Systems

Ozone secondary disinfection systems have to meet the general requirements, but the Technical Committee is also considering additional detailed guidelines to ensure that the systems are both safe and effective. We do not provide the exact language of the Technical Committee’s draft guidelines because they have not been finalized or approved. However, we believe the Committee’s approach will include the following concepts.

Ozone systems must meet standards

This is a general requirement for secondary disinfection systems to meet the testing and validation requirements of third party organizations like ANSI. But it is likely there will be additional guidelines for ozone systems. Manufacturers will be required to display system characteristics and standards compliance information on the system components themselves. Levels of disinfection potential will be stipulated using measureable indicators to ensure that installed systems can reliably produce the required outcomes.

Sizing is Critical

One of the most important factors in effective ozone disinfection is making sure the system is the right size to deliver the required disinfection potential to a particular aquatics installation. The Technical Committee is considering ways to calculate the size of the ozone system given the characteristics of each specific installation. Some of the variables considered include water temperature, volume, turnover and bather load. These variables may yield sizing formulas.
System Design

In addition to size, the specifics of ozone system design can affect the disinfection potential of ozone. System components related to ozone production and management can be specified to take into account the safety and efficacy goals of the Committee. Further, exactly how the ozone is injected, the point in the circulation system where it is injected, the sizing of both main and side stream circulation flows, and other factors can affect the outcomes.

Public Safety is Imperative

From one perspective, the whole point of the MAHC is public safety, first in creating an effective disinfection system and then in making sure the disinfection system itself does not have unintended harmful impacts.

A concern about ozone systems is always the control of ozone’s unmatched power. When properly dissolved in water it does not affect humans, but it is known to be dangerous when inhaled, even in very small concentrations (OSHA has set standards for both short and long term exposure). Therefore, the Technical Committee will create guidelines for operational safety with respect to off-gassing and ozone destruction.

More generally, ozone systems will be required to have safety management systems to alert operators to potentially hazardous situations and to shut down the system when unintended conditions occur. Ozone production, disinfection potential, and system integrity are all carefully managed in well-designed systems.

Ozone Success Story: 92nd Street Y, New York City

A good case study of the use of ozone disinfection systems is found in the 92nd Street Y May Center indoor pool in New York City (reprinted from the DEL Aquatics website). This story focuses on the use and benefits of ozone more than on its technical characteristics, but we choose it here because it illustrates a situation similar to that of many aquatics professionals across the country.

Key Players:
Dave Schmeltzer, Director of 92nd Street Y May Center for Health, Fitness & Sport
Beth Hamil, VP at DEL Ozone

Background

92nd Street Y pool was the busiest pool in NYC in the late 1990s, and is currently one of the busiest pools serving about 1,000 bathers per day, from toddlers to seniors and all ages in between. In a pool the size of 75 by 30 feet, bather concentration is markedly high creating a challenging environment for maintaining water sanitation and clarity.

Prior to its first installation of ozone, 92Y had trouble keeping its pool water clear and Schmeltzer recognized that the chemistry sanitation was, as he put it, “as much an art as a science”. It was frustrating at times, according to Schmeltzer, because as hard as 92Y tried to give its patrons a quality swimming experience, the pool water presented significant challenges.
The Role of Ozone

In solving the pool water quality puzzle, Schmeltzer did a significant amount of research. He considered both UV and ion systems in addition to ozone, and in the end concluded, “Ozone really made a lot of sense, particularly if it could burn off the chloramines”.

He also says that having ozone gives him peace of mind knowing that the pool is less likely to be infected by serious problems like the Crypto protozoan parasite.

92Y installed its first ozone systems in 1997 and recently updated the systems in 2007. With a large reduction in the amount of chlorine consumption needed to maintain clear, sanitized pool water, 92Y now saves on its pool chemical budget. In addition, the center has been impressed by the ease of maintenance associated with its ozone systems and recalls no major maintenance issues, aside from the upgrade, in its near 15 year track record with DEL Ozone systems. Since the installation of ozone and through his on-going acquaintance with ozone research, Schmeltzer says the experience has “solidified our confidence in having ozone”.

Specifically, Schmeltzer calls out what he refers to as “ancillary benefits of ozone. These include the feeling that his swimmers no longer need special shampoos to wash out the chlorine, their swimming suits last longer, and their eyes no longer burn. He remarked, “The results have far exceeded my expectations” and that ozone helped improve the “quality of swimming life”.

Schmeltzer further recalls that over the years 92Y members have especially recognized and appreciated the quality of the ozonated pool after they have travelled and had to swim in fully chlorinated pools. Based on their experience with ozone, 92Y went on to install ozone in the whirlpools and again achieved a similar improvement in water clarity and cleanliness.

Working with DEL Ozone

92Y selected DEL Ozone as its ozone partner and praised the onsite assistance, expertise, and overall handling of the ozone system installation process offered by DEL VP Beth Hamil and the DEL engineering staff. Schmeltzer also noted DEL’s ability to successfully work with the New York City health department to ensure the ozone installation was in compliance with code, and he noted that DEL actually helped “write the book” on how ozone pools should be regulated in NYC.

“DEL Ozone was smart in the way they handled the ozone installation and the NYC Department of Health was very pleased with DEL’s input,” Schmeltzer recalled of the initial installation that took place nearly 15 years ago.
The DEL Aquatics Sanitation Program: Getting Started

1. **Request a quote.** We’ll size your system according to probable MAHC guidelines and send a quote right away.
2. We’ll deliver and commission your pre-installed system within one to two months.
3. Begin to enjoy the improvements to your water quality and your facility right away.