2016 Annex to the Model Aquatic Health Code

Scientific Rationale

OPERATION AND MAINTENANCE

CS267224A

5.0 Facility Operation and Maintenance

The MAHC has worked extensively with ICC and IAPMO to eliminate conflicts between the three codes. These discussions have resulted in changes in the MAHC and plans to change items in the other codes as they are brought up for revision. The MAHC is committed to resolving these conflicts now and in the future as these codes evolve.

5.1 Operating Permits

5.1.1 Owner Responsibilities

5.1.2 Operating Permits

5.2 Inspections

5.2.1 Preoperational Inspections

5.2.2 Exemptions

5.2.3 Variances

The permit issuing official may waive, in writing, any of the requirements of this CODE, and include the variance as a condition of the permit to operate, when it reasonably appears that the public health and SAFETY will not be endangered by granting of such a variance and adequate alternative provisions have been made to protect the health and SAFETY of the BATHERS and the public. The burden of providing the data and proof that any alternative provision is at least as protective at the CODE requirement is entirely on the permit holder.

5.3 Equipment Standards [N/A]

5.4 Aquatic Venue Operations and Facility Maintenance

5.4.1 Closure and Reopening

5.4.1.1 Closure

Short Closures

It is important for the QUALIFIED OPERATOR to be aware that when closed for even short periods of time, the AQUATIC VENUE water distribution system, including drinking fountains and other potable water sources, may become stagnated. It is important to adequately ensure that all AQUATIC FEATURES should be adequately flushed and disinfected prior to reopening.

Standing water, including closed AQUATIC VENUES, can be a source of mosquitoes if DISINFECTION is halted. Although mosquitoes can carry infectious pathogens such as those that cause dengue, malaria, and encephalitis, one of the most common mosquito-borne infections in the US is due to West Nile virus which can cause fever and encephalitis. One study demonstrated a link between abandoned residential swimming POOLS, increases in mosquitos, and West Nile virus infections[317]. Swimming POOLS should be disinfected to prevent them from becoming public nuisance issues as mosquito breeding areas or SAFETY concerns.

Additionally, closed POOLS can be a SAFETY concern, especially for small children. When the POOL is not drained or covered tightly to prevent entry, children may knowingly or accidentally enter the POOL and drown. Because of the slime that often builds on the wall of these abandoned POOLS, it may be impossible for those that enter the POOL to climb out. Abandoned POOLS may also have limited visibility so people falling in cannot be seen by other persons in the area. While fence BARRIERS or SAFETY covers can create a "safe condition" for the POOL, these methods will not prevent the potential mosquito problems mentioned above.

Long Closures

The closing of an AQUATIC FACILITY for less than seven days is considered a temporary closure. A closure of more than seven days is considered a long term closure. Both types of closure require certain maintenance activities when closing or reopening to ensure a safe environment for PATRONS.

Drain / Cover

POOLS that use a cover should refer to ASTM F1346-91. For POOLS where covers are not used or are not practical, access should be restricted and routine check of fence integrity is advised.

ASTM F1346-91: *Standard Performance Specification for Safety Covers and Labeling Requirements for All Covers for Swimming Pools, Spas and Hot Tubs* establishes requirements for SAFETY covers for swimming POOLS, SPAS, hot tubs, and WADING POOLS. When correctly installed and used in accordance with the manufacturer's instructions, this specification is intended to reduce the risk of drowning by inhibiting the access of children under five years of age to the water.

For long term and seasonal closures, where no residual disinfectant is maintained in the pipes, further research is needed to understand the growth of biofilms during closure. More research is needed to develop protocols for removing biofilms in AQUATIC VENUES.

If the AQUATIC VENUE system becomes non-operational, such as during a power outage, the AQUATIC VENUE should be cleared of BATHERS. Prior to reopening, the QUALIFIED OPERATOR should confirm that all systems are operational as required by the MAHC. For example, recoating DE filters will be necessary and it should be confirmed that feed pumps did not continue feeding chemicals during a RECIRCULATION SYSTEM shutdown that may lead to outgassing into the POOL when the system is re-started.

317 Reisen WK, et al. Delinquent mortgages, neglected swimming pools, and West Nile virus, California. Emerg Infect Dis. 2008;14(11):1747-9.

5.4.1.2 Reopening

The QUALIFIED OPERATOR should refer to previous inspection reports for more details on repairs or replacements needed, and any replacements or new items should be discussed with the regulatory authority to verify they comply with current CODE requirements. It is recommended that a model reopening checklist be developed in the future.

5.4.2 Preventive Maintenance Plan

A preventive maintenance plan is a necessary and important part of any AQUATIC FACILITY operation based on data showing 22.8% of POOL chemical-related events were due to equipment failure indicating they could have potentially been prevented[318]. The best maintenance plan is one that follows the manufacturer's and POOL designer/engineer's recommendations for all equipment. A POOL maintenance plan is similar in many ways to the purchase of a new vehicle. With the purchase of a new vehicle, a manufacturer's maintenance schedule is included. The schedule lists the maintenance items that should be followed such as rotating tires and performing major tune-ups.

Likewise, the QUALIFIED OPERATOR should perform an inventory of all equipment used in the AQUATIC FACILITY operation. For each piece of equipment, the QUALIFIED OPERATOR should develop a list and schedule of maintenance items. By following this maintenance schedule, the operator can help prevent costly repairs and breakdowns in the future. Replacing items before they breakdown may prevent system breakdowns that could lead to outbreaks or injuries. For example, a common breakdown leading to loss of DISINFECTION is a break in the tubing leading from feed pumps to the RECIRCULATION SYSTEM. Although inexpensive, lack of replacement has been implicated in outbreaks.

AQUATIC FACILITIES need increased sophistication in plan maintenance and MONITORING.

5.4.2.2 Facility Documentation

This equipment inventory should contain information such as:

- Equipment name,
- Manufacturer and contact information,
- Local vendor/supplier & technical representative,
- Model number,
- Horsepower, GPM, & filter size,
- Year of manufacture,
- Original cost,
- Warranty, and
- Operating Manual.

Equipment may be cataloged by area, such as:

- DECK,

318 Anderson AR, et al. The distribution and public health consequences of releases of chemicals intended for pool use in 17 states, 2001-2009. J. Environ Hlth 2014;76:10-15.

- Lifesaving,
- HYGIENE FACILITY,
- Filter System,
- Concession Stand, and
- AQUATIC FEATURES.

5.4.3 General Operations

5.5 Aquatic Venue Structure

5.5.1 Shape [N/A]

5.5.2 Access Ladders [N/A]

5.5.3 Color and Finish [N/A]

5.5.4 Walls [N/A]

5.5.5 Depth Markings

Existing AQUATIC FACILITIES should still adhere to the requirements of MAHC 4.5.19 for depth and NO DIVING MARKERS. Existing AQUATIC FACILITIES may have to resort to using non-permanent (i.e., painted) alternatives if not already installed, which will need to be maintained to ensure they are readable and legible

5.5.6 Pool Shell Maintenance

These sections of the CODE require repairs related to health and SAFETY such as if the CRACKS could cause trips, falls, lacerations, trap dirt and debris, or harbor algae or bacteria. It is still good operational practice to identify and monitor CRACKS that could lead to water loss and structural failure and consult a structural engineer for assessment as needed.

CRACKS exhibiting any of the following characteristics shall be evaluated by a structural engineer:

1) CRACKS with vertical displacement;
2) CRACKS of varying width;
3) CRACKS concentrated to a specific area;
4) CRACKS exposing any reinforcement;
5) CRACKS obviously recurring from previous patches;
6) CRACKS in corners;
7) CRACKS drawing a defined line; and
8) Surface CRACKING over $^{1}/_{8}$ inch *(3.2 mm)* in width.

5.6 Indoor / Outdoor Environment

5.6.1 Lighting

5.6.1.1 Lighting Maintained

5.6.1.1.1 Light Levels

System components will deteriorate and eventually need to be replaced, but lamp performance will continue to change prior to complete lamp failure. Indoor overhead lights, outdoor pole mounted lights, and underwater lighting are the key POOL light sources. Building lighting must also be maintained to provide safe AQUATIC FACILITY use, building and area security, and meet the aesthetic goals. Planned lighting maintenance includes group relamping, cleaning lamps, cleaning luminaires, and replacing defective components on a regular basis.

Lamp lumen depreciation is a characteristic of all lamps. Each lamp type has a different lamp life, thus impacting your maintenance schedule. As lamps fail or burn out, the local light levels are decreased and the lighting uniformity is also affected.

Luminaire surface deterioration and dirt accumulation may also occur and can reduce the light reaching the needed areas. During relamping and cleaning, inspect each luminaire for deterioration or damage. Repair or replace components and inspect and clean light fixtures and luminaires as needed to maintain required light levels. Consider regular group relamping combined with cleaning as part of an efficient and effective maintenance plan.

Basic steps for cleaning and relamping operations include the following:

1. Turn off electrical circuits and carefully remove lenses, diffusers, shields and/or lamps.
2. Dispose of replaced lamps and ballasts per state and federal guidelines.
3. Contact the U.S. EPA for more information.
4. Follow the light fixture and lamp manufacturer's recommendations for cleaning, relamping, and maintaining each light in good condition.
5. Routinely monitor underwater lights for proper operation.

Windows and natural lighting need to be evaluated seasonally and throughout the operating day.

Light levels may also be altered by dirty windows. Ensure that windows are cleaned regularly to eliminate any buildup of material that would affect light transmission.

5.6.1.1.2 Main Drain Visible

The requirement for being able to see the main drain from POOLSIDE is a SAFETY issue. If QUALIFIED LIFEGUARDS or QUALIFIED OPERATORS cannot see the main drain, then they are unable to see a person on the bottom of the AQUATIC VENUE and unable to initiate rescue procedures. This is cause for immediate closure and rectification before re-opening.

Please refer to the MAHC 6.6.3 for more information. The section also clarifies that mixed use AQUATIC FACILITIES (for example, AQUATIC FACILITIES with mechanical rides, catering facilities) may host evening events where lighting does not allow main drains to be visible but these AQUATIC VENUES must have ENCLOSURES and be closed to PATRON use.

5.6.1.1.3 Underwater Lighting
Recent high-profile electrocution incidents have highlighted the need to clarify underwater lighting requirements to prevent these incidents. A defect occurring in an electrical circuit operating at greater than the Low Voltage Contact Limit that is not GFCI protected can result in serious injury or electrocution death of BATHERS.

5.6.1.2 Glare
In addition to discomfort, annoyance, interference, and eye fatigue, glare reduces the visibility of an object. Without clear vision, there are increased chances for accidents that can cause injuries or potential drowning. Glare can be from reflections as well as direct lighting problems.

5.6.1.2.1 Assessments
The AQUATIC FACILITY owner or LIFEGUARD SUPERVISOR may consider adjusting lifeguard positions to improve visibility.

5.6.2 Indoor Aquatic Facility Ventilation
Drains on AIR-HANDLING SYSTEM equipment should be tested before the system is started.

It is important that the drain system be checked regularly to ensure that the condensate drain pan, drain connection, and piping are free from buildup or blockages. In cases where air handling equipment is intended for use with P-trap type drains, the P-trap must be kept filled manually if normal operation does not keep the P-trap filled. If not kept filled, sewer gases, and odors can enter the system.

5.6.2.8 Combined Chlorine Reduction
Water chemistry affects air quality:

- The amount of disinfectant in the water should always be at sufficient level to disinfect properly, but high residual levels in an indoor environment contribute to the development of DBPs. A higher ratio of CHLORINE to nitrogen content in the water results in the formation of TRICHLORAMINE. Lower levels of CHLORINE/bromine in the POOL results in lower levels of DBPs in the presence of organic and inorganic CONTAMINANTS.
- High residual levels have been a requirement for outdoor AQUATIC VENUES that have sunlight exposure, but that requirement may not be necessary for INDOOR AQUATIC FACILITIES.
- FREE CHLORINE levels could likely be maintained at a lower level due to the absence of dechlorination due to sunlight.

- Lower pH levels increase the effectiveness of CHLORINE and by maintaining pH less than 7.5, less CHLORINE is required to achieve effective DISINFECTION[319].

The water quality will affect the air quality in INDOOR AQUATIC FACILITIES. Also BATHER practices will determine not only the water quality but also the air quality. Therefore, if air handling equipment is installed, INDOOR AQUATIC FACILITY operators should develop and implement a program to operate, monitor, and maintain the equipment as designed to reduce combined CHLORINE compounds introduced into the building from the AQUATIC FEATURES in accordance with the INDOOR AQUATIC FACILITY AIR HANDLING SYSTEM design engineer and/or the AIR HANDLING SYSTEM equipment manufacturer's recommendations.

5.6.3 Indoor/Outdoor Aquatic Facility Electrical Systems and Components

5.6.3.1 Electrical Repairs

NEC Article 225 provides installation requirements for outside branch circuits and feeders that run on *(or between)* structures or poles.

NEC Article 680 applies to the construction and installation of electrical wiring for and equipment in or adjacent to all swimming, wading, therapeutic, and decorative POOLS; fountains; hot tubs; SPAS; and hydro-massage bathtubs, whether permanently installed or storable, and to metallic auxiliary equipment, such as pumps, filters, and similar equipment.

5.6.3.2 Electrical Receptacles

NEC Article 680.22, "General Circuitry Pool Pump Motors," states that "all 15- and 20-amp, single-phase, 125-volt or 240-volt outlets supplying pool pump motors shall have GFCI protection."

29 CFR 1910.304, "Wiring Design and Protection," applies to temporary wiring installations that are used during construction-like activities, including certain maintenance, remodeling, or repair activities, involving buildings, structures or equipment.

5.6.3.3 Ground-Fault Circuit Interrupter

GFCI testing should follow the manufacturer's recommendations. However, the minimum test procedure should include:

1. Testing personnel must wear shoes during the entire test. Where exposed terminals may be present, or where conditions warrant, other PPE may be required.
2. A suitable indicating test load should be connected to the circuit under test, and remain so for the duration of the test.
3. Test personnel should press the "TEST" button on the GFCI device.

319 White GC. Handbook of Chlorination and Alternative Disinfectants 4th edition. John Wiley and Sons, Inc. Hoboken New Jersey 1999.

4. The test load should then be observed to have ceased operation due to loss of electrical power.
5. Test personnel should next press the "RESET" button on the GFCI device.
6. The test load should then be observed to have resumed operation.
7. Where any of the conditions specified in steps *(b)* through *(f)* fail, the GFCI circuit must then be inspected and tested. Replace the GFCI device as necessary.

Chemical-Free Storage

POOL chemicals, fertilizers, salt, oxidizing cleaning materials, and other CORROSIVE MATERIALS should not be stored in any INTERIOR SPACE containing electric light fixtures, panel boards, fuses, circuit breakers, disconnects, motors, motor overloads, bonding conductors, or similar devices.

- ***Exception (1):*** Otherwise approved CHEMICAL STORAGE AREAS having light fixtures which are approved for use in CORROSIVE atmospheres, and which serve the CHEMICAL STORAGE AREA only, should be acceptable.
- ***Exception (2):*** Otherwise approved CHEMICAL STORAGE AREAS having a light switch or switches approved for use in CORROSIVE atmospheres, and which serve the CHEMICAL STORAGE AREA only, should be acceptable.
- ***Exception (3):*** Otherwise approved CHEMICAL STORAGE AREA containing small motors and the associated controllers, such as those for exhaust-blowers and peristaltic pumps should be acceptable where such motor circuits are protected by GFCI.
- ***Exception (4):*** Otherwise approved CHEMICAL STORAGE AREA containing devices listed and labeled for use in interior POOL-CHEMICAL STORAGE AREAS should be acceptable.
- ***Exception (5):*** Otherwise approved CHEMICAL STORAGE AREAS containing devices listed and labeled for use in CORROSIVE atmospheres should be acceptable where approved by the AHJ.

Flammable liquids and flammable gases should not be stored in any INTERIOR SPACE containing electric light fixtures, panel boards, fuses, circuit breakers, disconnects, motors, motor overloads, bonding conductors, or similar devices, unless such devices comply with Article 500 of the NEC, or with the relevant local CODES.

POOL chemicals, acids, fertilizers, salt, oxidizing cleaning materials, and other CORROSIVE or oxidizing chemicals should not be stored in INTERIOR SPACES where electrical conduits enter or pass through the space.

- ***Exception (1):*** Otherwise approved CHEMICAL STORAGE AREAS into which conduits enter or pass through should be acceptable, where such conduits
    - Are sealed where they enter and exit the STORAGE space, and
    - Are listed as corrosion resistant, and
    - Serve only approved loads in the STORAGE space itself.

- ***Exception (2):*** Otherwise approved CHEMICAL STORAGE AREAS containing conduits approved for use in CORROSIVE atmospheres should be acceptable if approved by the AHJ.

Where an interior CHEMICAL STORAGE SPACE was previously approved for STORAGE of POOL chemicals, acids, fertilizers, salt, oxidizing cleaning materials, other CORROSIVE or oxidizing chemicals, or flammable liquids or gases and will continue to be used for such STORAGE, any replacement electrical parts or devices should be of the same type as the original equipment, or should be listed and labeled for such use.

No new electrical devices or equipment should be installed in an interior CHEMICAL STORAGE SPACE used for STORAGE of POOL chemicals, acids, fertilizers, salt, oxidizing cleaning materials, or flammable liquids or gases without re-inspection by the AHJ.

Isolation Of Chemical Storage Areas

An interior STORAGE space used for storing POOL chemicals, fertilizers, salt, oxidizing cleaning materials, other CORROSIVE or oxidizing chemicals, or pesticides must be kept in ISOLATION from other INTERIOR SPACES, except for entry, egress, material transport, or alarm testing. The period of each instance of entry, access, or alarm testing should not exceed 15 minutes. The sum of the periods of all instances of breach of ISOLATION should not exceed one hour in each 24-hour period. Where the ISOLATION of an interior STORAGE space containing such chemicals from other INTERIOR SPACES containing COMBUSTION DEVICES depends on an interior door, such door should be gasketed to prevent the passage of air, fumes, or vapors, and should be equipped with an automatic door closer and an alarm that will give notice if the door remains open for more than five minutes. Function of this alarm should be confirmed monthly as part of scheduled maintenance. Failures of door gasketing, or of the door closer, or of the alarm should be repaired immediately.

Unsealed Openings

Where any unsealed openings exist between an interior STORAGE space used for POOL chemicals, acids, fertilizers, salt, or CORROSIVE or oxidizing chemicals and any other INTERIOR SPACE containing electrical equipment, the air pressure in the CHEMICAL STORAGE SPACE should be maintained at a level low enough to insure that all air flow should be toward the CHEMICAL STORAGE SPACE. This pressure difference should be maintained by a continuously operating exhaust system used for no other purpose than to remove air from the CHEMICAL STORAGE SPACE. Function of this exhaust system should be monitored continuously by a pressure switch and alarm. Function of the pressure switch and alarm should be confirmed monthly as part of scheduled maintenance. In the event of failure of the exhaust system or of the alarm, repairs should be done immediately.

In any space containing electrical equipment, ambient conditions such as temperature, humidity, and maximum concentrations of chemical fumes or vapors, or of flammable fumes or vapors should be continuously maintained to meet the operational requirements of installed electrically powered equipment. Labels or other marks indicating the circuits served by fuses, circuit breakers, and disconnect switches should be maintained in a condition readable by a person unfamiliar with the function of the circuits.

For spaces containing fuses, circuit breakers, electric motors, or motor-operated loads, the recommended minimum illumination capability should be maintained as part of the scheduled monthly maintenance. STORAGE should not interfere with the largest of the minimum working clearances specified by the NEC, the equipment manufacturer, CFR 1910, or by local CODES or regulations.

Re-lamping

Re-lamping operations within 20 feet *(6.1 m)* horizontally of the nearest inside edge of a POOL, SPA, FLUME, WATERSLIDE, or other open AQUATIC FEATURE should be carried out in such a way as to minimize the likelihood of lamp breakage. New lamps should be kept in their packing until just before installation. Old lamps should be packed immediately upon removal into a suitable container to prevent breakage. New lamps should not be stored in an interior STORAGE space used for POOL chemicals, fertilizers, salt, or other CORROSIVE or oxidizing chemicals. Neither new lamps nor old lamps should be stored in the INDOOR AQUATIC FACILITY, SHOWER room, locker room, or hallways.

Where visible or accessible, any required bonding jumpers should be visually inspected for damage, breaks, looseness, or corrosion quarterly as part of scheduled maintenance. Where any doubt exists concerning the condition of bonding jumpers, they should be inspected and, if necessary, the effectiveness of such jumpers should be tested.

5.6.3.4 Grounding

The purpose and objective of NEC Article 250 - Grounding is to insure that the electrical system is safe against electric shock and fires by limiting the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and a GROUND-FAULT *(line-to-case fault)*. The rules contained in NEC Article 250 identify the installation methods that must be followed to insure a safe electrical installation.

NEC Article 680 applies to the construction and installation of electrical wiring for and equipment in or adjacent to all swimming, wading, therapeutic, and decorative POOLS, fountains, hot tubs, SPAS, and hydromassage bathtubs *(whether permanently installed or storable)* and to metallic auxiliary equipment, such as pumps, filters, and similar equipment.

5.6.3.6 Extension Cords

5.6.3.6.3 Exception

The intent is to prevent the extension cord from reaching the water.

5.6.3.6.6 Compliance

- See CFR 1910.304 (b)(2) at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9881

5.6.3.8 Communication Devices and Dispatch Systems

NEC Article 800 covers multi-purpose and communication cable. Multi-purpose cable is the highest listing for a cable and can be used for communication, Class 2, Class 3, and power-limited fire protective cable. Communication cable can be used for Class 2 and Class 3 cable and also as a power-limited fire protective cable with restrictions.

5.6.4 Facility Heating

5.6.4.1 Facility Heating

5.6.4.1.1 Maintenance and Repair

There are a number of CODES which can be consulted. These include but are not limited to the National Fuel Gas Code, NEC, and certain building CODES.

5.6.4.1.2 Defects

If inspection shows excessive fouling of air filters before the cleaning or replacement period has ended, that period should be reduced to prevent overloading of filters. Filters that become clogged with dirt, mold, or other CONTAMINANTS can become a source of increased operating costs and poor air circulation. In addition to the reduction of system effectiveness, which can result in costly repairs, air-borne CONTAMINANTS can be spread as a result of improper air handling.

5.6.4.1.3 Temperature

The air temperature of an indoor AQUATIC VENUE should be controlled to the original specifications where possible. Where this is not possible, the air temperature of an INDOOR AQUATIC FACILITY should be controlled so as to prevent unexpectedly high levels of evaporation and to prevent condensation of water onto surfaces not designed for condensation. Particular care should be taken to prevent the condensation of water inside INDOOR AQUATIC VENUE building surfaces such as walls and ceilings. Please note that this CODE only looks at the part of the facility where the water "vessel" is located and not at other areas of buildings *(the building CODE would cover)*. Particular attention needs to be given to the prevention of algae and mold growth on surfaces.

5.6.5 First Aid Room [N/A]

5.6.6 Emergency Exit

5.6.7 Plumbing

5.6.7.1 Water Supply

The potable water pressure should be maintained to enable the AQUATIC VENUE and all other water using PLUMBING FIXTURES to operate to design specifications.

5.6.7.3 Waste Water

In some AQUATIC FACILITIES, backwash water may be recycled for other purposes instead of wasted in order to conserve water. This water must be treated in accordance with local

CODE requirements prior to being re-used. Backwash water is likely to be routinely contaminated with pathogens so its use should be carefully considered and health issues planned for prior to re-use. It should not be re-used in AQUATIC VENUES, but may be used in landscaping or other non-potable water uses with AHJ approval.

5.6.7.4 Water Replenishment

See MAHC Annex Section 4.7.4 for more information.

A minimum of 4 gallons *(15 L)* of water per BATHER per day must be discharged from the POOL, but a volume of 8 gallons *(30 L)* per BATHER per day is recommended. Backwash water will count toward the total recommended volume of water to be discharged, but evaporated water will not count since inorganic CONTAMINANTS *(e.g., salts and metals)* and many organic CONTAMINANTS *(e.g., sweat and urine)* can simply be concentrated as water evaporates. Backwash water or other discharged water may not be returned to the POOL without treatment to reduce the total organic carbon concentration, DBP levels, turbidity, and microbial concentrations less than the limits set for tap water by the U.S. EPA.

5.6.8 Solid Waste

5.6.9 Decks

5.6.9.1 Food Preparation and Consumption

5.6.9.1.2 Eating and Drinking

Eating and drinking in AQUATIC VENUE areas may expose BATHERS to CONTAMINANTS. Food particles that fall into the POOL not only contribute to contamination burden, but may also affect POOL DISINFECTION. Additionally, contamination can occur through ingestion. Alcohol increases urine output and therefore creates more chloramines and other DBPs if BATHERS do not regularly get out of the POOL to urinate. Regular bathroom breaks should be considered to reduce urination in the AQUATIC VENUE that allows designated areas like “swim-up bars” that may increase POOL urination and create compliance issues with MAHC combined CHLORINE levels. However, at this time, the MAHC does not have data suggesting that AQUATIC VENUES containing “swim-up bars” have any more issues with water quality compliance issues that those AQUATIC VENUES that do not. AQUATIC VENUES considering “swim-up” bars need to be aware that these areas may also increase the risk of drowning caused by excessive alcohol consumption and should include this thinking in lifeguard training and in-service training.

Currently the majority of states do not allow swim-up bars; however, Ohio, Hawaii, Texas, and a few local jurisdictions do, mostly in resort areas. The MAHC defers to local jurisdictions to assess and determine potential risks.

Another topic to consider is nursing mothers and SAFETY and health risk to infants. While many mothers consider nursing in the POOL a pleasant experience for the baby there is a definite SAFETY risk for the infant from hypothermia and a health risk from potentially ingesting contaminated POOL water that may contain organisms such as *Cryptosporidium*.

- For more information about this topic, see CDC Healthy Swimming discussion at: http://www.cdc.gov/healthywater/swimming/protection/breastfeeding-in-pools.html

5.6.9.2 Glass

Glass is prohibited in the POOL DECK area to prevent injuries to PATRONS. Most BATHERS and PATRONS are bare foot, so stepping on glass can cause serious injuries. If a glass container breaks in the AQUATIC VENUE vicinity it could potentially fall into the water. Clear glass is virtually invisible in water and is difficult to remove. The only way to ensure all broken glass is removed from POOL water is to thoroughly drain and clean the POOL structure. Depending on the size, draining and cleaning an AQUATIC VENUE can cost thousands of dollars.

5.6.9.3 Deck Maintenance

5.6.9.3.1 Free From Obstructions

DECKS should always be kept clear of obstructions to preserve space that may be needed for rescue efforts. Obstructions also cause tripping hazards and can lead to falls and serious injuries. Attention must also be given to potential fall hazards from slippery DECK areas.

5.6.9.3.3 Vermin

It is important to maintain these areas free from debris, vermin, and vermin harborage. Animals can carry diseases which could be transmitted through bites or contact with bodily fluids or feces.

5.6.9.3.4 Original Design

Proper maintenance of surfaces will help prevent abrasions to BATHERS and biofilm growth.[320]

5.6.9.3.4.1 Crack Repair

CRACKS in the DECK shall be part of the daily inspection process and be repaired when they might increase the potential for injury. See MAHC 5.5.6.1.1, 5.5.6.1.2, and 5.5.6.1.3 and MAHC Annex 5.5.6, “Pool Shell Maintenance.”

5.6.10 Aquatic Facility Maintenance

5.6.10.1 Diving Boards and Platforms

Slip resistance can be accomplished by ensuring that the coefficient of friction is greater than or equal to that specified in MAHC 4.8.1.4.

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320 CDC. An outbreak of Pseudomonas folliculitis associated with a waterslide – Utah. MMWR Morb Mortal Wkly Rep. 1983;32(32):425-7.

5.6.10.3 Starting Platforms

Starting blocks are designed for use by trained persons or those under the supervision of a qualified individual. Use by untrained, unsupervised individuals can lead to serious injury. Since they can be an attraction for unqualified BATHERS to use, starting block use needs to be clearly prohibited by signage, covers, or other BARRIERS/deterrents. Since BATHERS are known to ignore signs or BARRIERS prohibiting use, the safest approach for removable blocks is to remove them and store elsewhere when not in use.

5.6.10.5 Fencing and Barriers

This wording refers to alarms associated with open gates or BARRIERS. It is not meant to include burglar or fire alarms.

5.6.10.6 Aquatic Facility Cleaning

In-POOL cleaning systems must be periodically inspected to make sure they retract and stay flush with the floor.

5.7 Recirculation and Water Treatment

5.7.1 Recirculation Systems and Equipment

5.7.1.1 General

The MAHC does not allow shut down of the RECIRCULATION SYSTEM during closure times since uncirculated water would soon become stagnant and loose residual disinfectant likely leading to biofilm proliferation in pipes and filters. This would likely compromise water quality and increase the risk to BATHERS. MAHC 4.7.1.10.5 describes turndown system design. The flow turndown system is intended to reduce energy consumption when AQUATIC VENUES are unoccupied without compromising water quality. A turbidity goal of less than 0.5 NTU has been chosen by a number of U.S. state CODES *(e.g., Florida)* as well as the PWTAG and WHO. The maximum turndown of 25% was selected to save energy while not necessarily compromising the ability of the RECIRCULATION SYSTEM to remove, treat, and return water to the center and other extremities of the POOL. Additional research in this area could identify innovative ways to optimize and improve this type of system and that more aggressive turndown rates are acceptable.

5.7.1.1.3 Gutter / Skimmer Pools

The recommendation for gutter or SKIMMER POOLS with main drains to have the majority of the water *(at least 80% of the recommended recirculation flow)* be drawn through the POS and no greater than 20% through the main drain during normal operation is based on subsurface distribution of bacteria data that showed most POOLS had higher surface concentrations of bacteria.[321] For the 65 POOLS examined, surface concentrations of bacteria were an average of 3.4 times greater at the surface. However, about 30% of the

321 Dick EC, et al. Surface-subsurface distribution of bacteria in swimming pools – field studies. Am. J. Pub. Health. 1960;50:5:689-695.

POOLS showed the opposite trend with higher subsurface concentrations, which is why some operational flexibility is provided with these values.

For reverse flow *(upflow)* POOLS, 100% of the recommended circulation flow should be through the POS, which is consistent with the German DIN Standards.[322] Efficient removal of surface water is critical for maintaining water quality because surface water contains the highest concentration of pollutants from body oils, sunscreens, as well as other chemicals or particles that are less dense than water. Bacteria appear to follow the same trend in most cases[323]. The distribution of CHLORINE-tolerant pathogens like *Cryptosporidium* is not known at present.

The majority of the organic pollution and contamination is concentrated at or near the surface irrespective of the mixing effects of the circulation.

5.7.1.3 Inlets

During regular seasonal operation following initial adjustments, INLETS should be checked at least weekly so that the rate and direction of flow through each INLET has not been changed substantially from the original conditions that established a uniform distribution pattern and facilitated the maintenance of a uniform disinfectant residual throughout the entire facility without the existence of dead spots.

A tracer test *(e.g., with a sodium chloride tracer injected on the suction side of the pump)* should be conducted annually at startup and documented to quantitatively assess distribution pattern in the POOL. An amount of salt sufficient to increase the baseline conductivity by at least 20% should be added over a one minute period, and the conductivity or TDS should be measured at one minute intervals until the conductivity increases by 20% and/or stops changing for ten consecutive readings after an initial increase. Samples may also be taken at the corners, center, and bottom of the POOL *(via a sample pump with the POOL unoccupied)* in small labeled containers for later measurement to increase the amount of information available to assist in interpreting the results. Increases greater than predicted by the amount of salt added to the POOL volume indicate poor mixing. Areas with conductivities lower than in the return stream at the time the sample was collected are likely to be areas with poor recirculation flows.

Note: It is possible to do a tracer test, which is quantifiable in terms of salt concentration ratios and/or time required to reach equilibrium concentration near the filter.

5.7.1.6 Piping

Winterization may involve dropping the water level below the level of the INLETS, blowing or draining all of the water out of the pipes, adding antifreeze, and closing off both ends. Pipes should be drained or winterized in regions where freezing temperatures are

322 PWTAG. Swimming pool water: treatment and quality standards for pools and spas, 2nd Ed. 2009. Micropress Printers, Ltd. ISBN: 0951700766.
323 Dick EC, Shull IF, and Armstrong AS. Surface-subsurface distribution of bacteria in swimming pools – field studies. Am. J. Pub. Health. 1960;50:5:689-695.

expected to be reached inside of the pipes. This should not be done with car antifreeze, and the antifreeze should not be toxic to humans.

5.7.1.8 Flow Meters

Flow meters are important for the maintenance of proper filtration, backwashing, and recirculation flow rates. It is also feasible to save money on electrical costs by using the flow meter to monitor and adjust the speed of the pump.

5.7.2 Filtration

5.7.2.2 Granular Media Filters

5.7.2.2.4 Backwashing Frequency

Backwashing frequency is important for multiple reasons. First, solids attach more strongly to the filter media over time and can be more difficult to remove following infrequent backwashing. Secondly, the organic particles *(e.g., skin cells)* held in the filter in contact with FREE CHLORINE can break down over time and produce DBPS and/or combined CHLORINE. The potential to form "mudballs" also increases with solids loading inside of a filter and can cause filter failures. The preceding items are the rationale for requiring backwashes at manufacturer prescribed pressure losses through the filter. Some data suggests tainted backwash water remains inside of the filter at the conclusion of the backwash procedure and therefore should be wasted to drain for at least the first two minutes after restarting.

5.7.2.2.4.1 Backwash Scheduling

Backwashing while PATRONS are in the water is not recommended. First, the MAHC requires that RECIRCULATION SYSTEMS are running at all times that an AQUATIC VENUE is open for BATHER use. Second, with no interlock in place, stopping recirculation while inadvertently continuing chemical feed pumps can cause a build-up of acid and CHLORINE product in the lines that leads to CHLORINE gas production. When the RECIRCULATION SYSTEM is turned back on, the risk increases dramatically of a CHLORINE gas plume being delivered into the AQUATIC VENUE causing injury to BATHERS and initiating an emergency response[324]. Exceptions to this would be if an AQUATIC VENUE has multiple filters and an individual filter can be taken off line without shutting down the RECIRCULATION SYSTEM and there is no chance of overfeeding chemicals that may lead to outgassing events or other chemical mixing emergencies.

5.7.2.2.7 Filtration Enhancing Products

Coagulants should be used with caution due to potential for filter bed fouling. Maintaining records of clean bed headloss is recommended to help detect problems of filters not being adequately cleaned via backwashing. If a facility decides to use coagulants, they should be used continuously. Not using coagulants when the water is clear to save money will

324 Hlavsa MC, et al. Surveillance for waterborne disease outbreaks and other health events associated with recreational water use — United States, 2007–2008. MMWR Surveill Summ. 2011;60:1-37.

significantly impair the capabilities of the filters to remove pathogens like *Cryptosporidium* and *Giardia*.

5.7.2.3 Precoat Filters

5.7.2.3.2 Return to the Pool

In closed-loop mode, it will be necessary to charge the media slurry to the suction side of the pump or precoat tank, prior to closing down the loop and putting the system into recirculation. Precoating of a filter typically takes 5 to 10 minutes. At the end of the precoat cycle, the discharge out of the filter should be clear and free of filter media. If the discharge is not clear, the filter should be opened, inspected, and repaired as necessary.

5.7.2.3.3 Operation

When flow or pressure is lost in the filter, the precoat layer may become unstable and fall off of the filter septum. To reduce the likelihood of debris and CONTAMINANTS being returned to the POOL, it is recommended that prior to restarting the filter, it should be backwashed and/or cleaned and the precoat re-established with new filter media in a closed loop recirculation mode or with water wasting until the discharge of the filter is clear to minimize the potential of media or debris returning to the POOL. It is important that flow not be interrupted after the precoating process is completed and the flow out of the filter is redirected from the recirculation or waste piping back to the POOL. It is acceptable to open and close valves on the filter effluent stream as long as the closed valves are opened first so that the filter effluent water can flow continuously. Allowing the media to fall off of the filter septum decreases the capability of the filter to remove particles. The critical importance of always cleaning the filter and replacing the media when the flow is interrupted for any reason is related to uneven recoating permitting pathogen passage as well as fouling of the media support layers.[325]

5.7.2.3.4 Cleaning

Septum covers should be properly cleaned and inspected to maintain proper performance of precoat filters. Filters should be backwashed following a significant drop in the flow rate or when the pressure differential across the filter is greater than 10 pounds per square inch *(69.90 KPa)*. Vacuum–type precoat filters should be cleaned when the vacuum gauge reading increases to greater than 8 inches *(20.3 cm)* of mercury or as recommended by the manufacturer. If after precoating with fresh media, the filter pressure does not return to the normal initial starting pressure noted on filter start-up, it would be advisable to disassemble the filter and clean the elements *(septum covers)* per the filter manual. Septum covers should be cleaned or replaced when they no longer provide effective filtration or create a friction loss preventing maintenance of the recommended recirculation rate. Water and spent media should be discharged in a manner approved by the appropriate regulatory agency.

5.7.2.3.6 Bumping

325 Cleasby JL, et al. Chapter 8: Granular Bed and Precoat Filtration. In Water Quality and Treatment, 5th Ed. McGraw Hill, Inc. NY:1999.

Bumping is the act of intentionally stopping the filter and forcing the precoat media and collected CONTAMINANTS to be removed from the filter septum. Bumping may impair pathogen removal and could facilitate the release of pathogens previously trapped in the filter. Therefore, bumping should be performed in accordance with the manufacturer's recommendations. Prior to restarting a bumped filter, it is recommended that the precoat be re-established in a closed loop recirculation mode or with water wasting until the discharge of the filter is clear to minimize the potential of media or CONTAMINANTS returning to the POOL.

Pending future research, bumping is strongly discouraged in any precoat filter application where pathogen removal is a concern. Bumping may impair pathogen removal as pathogens once trapped at the surface of the cake could be positioned close to the septum and penetrate the filter during operation.[326] Cyst-contaminated water used for precoating filters led to much higher cyst concentrations in the filter effluent.[327] Precoat filters have been demonstrated to remove greater than 99% of the OOCYSTS. Using clean precoat media to precoat filters as well as maintaining continuous flow is recommended.[328,329,330]

5.7.2.3.7 Filter Media

Continuous filter media feed *(or body-feed)* can be used to increase the permeability of the cake, maintain flow, and extend cycle length as it becomes coated with debris. Body-feed is filter media added during the normal filtration mode on a continuous basis. The amount of body-feed used is dependent upon the solids loading in the POOL. Turbidity is the best available method to quantify and estimate solids loading. For filter influent turbidities greater than 1.5 NTU, body-feed may be beneficial with addition rates ranging from 1.0 to 4.0 ounces of DE per square foot of filter area per day dependent on the solids loading in the POOL. The lowest effective concentration of suspension should be used in a body-feed system. The concentration of the suspension may not exceed 5% by weight. The body-feed system head and lines should be flushed once every 15 minutes for at least one minute to assure proper and continuous operation. Water from the discharge side of the recirculation pump may be used. If connection is to a potable water supply line, the supply line should be equipped with an approved BACKFLOW prevention device.

Precoat media should normally be fed into the filter at a concentration not to exceed 5% by weight. Since perlite is approximately half the density of DE, half of the weight of perlite will achieve a similar depth of media inside of the filter as shown in MAHC Annex Table 5.7.2.3.7.1.

Table 5.7.2.3.7.1: Required Use Rates for Precoat Media

326 Logsdon GS, et al. Alternative filtration methods for removal of Giardia cysts and cyst models. Journal AWWA. 1981;73(2):111-118.
327 Letterman RD. Water Quality and Treatment. 1999. 5th Ed. McGraw-Hill, NY.
328 Croll BT, et al. Simulated Cryptosporidium removal under swimming pool filtration conditions. Water Environment Journal. 2007;21:149-156.
329 Letterman RD. Water Quality and Treatment. 1999. 5th Ed. McGraw-Hill, NY.
330 Cleasby JL, et al. Chapter 8: Granular Bed and Precoat Filtration. In Water Quality and Treatment, 5th Ed. McGraw Hill, Inc. NY:1999. ISBN: 0070016593.

Media Type	Amount	Approximate Precoat Depth
DE	1.0-2.0 lb/10 ft^2 *(453.59 – 907.18 g/0.93 m^2)*	$^1/_{16}$ – $^1/_8$ inch *(1.59 mm – 3.18 mm)*
Perlite	0.5 – 1.0 lb/10 ft^2 *(226.80 – 453.59 g/0.93 m^2)*	$^1/_{16}$ – $^1/_8$ inch *(1.59 mm – 3.18 mm)*

5.7.2.3.7.1 Diatomaceous Earth

Drinking water applications typically recommend using DE at application rates of 0.2 pounds per square foot *(1 kg/m^2)*.[331] This practice seems to be based on research showing that the removal of 9-micron *(Giardia-sized)* microspheres increased from greater than 99% to greater than 99.9% as the precoat amount increased from 0.5 to 1 Kg/m^2.[332] Under the range of conditions tested, Logsdon and coworkers[333] found that the amount of DE had a greater impact on microsphere removal than did the grade of DE.

Alum-coated DE has been shown to significantly improve the removal of turbidity and bacteria not normally removed by DE filters.[334] Logsdon[335] reported that alum could be added at 0.05 gram of alum as $Al_2(SO_4)_3 \cdot 14\ H_2O$ per 1 gram of DE in a slurry to form a precipitate on the surface to enhance performance.

5.7.2.4 Cartridge Filters

5.7.2.4.1 NSF Standards

Cartridge filter elements should be cleaned *(or replaced)* when the differential pressure across the filter exceeds 10 psi *(68.9 KPa)*. Every cartridge filter should have two sets of cartridges. This will allow for one set to be in use while the other is being cleaned *(soaking and drying are recommended)*.

5.7.2.4.2 Filtration Rates

The 0.375 GPM per square foot *(0.26 L/s/m2)* maximum design flow rate is acceptable, but an allowance is necessary to accommodate irreversible fouling of cartridges *(i.e., cartridges that do not recover 100% of the original capacity when cleaned after fouling)*. Systems designed for a given TURNOVER time with a filter flow rate of 0.375 GPM per square foot *(0.26 L/s/m^2)* would not be in compliance if partially fouled cartridges dropped

331 Cleasby JL, et al. Chapter 8: Granular Bed and Precoat Filtration. In Water Quality and Treatment, 5th Ed. McGraw Hill, Inc. NY:1999. ISBN: 0070016593.
332 Croll BT, et al. Simulated Cryptosporidium removal under swimming pool filtration conditions. Water Environment Journal. 2007;21:149-156.
333 Logsdon GS, et al. Alternative filtration methods for removal of Giardia cysts and cyst models. Journal AWWA. 1981;73(2):111-118.
334 Lange KP, et al. Diatomaceous earth filtration of Giardia cysts and other substances. Journal AWWA. 1986;78(1):76-84.
335 Logsdon GS. Water filtration practices: including slow sand filters and precoat filtration. 2008. American Water Works Association, Denver, CO. ISBN: 9781583215951.

the flow rate to 0.30 GPM per square foot *(0.20 L/s/m²)*. Therefore, an acceptable operating range is provided beyond which cartridge replacement would be necessary.

5.7.2.4.3 Filter Elements

Cartridges should be cleaned when the gauge pressure differential is 10 psi *(68.9 KPa)* and in accordance with manufacturer's instructions. Cleaning equipment should include a soaking container properly sized to immerse the filter elements, a rinsing area with proper drainage, and a drying area protected from contamination *(e.g., birds and insects)*. New filters do not regain 100% of their capacity. Perhaps only about 80% of the capacity is recoverable, regardless of the treatment. If the recommended design flow rate exceeds 80% of the maximum flow allowed on the filter, the filter may be undersized.

5.7.2.4.3.1 Cleaning Procedure

Facilities with cartridge filters are recommended to have the equipment on-site to clean the cartridges. This includes a basin or tub large enough to immerse the entire cartridge. Water from the cleaning and soaking process must be discharged to the sanitary sewer. Proper cleaning is critical. Failure to clean the cartridge properly can lead to disease outbreaks.

How to Clean Cartridge Filters:

1) ***RINSE THOROUGHLY:*** Rinse the cartridge of as much dirt and debris as possible by washing inside and out with a garden hose and spray nozzle.

- **DO NOT** use a pressure washer. High flow/pressure can drive the dirt into the interior and permanently damage the cartridge. It can also aerosolize pathogens in filter.

2) ***DEGREASE:*** Cartridge filters need to be degreased each time they are cleaned. Body oil, suntan oil, cosmetics, hair products, and/or algae and biofilms can form a greasy coating on the filter pleats, which will clog the pores and reduce the filter capacity.

- Soak the cartridge overnight in:
  - Filter cleaner/degreaser, or
  - A solution of water with one cup *(236.6 g)* of TSP *(tri-sodium phosphate)*, or
  - One cup *(236.6 g)* of automatic dishwashing detergent per 5 gallons *(3.8 L)* of water.
- **Never use Muriatic Acid or products with acid in them prior to degreasing. Acid may permanently set the grease and ruin the cartridge.**

3) ***RINSE THOROUGHLY***

4) ***SANITIZE:*** To remove or prevent biofilms, algae, and bacteria growing on the cartridge, add one quart *(0.95 L)* of household bleach per 5 gallons *(19 L)* of clean water and soak one hour before rinsing.

5) RINSE: Remove the clean cartridge from the sanitization soak water and rinse thoroughly with a hose.

6) DRY: After the filter is cleaned and degreased, it should be allowed to dry completely. Some bacteria *(e.g., Legionella spp.)* that survive the cleaning process can be killed by drying. Do not allow the filter to become contaminated with dirt or soil after it is cleaned. Put the cartridges in a clean plastic trash bag if they are to be transported and the original boxes are not available.

7) ACID WASH – ONLY IF NECESSARY: Excessive calcium or mineral deposits on the filter media can be cleaned with a 1:20 solution of clean water and muriatic acid. Put a few drops of muriatic acid on the filter. If it foams, it might need to be acid washed. Very few filters need to be acid washed.

5.7.2.4.3.3.2 Pressure Washer

A pressure washer should not be used because high flow/pressure can drive the dirt into the interior and permanently damage the cartridge or can aerosolize pathogens in the filter biofilm, which expose and infect workers when cleaning the cartridge filters in an enclosed space[336].

5.7.3 Disinfection and pH Control

5.7.3.1 Primary Disinfectants

5.7.3.1.1 Chlorine (Hypochlorites)

Although CHLORINE and bromine are the only primary disinfectants allowed at this time, future research may produce other acceptable primary disinfectants.

5.7.3.1.1.2 Minimum FAC Concentrations

It is necessary to ensure that FAC is maintained at or above the 1.0 ppm (mg/L) minimum level at all times and in all areas of the POOL. Because CHLORINE efficacy is reduced in the presence of CYA, higher FAC levels may be necessary for POOLS using CYA or stabilized CHLORINE.

The minimum FAC level of 1.0 ppm (mg/L) for swimming POOLS is well-supported by available data. The CDC data indicates that a 1.0 ppm (mg/L) FAC residual can provide effective DISINFECTION of most pathogens other than *Cryptosporidium*.[337]

Table 5.7.3.1.1.2: Germ Inactivation of Chlorinated Water*

Germ*	***Time***

336 Moraga-McHaley SA, et al. Hypersensitivity pneumonitis with Mycobacterium avium complex among spa workers. J Occup Environ Health. 2013;19(1):55-61.
337 CDC. Chlorine Disinfection Timetable. Last modified May 04, 2016. Accessed July 6, 2016. http://www.cdc.gov/healthywater/swimming/pools/chlorine-disinfection-timetable.html.

E. coli O157:H7 Bacterium	Less than 1 minute
Hepatitis A Virus	About 16 minutes
Giardia Protozoan	About 45 minutes
Cryptosporidium Protozoan	About 15,300 minutes *(10.6 days)*
**Laboratory testing results using chlorine demand free water with 1 ppm (mg/L) chlorine at pH 7.5, 77°F (25 °C) and in the absence of cyanuric acid.*	

Substantial laboratory data shows that kill times for microbial CONTAMINANTS are increased in the presence of CYA. However, the precise impacts on CT INACTIVATION VALUES in a swimming POOL environment are not well-established. The impact on CT INACTIVATION VALUES is mostly related to the HOCl concentration that can be calculated using equilibrium constants. In general, studies show that the presence of CYA up to 50 mg/L increases CT INACTIVATION VALUES under demand free conditions, and the amount of this increase depends upon the pH and the ratio of CYA to AVAILABLE CHLORINE. Studies suggest that this effect is mitigated with the addition of ammonia nitrogen as low as 0.05 mg/L by producing monochloramine which, although a weaker disinfectant than HOCl, remains unbound to CYA.

Swimming POOL survey data demonstrates that 1.0 ppm *(mg/L)* FAC provides acceptable bacteriological quality[338].

However, another paper suggests that FREE CHLORINE levels significantly higher than 1.0 ppm *(mg/L)* may be required. Based on data collected from seven chlorinated POOLS, Ibarluzea et al. predicted that 2.6 ppm *(mg/L)* is needed "in order to guarantee, with a probability of 90%, the acceptability of bathing water at indoor chlorinated swimming pools."[339]

A minimum FAC level *(3.0 ppm (mg/L))* for SPAS addresses the relatively higher THEORETICAL PEAK OCCUPANCY, higher temperatures, and/or at-risk populations served by these venues. The THEORETICAL PEAK OCCUPANCY and temperatures of these venues favor microbial growth and can lead to rapid depletion of CHLORINE. This minimum requirement is consistent with CDC recommendations to minimize transmission of *Legionella* via whirlpool SPAS on cruise ships, published in 1997, which recommends maintaining free residual CHLORINE levels in SPA water at 3 to 10 ppm *(mg/L)*. It is further supported by a study reviewing both bromine and CHLORINE, which states, *Pseudomonas aeruginosa*

338 Esterman A, et al. Determinants of the microbiological characteristics of South Australian swimming pools. Appl Environ Microbiol. 1984 February; 47(2): 325–328.
339 Ibarluzea J, et al. Determinants of the microbiological water quality of indoor swimming pools in relation to disinfection. Water Research. 1998; 33(3): 865-871.

were rapidly reestablished in SPAS *(greater than 103 cells per mL)* when disinfectant concentrations decreased below recommended levels *[CHLORINE, 3.0 ppm (mg/L), bromine 6.0 ppm (mg/L)]*.[340]

In general, a range of 2-4 ppm *(mg/L)* FAC for POOLS *(3-5 ppm (mg/L) for spas)* is recommended to help ensure the minimum FAC is maintained and to provide a margin of SAFETY for BATHERS.

For individual POOLS, considerations for ideal FAC levels include:

- ***Chlorine demand:*** FAC levels should be sufficient to accommodate peak BATHER LOADS and other sources of contamination.
- ***Temperature and sunlight:*** FAC levels should be sufficient to accommodate loss of FAC from higher water temperatures and sunlight.
- ***Cyanuric acid:*** Because CHLORINE efficacy is reduced in the presence of CYA, higher FAC levels may be necessary for POOLS using CYA or stabilized CHLORINE.[341,342,343, 344]
- ***Algae control:*** Algae is more difficult to control than most pathogens and may require FAC residuals greater than 3.0 ppm *(mg/L)* although peer-reviewed data is lacking.
- ***Accuracy of FAC tests:*** POOL test kits have been reported to give FAC results which diverge significantly from true values although peer-reviewed data is lacking.
- ***Feeder equipment:*** Automated feeders help reduce variability in dosing and the potential for FAC levels to fall below minimum levels.
- ***Secondary disinfection:*** While the minimum FAC level must be maintained in all POOLS, approved SECONDARY DISINFECTION SYSTEMS such as UV and ozone reduce risks from CHLORINE-resistant pathogens and may reduce CHLORINE demand. However, the effects of UV/CHLORINE on water chemistry are still largely undefined. Recent research suggests that UV can increases some forms of CHLORINE demand.

5.7.3.1.1.5 Maximum FAC Concentrations

FAC levels should be consistent with label instructions of the disinfectant. All POOL and SPA disinfectants must be registered by the U.S. EPA under FIFRA The MAHC welcomes input and supporting data for establishing upper limits. At this time, the MAHC requires FAC maximum levels to be consistent with label instructions. An upper limit of 10 ppm *(mg/L)* has been chosen to ensure operators can still reasonably measure FAC. Issues have arisen with extremely high levels being added when poorly trained operators cannot

340 Price D, et al. Incidence and persistence of Pseudomonas aeruginosa in whirlpools. J Clin Microbiol. 1988 Sep;26(9):1650-4.
341 Anderson JR. A study of the influence of cyanuric acid on the bactericidal effectiveness of chlorine. Am J Public Health Nations Health. 1965 Oct;55(10):1629-37.
342 Fitzgerald GP, et al. Factors influencing the effectiveness of swimming pool bactericides. Appl Microbiol. 1967 May;15(3):504-9.
343 Golaszewski G, et al. The kinetics of the action of chloroisocyanurates on three bacteria: Pseudomonas aeruginosa, Streptococcus faecalis, and Staphylococcus aureus. Water Research 1994;28(1): 207-217.
344 Fitzgerald GP, et al. Pseudomonas aeruginosa for the evaluation of swimming pool chlorination and algicides. Appl Microbiol. 1969 Mar;17(3):415-21.

measure FAC and continue adding disinfectant without realizing the test is bleaching out rapidly.

EPA has not approved any POOL product use above 4 ppm *(mg/L)* FAC or SPA product use above 5 ppm *(mg/L)* FAC when BATHERS are present. The maximum FAC level approved for POOLS is consistent with EPA's Maximum Residual Disinfectant Level *(MRDL)* of 4 ppm *(mg/L)* for drinking water.

No data was identified suggesting health risks from FAC levels at, or even significantly above, these levels. The EPA MRDL and the World Health Organization's drinking water guideline value for CHLORINE *(5 ppm (mg/L))* are based on drinking water studies that found no adverse effects related to CHLORINE[345].

Use of high levels of CHLORINE as a "shock dose" when BATHERS are not present may be part of an overall water quality management strategy. Periodic shock dosing can be an effective tool to maintain microbial quality of water and to minimize build-up of biofilms and inorganic chloramines. For BATHER re-entry, FAC levels shall be consistent with label instructions of the disinfectant.

Salt water *(saline)* chlorination systems generate and deliver a CHLORINE disinfectant on-site directly into POOL water.

While cell size and configuration of these systems may differ depending on the manufacturer, the principles of their operation remain the same. Sodium chloride is added to balanced POOL water to establish a saline solution, which flows through the electrolytic cell. A low voltage electrical charge is passed through the saline solution and the current breaks the sodium and chloride bonds resulting in the formation of CHLORINE gas, hydrogen gas, and sodium hydroxide:

2 H20 + 2 NaCl (aq) □ Cl2 (g) + H2 (g) + 2 NaOH

The hydrogen gas is dissolved in the water and eventually vents to the atmosphere. The CHLORINE gas then dissociates into HOCl, which provides a residual of FAC:

Cl2 (g) + H20 □ HOCl (aq) + HCl (aq)

Salt water chlorination units should be sized appropriately to maintain minimum FAC levels during maximum load periods. The units should ideally be controlled by an ORP controller. Operators must still test the FAC residual of the water to ensure that the cell is producing adequate CHLORINE for the POOL. However, a separate chlorinating product may be needed to provide a sufficiently high FAC level for shock treatment or remediation following a fecal accident.

345 WHO. (2003). Chlorine in drinking water background document for development of WHO guidelines for drinking-water quality. WHO/SDE/WSH/03.04/45.World Health Organization, Geneva. Accessed at http://www.who.int/water_sanitation_health/dwq/chlorine.pdf.

MONITORING and maintaining the pH, total alkalinity, and TDS of the water in the POOL is important. Salt water POOLS intentionally have high concentrations of sodium chloride. The sodium chloride will contribute to TDS, but will not cause decreased disinfectant efficacy or cloudy water.

Electrolytic cells do wear out and need to be replaced. The life of the cell depends upon how many hours the cell operates each day, the pH of the water, and the calcium content of the water. The cells have to be cleaned to remove scale build-up. The systems usually utilize reversal of the polarity on the cells to minimize the scale formation, but eventually the cell will have deposits that require the cell to be removed from the plumbing and soaked in an acid solution.

The cells are also vulnerable to damage if they are operated in conditions of lower than recommended salt residuals or in water that is too cold. The systems have sensors and cut-offs to prevent this damage, but operators must be sure to monitor the unit to recognize when there is a problem.

5.7.3.1.2 Bromine

5.7.3.1.2.1 EPA Registered

The U.S. EPA Office of Pesticides registers products and approves labels for bromine. Currently bromine products on the market for use in recreational water are registered with use levels ranging from 1-8 ppm *(mg/L)*, depending on the product. The efficacy of these products have been studied by the manufacturers and submitted to the U.S. EPA under FIFRA. The efficacy data analyzed by the U.S. EPA is company confidential and has not been reviewed as part of the development of the MAHC.

5.7.3.1.2.2 Minimum Bromine Concentrations

Bromine concentrations established by state and local jurisdictions have not been found to correlate with data supporting the concentrations being used. However, every state or local jurisdiction that allows bromine as a disinfectant requires bromine at higher concentrations than CHLORINE and almost twice as much in SPAS and warmer POOLS.

Commercially available test kits are not capable of distinguishing free bromine *(Br_2, HOBr, OBr-)* from combined bromine *(bromamines)*. The bromine value specified in test results is the concentration of total bromine, not the free available halogen that is tested with CHLORINE. To determine total bromine, test kit manufacturers use a CHLORINE value and multiply it by 2.25. The 2.25 conversion factor accounts for the molecular weight difference between elemental bromine and elemental CHLORINE *(Br = 79.90 grams per mole and Cl = 35.45 grams per mole)*. Further, presently used field test kits assay only for total bromine.

Bromine is commonly used in indoor commercial SPAS, probably due to these two factors. First, bromamines *(bromine and ammonia combined)* do not produce irritating odors as do chloramines. Second, bromine efficacy is less impacted than CHLORINE'S at a higher pH, which typically occurs in a SPA environment. At pH of 7.5, 94% of bromine is HOBr, whereas at the same pH, HOCl is 55% in chlorinated water. At pH of 8.0 bromine still has 83% HOBr, while in a chlorinated water, HOCl is 28%.[346]

Bromine is also not very common in outdoor POOLS because like CHLORINE, bromine is destroyed rapidly in sunlight. CYA was developed to combat the problem in chlorinated POOLS, but does not provide a stabilizing effect for bromine.

While reviewing the literature and surveillance data from CDC, evidence that outbreaks have occurred when required minimum bromine concentrations have been maintained is lacking. Therefore, in absence of any clear research, the decision to use common state requirements as the recommended levels is prudent.

SPAS have been implicated in many skin disease outbreaks throughout the years. One paper suggests that a common culprit, *Pseudomonas aeruginosa,* were rapidly reestablished in SPAS *(less than 103 cells per mL)* when disinfectant concentrations decreased below recommended levels *(CHLORINE: 3.0 ppm (mg/L); bromine: 6.0 ppm (mg/L))*. The authors studied the reoccurrence of bacteria following cleaning and halogen shock treatment[347]. This study emphasized the need for maintaining a consistent CHLORINE level in the SPA. CDC recommends 4-6 ppm *(mg/L)* for bromine.

The MAHC recommends a follow up study to evaluate the efficacy of bromine on *P. aeruginosa,* since it is so commonly found in SPAS; and because bromine is very common disinfectant used in SPAS, prevention and treatment is essential.

There are few peer-reviewed studies on bromine efficacy in real world POOLS and SPAS in the literature. Brown et al. reported reasonable bacterial control with 2.0 ppm total bromine in an 118,000 gallon *(447 m^3)* INDOOR POOL using BCDMH[348]. Normal day time BATHER COUNTS were around 0.21 persons per 500 gallons *(1893 L)* per hour but often increased to as high as 0.85 in the evening. The POOL did not use supplemental OXIDATION but did replace 5% of the water daily which likely contributed to the low reported ammonia nitrogen and organic nitrogen. Shaw reports a retrospective analysis of brominated and chlorinated semi-public SPAS in Alberta.[349] The data used was from the microbiological results of the weekly samples required under provincial regulations. The treatment systems compared include BCDMH *(OXIDATION method not specified)*, bromide salt regenerated by HOCl/potassium monopersulfate continuous feed, CHLORINE gas, hypochlorite *(type not specified)*, dichlor, and trichlor. The concentrations were generally in line with provincial regulations of 2 ppm *(mg/L)* total bromine and 1 ppm *(mg/L)* free CHLORINE. The brominated SPAS had a higher failure rate in all three bacterial parameters. There were several complaints of both contact dermatitis and *Pseudomonas* folliculitis from the brominated SPAS during the period studied, but due to the nature of the retrospective studies, it was not possible to link the reported RWIs to the concentration of

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346 White GC. 1999. Handbook of chlorination and alternative disinfectants. 4th ed.: John Wiley and Sons, Inc. New York.

347 Esterman A, et al. Determinants of the microbiological characteristics of South Australian swimming pools. Appl Environ Microbiol. 1984 February; 47(2): 325–328.

348Brown JR, et al. Bromine disinfection of a large swimming pool. Can J Public Health. 1964 Jun;55:251-6.

349Shaw JW. A retrospective comparison of the effectiveness of bromination and chlorination in controlling Pseudomonas aeruginosa in spas (whirlpools) in Alberta. Can J Public Health. 1984 Jan-Feb;75(1):61-8.

the disinfectant at the time of the complaint. It appears from composite data that when semi-public SPAS are operated using the U.S. EPA minimum halogen concentration of 1.0 ppm *(mg/L)* free CHLORINE or 2 ppm *(mg/L)* total bromine that *Pseudomonas aeruginosa* can be isolated from the brominated SPAS at greater than twice the frequency than from chlorinated SPAS.

Bromates

Ozone and bromide ions in water form HOBr and bromate ions. Bromates have been classified by the IARC as having sufficient evidence of carcinogenicity in laboratory animals. As a result, WHO has set a provisional drinking water guideline value of 10 ug/L. The U.S. EPA has established a maximum CONTAMINANT level of 10 ug/L for bromate in drinking water.

BCDMH *(1-bromo-3-chloro-5, 5-dimethylhydantoin)* is the most common form of bromine used in commercial POOLS and SPAS today. The function of DMH is to inhibit the formation of bromates.

At present there is little information on the functionality of using DMH in this manner. Since there is not a convenient field test kit available, an operator has no way of knowing what the DMH level is in the water or when it may go below 10 ppm *(mg/L)* to allow bromates to form. We also do not know what the maximum safe level of DMH should be. To rely on DMH for bromate prevention, suitable test methods and further research are necessary.

Operators should consider that ozone should likely not be used with bromine systems when there is a substantial likelihood of ingestion of the water. When ozone is used in conjunction with organic bromine sources *(BCDMH or DBDMH—another common source of bromine)*, the ozone readily converts residual bromide ion back to HOBr. This process reduces ozone. With the continued addition of BCDMH, DBDMH, or sodium bromide, the bromide levels will continue to climb in the POOL or SPA. Continuous build-up of bromide will constantly reduce ozone; diminishing ozone's effective OXIDATION *(and destruction)* of organics and microorganisms in the water. Because of the wide variation in the concentration of bromide and the potential for bromate ingestion at least one ozone manufacturer does not recommend the installation of ozone units in bromine-treated facilities.

Disinfection

DISINFECTION using bromine is more complex but less well documented than DISINFECTION using CHLORINE. HOBr is the putative biocidal chemical species at recreational water pH. HOBr reacts with inorganic ammonia and forms monobromamine, dibromamine, and nitrogen tribromide, depending on the pH and concentration of ammonia.[350] These inorganic bromamines are all considered more biocidal than their corresponding CHLORINE analogs. HOBr is converted to inert bromide ion upon biocidal action in a manner similar to that seen with HOCl. One key difference between bromine and CHLORINE DISINFECTION is that bromide is readily OXIDIZED back to HOBr and chloride is not. Further, HOBr is a

350 Galal-Gorchev H, et al. Formation and stability of bromamide, bromimide, and nitrogen tribromide in aqueous solution. Inorganic Chemistry. 1965;4(6):899-905.

much weaker OXIDIZER than HOCl. As a consequence of these two differences, exogenous OXIDATION of brominated waters *(e.g. shocking with CHLORINE)* is more important for safe operation than it is in chlorinated waters. In reviewing the published epidemiological studies on RWIs, it is often difficult to determine the exact treatment system used because the SUPPLEMENTAL TREATMENT SYSTEM is not described. Further, presently used field test kits assay only for total bromine and are not capable of distinguishing free bromine from biocidal inorganic bromamines or from non-biocidal organic bromamines.

Bromamines

Current POOL and SPA operating manuals state that combined bromine *(bromamines)* is as efficacious as free bromine. This may be an over generalization of the complex nature of bromine chemistry. Bromine reacts with inorganic ammonia and forms analogous compounds *(Br_2, HOBr, monobromamine, dibromamine, and nitrogen tribromamide)* depending on the pH and concentration of ammonia.[351] All three bromine-ammonia derivatives are biocidal, but all three are also less stable than their corresponding CHLORINE compounds. As with their CHLORINE analogs, the ratios of the bromamines are highly dependent on the ratio of ammonia to bromine. Further, at low ammonia to bromine ratios the biocidal action appears to be substantially reduced[352]. The levels of ammonia that result in loss of bromine efficacy have been detected in SPA water[353]. At these documented concentrations of bromine and ammonia, the predominant bromamine is most likely dibromamine, which has an estimated half-life of 10 minutes[354]. The MAHC was not able to locate data on the efficacy of organic bromamines.

Future Research Needs

Cryptosporidium Inactivation

Methods to hyper-brominate recreational water in response to diarrheal fecal accidents have not been established. Research in this area is lacking.

Bromine Associated Rashes

Note to readers: These comments have been inserted to point future researchers toward an under-investigated area of public health and are not meant to imply a negative bias toward bromine.

Literature reviews demonstrate a large number of reports describing rashes associated with brominated water. These rashes fall into two general categories:

- Contact dermatitis due to brominated species in the water, and

351 Galal-Gorchev H, et al. Formation and stability of bromamide, bromimide, and nitrogen tribromide in aqueous solution. Inorganic Chemistry. 1965;4(6):899-905.
352 Wyss O, et al. The germicidal action of bromine. Arch Biochem. 1947 Feb;12(2):267-71.
353 Kush BJ, et al. A preliminary survey of the association of Pseudomonas aeruginosa with commercial whirlpool bath waters. Am J Public Health. 1980 Mar;70(3):279-81.
354 Johnson JD, et al. Bromine and bromamine disinfection chemistry. J of Sanitary Engineering Division Am Soc of Civil Eng, 1971;97:617-628.

- Dermal infections due to *Pseudomonas aeruginosa*.

These are most easily differentiated by incubation time. The vast majority of contact dermatitis reactions occur within 24 hours of immersion, sometimes within minutes. These are often referred to as “bromine itch” and are widely reported in the medical literature[355, 356, 357]. In most cases the putative etiological agent is thought to be bromamines. This type of dermatitis appears to be a result of cumulative exposure to bromine treated water and is particularly prevalent among medical personnel who provide aquatic physical therapy[358]. The exact compounds inducing contact dermatitis have not been identified. One study strongly suggests that the use of bromine with supplemental OXIDATION minimizes contact dermatitis[359]. In numerous epidemiological studies, poor water quality is commonly, but not always, reported *(Woolf and Shannon report an extreme example of a foamy POOL leading to multiple cases of contact-related RWI[360])*. The typical incubation period for *Pseudomonas aeruginosa* folliculitis is several days but can be as short as 24 hours. Outbreaks of *Pseudomonas aeruginosa* folliculitis are routinely associated with inadequate sanitation in both chlorinated and brominated waters. The minimum concentration to prevent such outbreaks has not been established but appears to be at least one ppm *(mg/L)* free CHLORINE and two ppm *(mg/L)* total bromine. A survey of the literature since the mid-1980s shows more dermal RWI outbreaks reported in brominated waters than in chlorinated waters. It is not known whether the reports reflect the true incidence, a bias in reporting of bromine systems, or a bias in reporting RWIs in SPAS, which tend to use bromine disinfectants.

There are many unanswered questions surrounding bromine-treatment systems commonly used in AQUATIC VENUE DISINFECTION. After reviewing the literature, the MAHC has concluded the following research is essential to understanding bromine DISINFECTION.

Further research needs to address, in priority order:

- The efficacy of bromine to establish a minimum concentration for AQUATIC VENUES and warm water SPAS and THERAPY POOLS,
- The maximum bromine concentration that should be allowed,
- The contribution of bromamines to DISINFECTION and BATHER rashes,
- Methods to better control bromamines,
- Creation of a test kit to differentiate free bromine from combined *(as is currently practiced with CHLORINE)* in the water,
- Use of DMH in respect to bromate formation,

355 Rycroft RJ, et al. Dermatoses associated with brominated swimming pools. Br Med J (Clin Res Ed). 1983 Aug 13;287(6390):462.
356 Fitzgerald DA, et al. Spa pool dermatitis. Contact Dermatitis. 1995 Jul;33(1):53.
357 Loughney E, et al . Irritant contact dermatitis due to 1-bromo-3-chloro-5,5-dimethylhydantoin in a hydrotherapy pool. Risk assessments: the need for continuous evidence-based assessments. Occup Med (Lond). 1998 Oct;48(7):461-3.
358 Lazarov A, et al. Self-reported skin disease in hydrotherapists working in swimming pools. Contact Dermatitis. 2005 Dec;53(6):327-31.
359 Kelsall HL, et al. Skin irritation in users of brominated pools. Int J Environ Health Res. 2001 Mar;11(1):29-40.
360 Woolf A, et al. Reactive airways dysfunction and systemic complaints after mass exposure to bromine. Environ Health Perspect. 1999 Jun;107(6):507-9.

- Establish a safe maximum level,
- Creation of a test kit to establish levels in the water, and
- Fecal accident recommendations to control *Cryptosporidium* when using a bromine POOL.

5.7.3.1.2.3 Maximum Bromine Concentrations

Maximum bromine levels have been set to prevent exposure of BATHERS to high levels of bromine. Without an upper limit, very high levels may be present with no requirement to prohibit BATHERS from entering the water. Currently, the US EPA Office of Pesticides registers products and approves labels for bromine. Currently bromine products on the market for use in recreational water are registered with use levels ranging from 1-8 ppm (mg/L), depending on the product. At present time, no manufacturer specifies a level above 8.0 ppm.

5.7.3.1.3 Stabilizers

5.7.3.1.3.1 Cyanuric Acid

CYA is effective in protecting AVAILABLE CHLORINE from UV degradation. The chemical associates with CHLORINE to form chlorinated isocyanurates: trichlor *(trichloroisocyanuric acid)* and dichlor *(sodium dichloroisocyanururic acid)*. It can also be added as a separate chemical in the form of isocyanuric acid, commonly referred to as CYA. Trichlor is commonly found as tablets or sticks. Dichlor is a granular material, as is the isocyanuric acid.

Products containing or forming CYA must be clearly labeled and directions provided to the user for proper use, limitations, toxicity, cautions, and effects.

The most important factor in POOL DISINFECTION is the presence of sufficient levels of free CHLORINE. CYA helps maintain free CHLORINE levels in outdoor POOLS.

CYA is not a disinfectant, so it is not registered by the EPA. Stabilized CHLORINES are registered with the EPA as disinfectants; however, EPA has not reviewed efficacy data on CHLORINE in the presence of increasing stabilizer to date. The EPA reviewed efficacy data on dichlor and trichlor when it approved registrations for drinking water DISINFECTION. However, these data are not directly applicable to swimming POOLS where repeated doses lead to higher CYA levels.

Minimum Disinfection

Minimum CHLORINE levels should be increased by a factor of at least two when using CYA. Robinton et al. found that “50 mg/L of CYA produced pronounced retardation of the bactericidal efficiencies of solutions of calcium hypochlorite, trichloroiso-cyanuric acid, and potassium dichloroisocyanurate such that a four- to eightfold increase in the amount of "free" available residual CHLORINE may be necessary to attain the same degree of inactivation of the same organisms in the same interval of time"[361].

Laboratory studies by Warren and Ridgway show that addition of 50 mg/L CYA to 0.5 - 1.0 mg/L AVAILABLE CHLORINE resulted in a significant increase in the CT of *Staphylococcus aureus*, in parallel with the increase in AVAILABLE CHLORINE stability in sunlight. However, higher concentrations of CYA resulted in little to modest further increases in CT over that for 50 mg/L CYA. For example, the data suggest that for 50, 100 and 200 mg/L of CYA, the level of CHLORINE required for 99% kill of *Staphylococcus aureus* in one minute would be 1.9, 2.15, and 2.5 mg/L, respectively[362].

The MAHC has adopted a SAFETY factor of 2 so that 2 ppm is the minimum concentration of using stabilized products. More data are needed to understand the impact of increasing cyanurate levels on pathogen inactivation to assess what this level should be so the MAHC has adopted less than or equal to 100 ppm, as has the World Health Organization[363]. The maximum allowable CYA value was reduced from 100 ppm to 90 ppm to avoid the need for operators to make dilutions since 100 ppm is the maximum level measured in the test.

The level of cyanurate allowed in outdoor AQUATIC VENUES is double that for non-stabilized CHLORINE, which is a SAFETY factor for the decrease in oxidative capacity. The MAHC has decided that from a public health standpoint it cannot support a prohibition of the use of cyanurate in most INCREASED RISK AQUATIC VENUES. The SAFETY margin of two times the level of non-stabilized product would also apply for increased indoor settings in addition to the requirement for a SECONDARY DISINFECTION SYSTEM and therefore prohibition in an INCREASED RISK VENUE cannot, at this time, be supported with a public health argument. The exception to this is operation of SPAS and THERAPY POOLS, which have large issues with efficacy of agents against pathogens in biofilms and difficulties with maintaining needed pH levels *(spas)* and the use by INCREASED RISK groups of patients *(THERAPY POOLS)*. SPAS and THERAPY POOLS will, therefore, not be allowed to use CYA or stabilized CHLORINE products.

Users should be aware that if AQUATIC VENUES using CYA or stabilized CHLORINE products have a fecal incident, they will need to close for more prolonged periods for a diarrheal fecal incident and HYPERCHLORINATION, circulate water through a SECONDARY DISINFECTION SYSTEM, or replace the water in the AQUATIC VENUE per MAHC 6.5.3.2.1[364,365].

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361 Robinton ED, et al. An evaluation of the inhibitory influence of cyanuric acid upon swimming pool disinfection. Am J Public Health. 1967 Feb;57(2):301-10.
362 Warren IC, et al. Swimming pool disinfection. Investigations on behalf of the Department of the Environment into the practice of disinfection of swimming pools during 1972 to 1975. Water Research Centre, Henly-on-Thames, England, 35 pp., Oct 1978.
363 WHO. Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments. 2006. WHO Press, Geneva, Switzerland. Available at http://www.who.int/water_sanitation_health/bathing/bathing2/en/. Accessed on April 24, 2016.
364 Shields JM, et al. The effect of cyanuric acid on the disinfection rate of Cryptosporidium parvum in 20-ppm free chlorine. J Water Health. 2009 Mar;7(1):109-14.
365 Murphy JL, et al. Effect of cyanuric acid on the inactivation of Cryptosporidium parvum under hyperchlorination conditions. Environ Sci Technol. 2015;49(12):7348-55.

Indoor Pools

There appears to be no operational or public health reason for INDOOR AQUATIC VENUES to use CYA. It is a stabilizer for degradation from direct sunlight and so likely has limited benefits for indoor POOLS despite some operators claiming a benefit for indoor POOLS with large glassed areas. However, the level of FAC required in all AQUATIC VENUES using cyanurate or stabilized CHLORINE products is double that for non-stabilized CHLORINE, which was included to add a SAFETY factor for the decrease in oxidative capacity. The MAHC has decided that it cannot support, from a public health standpoint, a prohibition of the use of cyanurate in indoor settings. The SAFETY margin applies to all AQUATIC VENUES, including indoor settings. Prohibition in an indoor setting would require specific data on the direct impact in indoor settings since the MAHC allows it in outdoor settings.

CDC still does not recommend CYA use for indoor POOLS or hot tubs. The recommendation was underscored in a 2000 MMWR after investigating a *Pseudomonas dermatitis/folliculitis* outbreak associated with indoor POOLS and hot tubs in Maine, noting that CYA was added to an indoor POOL, which reduces the antimicrobial capacity of free CHLORINE[366,367].

Users should be aware that if AQUATIC VENUES using CYA or stabilized CHLORINE products have a fecal incident, they will need to close for more prolonged periods for a diarrheal fecal incident and HYPERCHLORINATION, circulate water through a SECONDARY DISINFECTION SYSTEM, or replace the water in the AQUATIC VENUE per MAHC 6.5.3.2.1 [368]. *Cryptosporidium* inactivation data collected in the presence of increasing quantities of CYA demonstrate that at 50 ppm or 100 ppm cyanurate do not reach 3-log inactivation in reasonable amounts of time.[369] See MAHC Annex 6.5.3.2.1 for more detailed discussion.

Effects of Cyanuric Acid on Microbial Inactivation

There are a large number of references on the effect of CYA on kill times (CT INACTIVATION VALUES). In general, they show that the presence of CYA increases CT INACTIVATION VALUES, and the amount of this increase depends on the pH and the ratio of CYA to AVAILABLE CHLORINE. However, there are few reports that relate specifically to the issue of what levels of AVAILABLE CHLORINE and CYA are required to maintain a swimming POOL in a biologically satisfactory state.

Studies examining the effect of CYA on the DISINFECTION capacity of CHLORINE show that using CYA or stabilized CHLORINE slows down the inactivation times on bacteria, algae, protozoa *(Naegleria gruberi and Cryptosporidium parvum)*, and viruses. Yamashita et al.

366 Fitzgerald GP, et al. Pseudomonas aeruginosa for the evaluation of swimming pool chlorination and algicides. Appl Microbiol. 1969 Mar;17(3):415-21.
367 CDC. Pseudomonas dermatitis/folliculitis associated with pools and hot tubs--Colorado and Maine, 1999-2000. MMWR Morb Mortal Wkly Rep. 2000 Dec 8;49(48):1087-91.
368 Shields JM, et al. The effect of cyanuric acid on the disinfection rate of Cryptosporidium parvum in 20-ppm free chlorine. J Water Health. 2009 Mar;7(1):109-14.
369 Murphy JL, et al. Effect of cyanuric acid on the inactivation of Cryptosporidium parvum under hyperchlorination conditions. Environ Sci Technol. 2015;49(12):7348-55.

concluded the addition of CYA increased the time needed for DISINFECTION of 12 virus types by a factor of 4.8-28.8 compared with free CHLORINE alone[370,371].

Table 5.7.3.1.3.1: 99.9% Inactivation time in buffer studies, 0.5 ppm (mg/L) FAC, 25 C

Organism	*No CYA, min*	*30 ppm (mg/L) CYA, min*
Poliovirus 1	0.8	5.6
Coxsackievirus A24	0.5	14.4
Enterovirus 70	0.12	2.5
Adenovirus type 3	0.14	2.1

Table 5.7.3.1.3.2: 99.9% Inactivation time in pool water studies, 1.0 ppm (mg/L) FAC, 25 C

Organism	*No CYA, min*	*30 ppm (mg/L) CYA, min*
Poliovirus 1	0.4	4.4

In a later study, Yamashita et al. [372] found "Total plate counts ranged from 0 to 1 per mL in the swimming POOLS treated with sodium hypochlorite and 0 to 51 in those with trichloroisocyanurates. In 11 of 12 water samples of 3 swimming POOLS using trichloroisocyanurates, poliovirus type 1 survived after 2 minute contact while in 5 samples poliovirus type 1 survived after 5 minute contact." The researchers concluded this showed that the risk of viral infection is greater in swimming POOL water treated with chlorinated isocyanurates than that with sodium hypochlorite.

The addition of CYA similarly impaired the inactivation of poliovirus[373]. CYA, used as CHLORINE stabilizer in swimming POOL waters, had a relatively minor effect on the algicidal efficiency of FREE CHLORINE[374]. There are few data regarding protozoa and the effect of

370 Yamashita T, et al. Influence of cyanuric acid on virucidal effect of chlorine and the comparative study in actual swimming pool waters. Kansenshogaku Zasshi. 1988 Mar;62(3):200-5.
371 Yamashita T, et al. Virucidal effect of chlorinated water containing cyanuric acid. Epidemiol Infect. 1988 Dec;101(3):631-9.
372 Yamashita T, et al. Microbiological and chemical analyses of indoor swimming pools and virucidal effect of chlorine in these waters. Nihon Koshu Eisei Zasshi. 1990 Dec;37(12):962-6.
373 Saita K, et al. Effects of isocyanuric acid on the polio virus inactivation with hypochlorous acid. Jpn. J. Toxicol. Environ. Health 1998;44:442–450.
374 Sommerfeld MR, et al. Influence of stabilizer concentration on effectiveness of chlorine as an algicide. Appl Environ Microbiol. 1982 Feb;43(2):497-9.

CYA on inactivation though the DISINFECTION rate for *Naegleria gruberi* was reduced by CYA in laboratory-controlled CHLORINE demand free conditions[375].

Shields et al.[376] extended the previous findings by demonstrating that CYA significantly decreases the rate of inactivation for *Cryptosporidium parvum* OOCYSTS. In this study a three-log reduction of OOCYSTS was found to take place in the presence of 20 ppm *(mg/L)* FAC. When 50 ppm *(mg/L)* CYA was introduced, the 10-hour kill rate was less than ½ log. Recent data show that 3-log inactivation of *Cryptosporidium* is possible with CYA concentrations of 15-16 ppm or less.[377] A 3-log inactivation could not be achieved with 50 ppm or 100 ppm CYA. A 1-log inactivation of OOCYSTS was achieved with 50 ppm cyanurate concentrations after an average contact time of 61.9 hours with 20 ppm FREE CHLORINE RESIDUAL, for an average estimated CT INACTIVATION VALUE for 1-log inactivation of 76,500 mg min/L. With 40 ppm FREE CHLORINE RESIDUAL and 50 ppm CYA, a 1-log inactivation of OOCYSTS was achieved after an average contact time of 17.2 hours, giving an average estimated CT INACTIVATION VALUE for 1-log inactivation of 40,000 mg•min/L. Increasing the concentration to 100 ppm CYA showed even more limited OOCYST inactivation, which did not differ much from natural decay curves for *Cryptosporidium* in water.

Pseudomonas inactivation in the presence of CYA was also studied in POOL water and it was found that increased CYA concentrations lengthened the kill times. The effect of CYA was greater as the concentration of CHLORINE in the water decreased[378].

Favero et al. found that at free CHLORINE concentrations of more than 0.5 ppm *(mg/L)*, *P. aeruginosa* was rarely found except in those POOLS which used sodium dichloroisocyanurate as a POOL disinfectant. Three private swimming POOLS using sodium dichloroisocyanurate as a POOL disinfectant were found to contain large numbers of the potential pathogen, *P. aeruginosa*[379]. Fitzgerald found concentrations of 25, 50, and 100 mg of CYA per liter had large effects on the *Pseudomonas* kill rate of 0.1 mg/L free CHLORINE but this effect diminished with increasing free CHLORINE content *(0.25, 0.5 mg/L)*. Fitzgerald found concentrations of 25, 50, and 100 mg of CYA per liter had little effect on the kill rate of 0.5 mg of CHLORINE plus 0.1 mg of NH4-N per liter; however, CYA did reduce the time required for 99.9% kills when tested in the presence of higher concentrations of ammonia[380]. The basis for this finding should be explored further.

Fecal Accident Response

375 Engel J P, et al. Inactivation of Naegleria gruberi cysts by chlorinated cyanurates. Appl Environ Microbiol. 1983;46:1157–1162.
376 Shields JM, et al. The effect of cyanuric acid on the disinfection rate of Cryptosporidium parvum in 20-ppm free chlorine. J Water Health. 2009 Mar;7(1):109-14.
377 Murphy JL, et al. Effect of cyanuric acid on the inactivation of Cryptosporidium parvum under hyperchlorination conditions. Environ Sci Technol. 2015;49(12):7348-55.
378 Woolf A, et al. Reactive airways dysfunction and systemic complaints after mass exposure to bromine. Environ Health Perspect. 1999 Jun;107(6):507-9.
379 Favero MS, et al. Use of staphylococci as indicators of swimming pool. Public Health Rep. 1964 Jan;79:61-70.
380 Fitzgerald GP, et al. Pseudomonas aeruginosa for the evaluation of swimming pool chlorination and algicides. Appl Microbiol. 1969 Mar;17(3):415-21.

The use of stabilized CHLORINE is not recommended for HYPERCHLORINATION in RWI outbreaks caused by *Cryptosporidium*, or in response to diarrheal fecal accidents. Present MAHC requirements for HYPERCHLORINATION and POOL remediation are ineffective for *Cryptosporidium* in AQUATIC VENUES using cyanurate-stabilized CHLORINE. CHLORINE stabilizers such as CYA slow DISINFECTION (see MAHC Annex 5.7.3.1.3.1 for more discussion); therefore, higher CHLORINE levels are necessary to reach the CT INACTIVATION VALUE for *Cryptosporidium* inactivation in POOLS that use CHLORINE stabilizers.[381] As the stabilizer concentration rises, parasite inactivation is inhibited to the point where inactivation is similar to natural decay of the parasite.[382] As a result, higher levels of stabilizer must be reduced in order to reach 3-log inactivation levels using HYPERCHLORINATION.

Recent data show that 3-log inactivation of *Cryptosporidium* is possible with CYA concentrations of 15-16 ppm or less.[383] A 3-log inactivation could not be achieved with 50 ppm or 100 ppm CYA. A 1-log inactivation of OOCYSTS was achieved with 50 ppm cyanurate concentrations after an average contact time of 61.9 hours with 20 ppm FREE CHLORINE RESIDUAL, for an average estimated CT INACTIVATION VALUE for 1-log inactivation of 76,500 mg min/L. With 40 ppm FREE CHLORINE RESIDUAL and 50 ppm CYA, a 1-log inactivation of OOCYSTS was achieved after an average contact time of 17.2 hours, giving an average estimated CT INACTIVATION VALUE for 1-log inactivation of 40,000 mg min/L. Increasing the concentration to 100 ppm CYA showed even more limited OOCYST inactivation, which did not differ much from natural decay curves for *Cryptosporidium* in water.

Because 3-log OOCYST inactivation was achieved with 16 ppm CYA and was not achieved with 50 ppm CYA, the remediation protocol must be conducted in water with ≤15 ppm CYA. If the CYA concentration is above 15 ppm, the POOL will need to be partially drained to reduce the concentration. Alternate methods of reducing the CYA concentration are acceptable, as long as test data shows that the CYA concentration is at or below 15 ppm.

Toxicity

The maximum CYA concentration of 90 ppm *(mg/L)* should be considered protective from a toxicological perspective. Using an assumption that 100 mL of POOL water is swallowed per swim session; the World Health Organization *(WHO)* concluded that CYA levels in POOLS should be below 117 ppm *(mg/L)*. This is based on a tolerable daily intake *(TDI)* for anhydrous sodium dichloroisocyanurate *(NaDCC)* of 2 mg/kg of body weight, which translates into an intake of 20 mg of NaDCC (or 11.7 mg of CYA per day) for a 10 kg child. The U.S. EPA SWIMODEL, relying on somewhat lower exposure assumptions, would yield a higher acceptable level for CYA.

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381 Shields JM, et al. The effect of cyanuric acid on the chlorine inactivation of Cryptosporidium parvum. J Water Health 2008;6 (4):513-20.
382 Murphy JL, et al. Effect of cyanuric acid on the inactivation of Cryptosporidium parvum under hyperchlorination conditions. Environ Sci Technol. 2015;49(12):7348-55.
383 Murphy JL, et al. Effect of cyanuric acid on the inactivation of Cryptosporidium parvum under hyperchlorination conditions. Environ Sci Technol. 2015;49(12):7348-55.

Research

Though the data shows CYA use increases the inactivation time of many pathogens, the MAHC would like to have a study done on specific pathogens and inactivation rates at differing CYA levels, up to at least 200 ppm *(mg/L)*. New *Cryptosporidium* inactivation data demonstrate that, at higher levels of cyanurate, inactivation is similar to natural die off rates.[384] Further research on the inhibitory effect of CYA on DISINFECTION should evaluate the level at which CYA can still protect CHLORINE from UV and also balance the inactivation rate of the most common AQUATIC VENUE pathogens. The effect of pH in the presence of CYA should also be investigated. Additionally, a test kit should be created to test lower and higher levels of CYA. The current products on the market are not very accurate and need to operate over a wider range of CYA levels. During RWI outbreaks, it is strongly recommended that the investigation team measure CYA levels.

5.7.3.1.4 Compressed Chlorine Gas

Installation/use of compressed CHLORINE gas is prohibited for new AQUATIC FACILITIES; however there are existing facilities that continue to use these gas systems. Because of the potential hazard, it is important that existing facilities meet STORAGE, ventilation, handling, and operator training requirements if use is to continue. If these requirements are not met, use must be discontinued and a properly designed/sized and approved disinfectant system installed.

The following design criteria from an existing health CODE provide additional details for consideration when evaluating acceptability of an existing compressed gas installation.

- ***Location.*** The chlorinator room shall be located on the opposite side of the POOL from the direction of the prevailing winds. CHLORINE STORAGE and chlorinating equipment shall be in a separate room. This room shall be at or above grade.
- ***Venting.*** The CHLORINE room shall have a ventilating fan with an airtight duct beginning near the floor and terminating at a safe point of discharge to the out-of-doors. A louvered air intake shall be provided near the ceiling. The ventilating fan shall provide one air change per minute and operate from a switch located outside the door.
- ***Door.*** The door of the chlorinator room shall not open to the swimming POOL, and shall open outward directly to the exterior of the building. The door shall be provided with a shatterproof inspection window and should be provided with "panic hardware."
- ***Chlorine cylinders.*** CHLORINE cylinders shall be anchored. The cylinders in use shall stand on a scale capable of indicating gross weight with one-half pound accuracy. STORAGE space shall be provided so that CHLORINE cylinders are not subjected to direct sunlight. STORAGE space shall be in an area inaccessible to the general public.
- ***Injection location.*** Mixing of CHLORINE gas and water shall occur in the CHLORINE room, except where vacuum-type chlorinators are used.

384 Murphy JL, et al. Effect of cyanuric acid on the inactivation of Cryptosporidium parvum under hyperchlorination conditions. Environ Sci Technol. 2015;49(12):7348-55.

- ***Backflow.*** The chlorinators shall be designed to prevent the BACKFLOW of water or moisture into the CHLORINE gas cylinder

5.7.3.1.5 Salt Electrolytic Chlorine Generators, Brine Electrolytic Chlorine or Bromine Generators

In-line generators shall use only POOL-grade salt dosed into the POOL to introduce CHLORINE into the POOL vessel through an electrolytic chamber to avoid potential health risks associated with DISINFECTION byproducts forming from salt impurities, including bromide and iodide. For example, Kristensen et al. directly correlated bursts of bromodichloro-methane formation to salt addition to POOL water over a MONITORING period of more than one year.[385] In a comparison study of common disinfectant methods, Lee et al. found salt brine electrolysis formed the highest levels of bromodichloro-methane, dibromochloro-methane and bromoform.[386] Zwiener et al. noted that iodized table salt should not be used in salt POOLS because iodized DISINFECTION byproducts, which are generally more toxic than chlorinated DISINFECTION byproducts, could form. [387] Additionally, there is a perception by some that salt water POOLS can be operated with table salt *(which is commonly iodized)*.

5.7.3.2 Secondary or Supplemental Treatment Systems

Due to the risk of outbreaks of RWIs associated with halogen-tolerant pathogens such as *Cryptosporidium*, it is strongly recommended that all AQUATIC FACILITIES include SECONDARY DISINFECTION SYSTEMS to minimize the risk to the public associated with these outbreaks.

All existing regulations covering fecal events or detection of pathogens must still be adhered to when SECONDARY DISINFECTION SYSTEMS are utilized. SECONDARY DISINFECTION SYSTEMS can only minimize the risk and are not a guarantee of treatment due to the possibility of cross contamination of the POOL or water feature and the time required to pass the entire volume of water through the treatment process.

As the general effectiveness of a SECONDARY DISINFECTION SYSTEM is affected by the AQUATIC VENUE TURNOVER RATE and mixing/circulation within the AQUATIC VENUE, the MAHC requirements for filter recirculation and TURNOVER RATES must be followed. The performance of SECONDARY DISINFECTION SYSTEMS will be enhanced when the shortest TURNOVER times are achieved for any particular type of AQUATIC FACILITY.

The use of certain types of AQUATIC VENUES presents an increased risk of RWI to users. These AQUATIC VENUES include THERAPY POOLS, WADING POOLS, SPRAY PADS, swim schools, INTERACTIVE WATER PLAY AQUATIC VENUES, and AQUATIC FEATURES. Given that users of these types of facilities frequently have naive immune systems *(e.g., children less than*

385 Kristensen GH, et al. On-line monitoring of the dynamics of trihalomethane concentrations in a warm public swimming pool using an unsupervised membrane inlet mass spectrometry system with off-site real-time surveillance. Rapid Commun Mass Spectrom. 2010 Jan;24(1):30-4.
386 Lee J, et al . Characteristics of trihalomethane (THM) production and associated health risk assessment in swimming pool waters treated with different disinfection methods. Sci Total Environ. 2009 Mar 1;407(6):1990-7.
387 Zwiener C, et al. Drowning in disinfection byproducts? Assessing swimming pool water. Environ Sci Technol. 2007 Jan 15;41(2):363-72.

five years of age), higher prevalence of disease *(e.g., children less than five years of age and older adults)*, compromised immune systems, or open wounds, additional precautions against RWIs are warranted.

CDC data on public AQUATIC VENUES indicate disinfectant violations were identified during 9.2% of POOL, 19.2% of SPA, 19.2% WADING POOL, and 10.1% of INTERACTIVE WATER PLAY VENUE routine inspections[388].

The use of INTERACTIVE WATER PLAY AQUATIC VENUES has previously been associated with outbreaks of gastroenteritis. In 1999, an estimated 2,100 people became ill with *Shigella sonnei* and/or *Cryptosporidium parvum* infections after playing at an "interactive" water fountain at a beachside park in Florida[389].

In one of the largest outbreaks reported, approximately 2,300 persons developed cryptosporidiosis following exposure to a New York spray park. The environmental investigation revealed that filtration and DISINFECTION of the recycled water were not sufficient to protect the PATRONS from this disease. In response, emergency legislation was passed, which required the installation of SECONDARY DISINFECTION *(e.g., UV radiation or ozonation)* on water returning through the sprayers[390].

5.7.3.2.1 Ultraviolet Light

5.7.3.2.1.2 3-log Inactivation

Records of the correct calibration, maintenance, and operation of SECONDARY DISINFECTION SYSTEMS should be maintained by the facility's management.

5.7.3.2.1.4 Calibrated Sensors

Owners/operators need to consult the unit manual and the manufacturer's manual for guidance on how to accomplish this and who is qualified to do so.

5.7.3.2.3 Copper / Silver Ions

EPA has set current drinking water STANDARDS at 1.3 ppm for copper and 0.10 ppm for silver, which are generally accepted in the states that have requirements for this treatment. These ion generation systems are not meant to replace disinfecting halogen and the minimum levels must continue to be provided.

The manufacturer's recommended procedures should be followed to avoid the potential of staining, and operating the POOL with copper levels outside the recommended range may cause staining. Copper-based algaecides should not be used in these systems since

388 CDC. Immediate closures and violations identified during routine inspections of public aquatic facilities - network for aquatic facility inspection surveillance, five states, 2013. MMWR Surveill Summ. 2016 May 20;65(5):1-26.
389 CDC. Outbreak of gastroenteritis associated with an interactive water fountain at a beachside park--Florida, 1999. MMWR Morb Mortal Wkly Rep 2000;49:565-8.
390 CDC. Surveillance for waterborne disease and outbreaks associated with recreational water use and other aquatic facility-associated health events--United States, 2005-2006. MMWR Surveill Summ 2008;57:1-29.

use of these products increase the level of copper in the POOL and increases the potential to cause health effects or stain surfaces.

In addition, studies have shown that the presence of copper in POOL water has a catalytic effect on the formation of THMs[391].

5.7.3.3 Other Sanitizers, Disinfectants, or Chemicals

The MAHC has opted to not include lists of disinfectants that should not be used in AQUATIC VENUES versus just saying that they must not pose a hazardous issue with the CHLORINE or bromine disinfectants in use and that all water quality criteria must be met.

PHMB

Polyhexamethylene biguanide hydrochloride *(PHMB)* is a polymeric antimicrobial that has been used as an alternative to CHLORINE and bromine. PHMB is often referred to as biguanide in the industry. The formal name for PHMB on US EPA accepted labels is "Poly *(iminoimidocarbonyliminoimido-carbonyl iminohexamethylene)* hydrochloride". The U.S. EPA has registered PHMB for use in POOLS and SPAS as a "SANITIZER" with label directions requiring that the concentration be maintained between 30 and 50 ppm *(mg/L)* as product *(6 to 10 ppm (mg/L) of active ingredient)*.

PHMB is not an OXIDIZER and must be used in conjunction with a separately added product. Hydrogen peroxide is the strongly preferred OXIDIZER.

The vast majority of the PHMB used in POOLS and SPAS is in private residences but a limited number of public facilities have used PHMB.

Because of its limited use in public AQUATIC FACILITIES, there are few independent studies on the efficacy of PHMB in recreational water. Studies report that the rate of kill of bacteria is slower than that of CHLORINE under laboratory conditions. However, the U.S. EPA found that manufacturer's generated data demonstrated adequate efficacy under the EPA guideline DIS/TSS-12 to grant registration under FIFRA and without regard to whether the facility is public, semi-public, or private. As part of their registration process, the US EPA does not distinguish between public and private facilities. The efficacy data analyzed by the U.S. EPA is company confidential and has not been reviewed as part of the development of the MAHC.

There are no known published studies of the efficacy of PHMB against non-bacterial POOL and SPA infectious agents *(e.g. norovirus, hepatitis A, Giardia sp., Cryptosporidium spp.)*, under use conditions. PHMB is generally compatible with both UV and ozone, but both UV and ozone will increase the rate of loss of PHMB. Since SECONDARY DISINFECTION SYSTEMS require the use of a halogen as the primary disinfectant, the use of PHMB, even with a secondary system is problematic.

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391 Blatchley ER, et al. Copper catalysis in chloroform formation during water chlorination. Wat Res 2003;37:4385-4394.

PHMB **IS NOT** compatible with CHLORINE or bromine. POOLS using PHMB have a serious treatment dilemma for control of *Cryptosporidium* after a suspected outbreak or even a diarrheal fecal accident. The addition of a 3 ppm *(mg/L)* of CHLORINE to a properly maintained PHMB-treated POOL results in the precipitation of the PHMB as a sticky mass on the POOL surfaces and in the filter. Removal of the precipitated material can be labor intensive.

Testing for PHMB requires special test kits. Conventional kits for halogens are not suitable. PHMB test kits are readily available at most specialty retail POOL stores and on-line.

Hydrogen Peroxide

Hydrogen peroxide is not registered by the U.S. EPA as a disinfectant for recreational water. Since it is not registered, the use of hydrogen peroxide as a recreational water disinfectant, or any market claims that implies hydrogen peroxide provides any biological control in recreational water is a violation of FIFRA. Hydrogen peroxide has been granted registration by the U.S. EPA as a hard surface disinfectant and several other applications. The U.S. EPA Registration Eligibility Document *(RED)* on hydrogen peroxide is available from the EPA website at https://archive.epa.gov/pesticides/reregistration/web/pdf/4072fact.pdf. The U.S. EPA posts PDF copies of accepted product labels on the National Pesticide Information Retrieval System website (http://ppis.ceris.purdue.edu/#.) Product claims for uses and concentration may be verified by reading the PDF of the U.S. EPA stamped and accepted copy of the product use directions at this website.

When used as a hard surface disinfectant, hydrogen peroxide is normally used at around 3%. When used in recreational water, hydrogen peroxide is used at 27 to 100 ppm *(mg/L)*, which is 1111 and 300 times, respectively, more dilute than that used on hard surfaces. Borgmann-Strahsen evaluated the antimicrobial properties of hydrogen peroxide at 80 and 150 ppm *(mg/L)* in simulated POOL conditions.[392] Whether 150 ppm *(mg/L)* of hydrogen peroxide was used by itself or in combination with 24 ppb of silver nitrate it had negligible killing power against *Pseudomonas aeruginosa, E. coli. Staphylococcus aureus, Legionella pneumophila* or *Candida albicans*, even with a 30 minute contact period. In the same tests, the sodium hypochlorite controls displayed typical kill patterns widely reported in literature. Borgmann-Strahsen concluded that hydrogen peroxide, with or without the addition of silver ions, was, "no real alternative to CHLORINE-based DISINFECTION of swimming pool water from the microbiological point of view."

5.7.3.3.1 Chlorine Dioxide

Chlorine dioxide is not presently registered by the U.S. EPA for any use in recreational water. Since it is not registered, the use of chlorine dioxide as an antimicrobial treatment *(e.g. disinfectant, SANITIZER, algaecide, slimicide, biofilm control agent)* in recreational water, or any market claims that implies chlorine dioxide provides any biological control in recreational water is a violation of FIFRA. Chlorine dioxide has been granted

392 Borgmann-Strahsen, R. Comparative assessment of different biocides in swimming pool water, International Biodeterioration and Biodegradation 2003;51:291-297.

registration by the U.S. EPA as an antimicrobial for other applications, including drinking water. One product was previously registered as a slimicide for use in PHMB-treated recreational water but that registration has since been dropped. The U.S. EPA Registration Eligibility Document *(RED)* on chlorine dioxide is available from the US EPA website at https://archive.epa.gov/pesticides/reregistration/web/pdf/chlorine_dioxide_red.pdf.

The U.S. EPA posts PDF copies of accepted product labels on the National Pesticide Information Retrieval System website (http://ppis.ceris.purdue.edu/#). Product claims for uses and concentration may be verified by reading the PDF of the U.S. EPA stamped and accepted copy of the product use directions at this website.

Chlorine dioxide has the potential to be an alternative remediation tool, but it has not yet been approved by EPA for this use and can be hazardous unless appropriate SAFETY protocols are included. CDC has determined that chlorine dioxide can be used instead of HYPERCHLORINATION for rapid inactivation of *Cryptosporidium* (3-log inactivation in 105 to 128 minutes) and that this effect was synergistically enhanced with a FREE CHLORINE RESIDUAL in place.[393] This suggest chlorine dioxide might be very useful in remediating contaminated AQUATIC VENUES in the absence of BATHERS.

Potential for Using Chlorine Dioxide in the Future

During the drafting of this section of the MAHC, several members of the MAHC had interest in using chlorine dioxide as a remedial treatment for *Cryptosporidium* and *Legionella*. Published studies, including the *EPA Alternate Disinfection Manual* for drinking water shows that chlorine dioxide may be a very rapid remedial treatment for these life-threatening pathogens. If the EPA registration status of chlorine dioxide changes, the MAHC suggests that chlorine dioxide use should be reconsidered.

Provisions for Emergency Use of Chlorine Dioxide

Even though chlorine dioxide is not presently registered for use in recreational water, it is possible to use it under Section 18 of FIFRA. An example of this would be the remediation of a *Legionella*-contaminated health club SPA where other treatments were proven to be ineffective. More information on emergency exemptions can be found on the U.S. EPA website at http://www.epa.gov/opprd001/section18/. Because of the lack of existing use directions and potential for occupational exposure, it is strongly suggested that a certified industrial hygienist be included in developing emergency treatment plans.

5.7.3.3.2 Clarifiers, Flocculants, and Defoamers

POOLS and SPAS may benefit from the use of one or more of these types of products. There are numerous brands available that are formulated for commercial POOLS and SPAS. Each product is marketed for a specific procedure. Each may contain one or more natural or synthetic polymers, chemical or metallic ingredients. Neither the efficacy nor the SAFETY

393 Murphy JL et al. Efficacy of chlorine dioxide tablets on inactivation of *Cryptosporidium* oocysts. Environ Sci Technol. 2014;48(10):5849-5856.

of product chemistry of these products has been reviewed by the US EPA or any other federal agency. The state of California does require submission of a detailed data package prior to registration. Products sold in the state of California must have the state registration number on the label. Products registered in California but sold outside of the state usually, but are not required to, have the California registration number on the label. Any local agency concerned about a particular product could request the producer supply the California registration number and then verify the status of the product with the California Department of Pesticide Regulation.

5.7.3.4 pH

There are three reasons to maintain pH:

- Efficacy of the CHLORINE,
- BATHER comfort, and
- Maintenance of balanced water.

Each of these reasons are discussed briefly below:

Efficacy of Chlorine

The efficacy of CHLORINE/HOCl is dramatically impacted by pH and therefore pathogen inactivation can be severely affected by higher pH levels where only a small percentage of FREE CHLORINE is active. Lower pH levels below this range allow a greater percentage of FREE CHLORINE to be “active”. Further data are needed to ensure that lower levels *(e.g., 6.8 to 7.2)* do not adversely impact membranes, particularly eyes. The present practice of maintaining the pH between 7.2 and 7.8 has been developed by coupling physical chemistry with empirical observations. There is no definitive peer-reviewed study that extensively covers the subject of pH in POOL and SPA water except those showing the titration of HOCl and the importance of pH for assuring maximal efficiency. The best general authority is the 1972 edition of the Handbook of Chlorination by Geo. Clifford White. The 1972 edition of this widely recognized authority on CHLORINE chemistry is the only edition that has a chapter especially on POOLS. Much, but not all, of the POOL chemistry chapter can be found in subsequent editions. Copies of the 1972 edition are difficult to locate in libraries but are available for sale on the internet as of July 2009. The discussion on efficacy and BATHER comfort is a summary of the 1972 edition discussion on pH.

CHLORINE used in POOLS refers to HOCl, a weak acid that readily dissociates to form hypochlorite *(OCl-)* and hydrogen ion *(H+)*. The mid-point of the dissociation *(the pKa)* is at pH 7.5. Functionally, this means that at pH of 7.5, 50% of the FREE CHLORINE present will be in the form of HOCl and 50% will be in the form of hypochlorite. As the pH decreases below 7.5, the proportion of HOCl increases and proportion of hypochlorite ion decreases. The opposite occurs as the pH increases above 7.5. Numerous investigators have reported that HOCl is approximately 100 times more effective at killing microorganisms than the hypochlorite ion. Thus from a public health perspective, it is desirable to maintain the pH so as to maximize the portion of HOCl portion of the FREE CHLORINE present in the water.

Bather Comfort

As BATHERS enter the water, their skin and eyes come into direct contact with the water and its constituent components. In general, the eyes of BATHERS are more sensitive to irritation than the skin. Studies on the sensitivity of BATHERS' eyes to pH changes of the water show wide variations in tolerance limits. The tolerance of the eye to shifts in pH is also impacted by the concentration of FREE CHLORINE, combined CHLORINE, and alkalinity. Under normal POOL conditions, the optimum limits for BATHER comfort appears to be from pH 7.5 to 8.0.

Potential for Lowering pH in the Future

During the review of the data, the MAHC had a broad interest in lowering the minimum pH. This would increase the efficacy of the CHLORINE by increasing the proportion of HOCl *(at the expense of hypochlorite)* and thus increase DISINFECTION efficacy. This was not recommended because of the lack of data on the impact on BATHERS, particularly the eyes. If additional information on the impact of lower pH on BATHERS' skin and eyes is developed, the MAHC suggests that the acceptable range for pH be reexamined. As part of the reexamination, consideration should also be made concerning how this change will impact the water balance and any possible negative impact on the facility.

5.7.3.5 Feed Equipment

The Chlorine Institute has checklists and guidance for working with compressed CHLORINE gas at: http://chlorineinstitute.org/stewardship/ci-checklists.cfm.

5.7.3.7 Automated Controllers and Equipment Monitoring

5.7.3.7.7 Ozone System

As a SECONDARY DISINFECTION SYSTEM, it is critical to monitor the system to ensure it is performing as required.

Table 5.7.3.7.7: Ozone System Monitoring Frequency

Parameter	Monitoring Frequency	Recording Frequency
ORP	Continuous	Every 4 hours
Control System Indicating O_3 Being Created	Continuous	Every 4 Hours
Operational Indicators in Range	Continuous	Every 4 hours
O_3 Within 6 inches of Aquatic Venue Water Surface	Annual	Annual

5.7.3.7.8 UV System

As a SECONDARY DISINFECTION SYSTEM, it is critical to monitor the system to ensure it is performing as required.

Table 5.7.3.7.8: UV System Monitoring and Calibration Frequency

Parameter	Monitoring Frequency	Recording Frequency
Flow Rate	Continuous	Every 4 Hours
Intensity	Continuous	Every 4 Hours
Water Temperature *(MP Medium Pressure)*	Continuous	Daily
Set Point for Intensity	Continuous	Daily
UV Lamp On/Off Cycles	Continuous	Weekly *(Total Cycles/Week)*
Iron, Calcium Hardness	Weekly *(If Fouling is Prevalent)*	Weekly
UVT *(UV Transmittance)* **Analyzer Calibration**	Weekly	Weekly
Calibration of Intensity	Annual	At Time of Calibration
Calibration of Flow Meter	Per Manufacturer's Requirements	At Time of Calibration

5.7.4 Water Sample Collection and Testing

5.7.4.3 Bulk Water Sample

When collecting samples from AQUATIC VENUE, an 18-inch *(45.7 cm)* water depth for sample collection is recommended. Both the National Swimming Pool Foundation *(NSPF)* Certified Pool Operator Manual and the National Recreation and Park Association *(NRPA)* Aquatic Facility Operator Manual instruct the operator to reach at least 18 inches

(45.7 cm) below the water's surface to collect the water sample. In an outdoor POOL, there is chemical interaction with UV light at the surface which will affect the reading. Most of the chemical CONTAMINANTS in a POOL are located within the top 18 inches *(45.7 cm)*, which is why most studies of POOL CONTAMINANTS are performed by collecting samples at a depth of less than or equal to 30 centimeters *(11.8 inches)* below the POOL water surface[394,395]. These CONTAMINANTS will give false pH and DISINFECTANT readings in indoor and outdoor AQUATIC VENUES. To sample, plunge the assembly *(mouth first)* quickly to the marked depth, invert, and let the bottle fill. Remove when full of water and begin testing.

A consistent sampling point is important and this sampling point is the feed into the ORP controller which is required by section 5.7.3.7.1.However, the purpose of the samples in section 5.7.4.3 is to ensure that the disinfectant feed settings based off of the ORP are sufficient to ensure that there is a disinfectant residual throughout the POOL at all times BATHERS are present. Since there is usually a higher concentration of BATHERS (and hence BATHER load) in the shallow end, it is especially important to get samples from that area. In other words, the fixed sampling point of the ORP controller provides the variation over time (temporal variation), while the rotating sample points provide the spatial variation. It is important to cover both kinds (temporal and spatial) of variation.

5.7.4.4 Aquatic Venue Water Chemical Balance

Water balance is a term used to describe the tendency of water to dissolve *(corrode)* or deposit minerals *(form scale)* on surfaces contacted by the water. Balanced water will neither corrode surfaces nor form scale. Factors that impact water balance are pH, hardness, alkalinity, dissolved solids, and temperature. The presently used water balance parameters are used to protect AQUATIC VENUE equipment and surfaces from deleterious effects of corrosion and scale formation. Improperly balanced water is not in itself a threat to public health. Water balance is expressed in several ways but the most common one is by the SATURATION INDEX. Each factor in the SATURATION INDEX equation can vary within a limited range and the water is still considered balanced. Shifts in pH have a significant impact on water balance. Water balance chemistry is discussed extensively in all POOL operator classes and is well beyond the scope of this Annex.

5.7.4.4.1 Total Alkalinity Level

Total alkalinity is closely associated with pH, but rather than a measure of hydrogen ion concentration, it is a measure of the ability of a solution to neutralize *(buffer)* hydrogen ions. Expressed in parts per million *(ppm)*, total alkalinity is the result of alkaline materials including carbonates, bicarbonates and hydroxides - mostly bicarbonates. As noted in the MAHC, the ideal range is 60 ppm to 180 ppm. This acid neutralizing *(buffering)* capacity of water is desirable because it helps prevent wide variations in pH *(pH bounce)* whenever small amounts of acid or alkali are added to the POOL. Total alkalinity is a measure of

394 De Laat J, et al. Concentration levels of urea in swimming pool water and reactivity of chlorine with urea. Water Research, 2011, 45(3) 1139-1146.
395 Weaver, et al. (2009) Volatile disinfection by-product analysis from chlorinated indoor swimming pools. Water Research, 43(13):3308-3318.

water's resistance to change in pH and is a source of rising pH itself from the outgassing of carbon dioxide.

Too Low

If total alkalinity is too low: pH changes rapidly when chemicals or impurities enter the water. pH may drop rapidly when using net acidic sources of CHLORINE or other acidic chemicals *(e.g. Trichlor (trichloro-s-triazinetrione), Dichlor (sodium dichloro-s-triazinetrione), potassium monopersulfate)*, causing etching and corrosion.

Raising Total Alkalinity

Total alkalinity can be raised by the addition of bicarbonate of soda *(sodium bicarbonate, baking soda)*. 1.4 lbs. bicarbonate of soda per 10,000 gallons *(635.0 g per 37,854.1 L)* will raise total alkalinity approximately 10 ppm.

Too High

If total alkalinity is too high: pH becomes difficult to adjust. High pH often occurs causing other problems, such as cloudy water, decreased disinfectant effectiveness, scale formation, and filter problems. The higher the total alkalinity, the more resistant the water is to large changes in pH in response to changes in the dosage of disinfectant and pH correction chemicals. If the total alkalinity is too high, it can make pH adjustment difficult.

Lowering Total Alkalinity

Add acid - The acid reacts with bicarbonates in the water and reduces the total alkalinity. Add 1.6 pounds of Dry Acid *(Sodium Bisulfate)* per 10,000 gallons of water, or 1.3 quarts of Muriatic Acid, to decrease the Total Alkalinity by 10 ppm. Retest and adjust the pH.

High levels of CYA will cause interference in the total alkalinity test. This interference is magnified at low levels of total alkalinity. To correct for CYA interference, measure the concentration of CYA, divide that number by 3, and then subtract that value from the measured total alkalinity value.

Minor deviations from the alkalinity levels stated in the CODE do not in themselves present imminent health threats to the BATHERS. As such, minor deviations in alkalinity levels do not require the immediate closure of the facility. Rather, deviations from permissible alkalinity levels indicate poor management of the water balance and should indicate a need for a thorough inspection of the entire facility.

5.7.4.4.2 Combined Chlorine (Chloramines)

Combined CHLORINE compounds *(chloramines)* are formed when FAC combines with amine-containing compounds such as urea, amino acids, and ammonia from perspiration and urine. Chloramines include inorganic compounds *(monochloramine (NH_2Cl), DICHLORAMINE ($NHCl_2$) and TRICHLORAMINE (NCl_3))* as well as a variety of organic compounds. Inorganic chloramines are biocides, but are much less effective as quick kill disinfectants than FAC. If the local water treatment plant uses chloramination for drinking water DISINFECTION, inorganic chloramines *(predominantly monochloramine)* may be present in the fill water.

High Chloramines

A high level of chloramines is undesirable in AQUATIC VENUES. The action level for combined CHLORINE is 0.4 ppm *(mg/L)*. Higher levels indicate that BATHER loads or pollution from BATHERS may be too high, or that treatment is inadequate. Higher levels may also pose a health concern to BATHERS, employees, and other PATRONS.

The World Health Organization recommends that combined CHLORINE levels be "as low as possible, ideally below 0.2 mg/L"[396]. However, this "ideal" level would be challenging to implement as a CODE requirement. Since the combined CHLORINE values reflect the combination of inorganic *(well demonstrated health effects)* and organic *(poorly understood relationship to health effects)* chloramines, the MAHC has decided to work with an "action" level until they can be differentiated. Development of tests that can measure the inorganic chloramines separately from the organic chloramines is needed so actionable levels can be set. With such tests, aquatics staff will be able to respond to actionable levels of volatile chloramines so appropriate air quality can be maintained. The separate measurement of organic chloramines, which accumulate in the POOL, may be a useful marker for the need to replace water or supplement with a system known to remove these compounds.

Published data are limited, but suggest that combined CHLORINE levels are commonly above 0.2 ppm *(mg/L)* in swimming POOL water[397, 398, 399].

Inorganic Chloramines

Volatilization of chloramine compounds can lead to strong objectionable odors in AQUATIC VENUE environments, as well as eye, mucous membrane, and skin irritation for BATHERS and PATRONS. Among the inorganic chloramines, NCl_3 has the greatest impact on air quality, owing to its relatively low affinity for water and its irritant properties. NCl_3 has been reported to be an irritant at concentrations in water as low as 0.02 ppm *(mg/L)*.

Odors are unlikely to be present from inorganic chloramines below the following concentrations:

- Monochloramine *(NH_2Cl)*: 5.0 ppm *(mg/L)*
- DICHLORAMINE *($NHCl_2$)*: 0.8 ppm *(mg/L)*
- TRICHLORAMINE *(NCl_3)*: 0.02 ppm *(mg/L)*

Research to understand the relationship between inorganic chloramine concentrations in water and their impact on air quality is limited, although some research indicates that the gas phase NCl_3 concentration is dynamic and impacted by BATHER COUNT, swimmer

396 WHO. Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments. 2006. WHO Press, Geneva, Switzerland. Available at http://www.who.int/water_sanitation_health/bathing/bathing2/en/. Accessed on April 24, 2016.
397 Weaver WA, et al. Volatile disinfection by-product analysis from chlorinated indoor swimming pools. Water Res. 2009 Jul;43(13):3308-18.
398 Lahl U, et al. Distribution and balance of volatile halogenated hydrocarbons in the water and air of covered swimming pools using chlorine for water disinfection. Water Res. 1981;15:803-814.
399 Lévesque B, et al. The determinants of prevalence of health complaints among young competitive swimmers. Int Arch Occup Environ Health. 2006 Oct;80(1):32-9.

activity, liquid phase NCl_3 concentration. Reliable sampling and analytical methods affect the accuracy of the characterization of the AQUATIC VENUE water and air.

Health Incidents

Studies of swimming POOL users and non-swimming attendants have shown a number of changes and symptoms that appear to be associated with exposure to the atmosphere in indoor AQUATIC VENUES. CDC has investigated various health incidents reporting skin and eye irritation and acute respiratory outbreaks that could be associated with exposures to chloramines and other by-products at recreational water facilities, including swimming POOLS[400,401].

Lifeguard Exposure

For lifeguards at swimming POOLS, a dose–response relationship has been identified between NCl_3, measured as total chloramines, and irritant eye, nasal, and throat symptoms, although not chronic respiratory symptoms or bronchial hyper responsiveness[402].

Respiratory Conditions

In addition to potential occupational exposures, there have been a number of studies investigating respiratory conditions, including asthma, related to swimming *POOLS*.

There appears to be no consistent association between swimming POOL attendance during childhood and the prevalence of asthma or atopic disease[403, 404, 405]. Studies indicate that asthma is more commonly found among elite swimmers than among other high-level athletes, although it is premature to draw conclusions about the causal link between swimming and asthma because most studies available to date used cross-sectional design, because the association is not confirmed among non-competitive swimmers, and because asthmatics may be more likely to select swimming as the activity of choice because of their condition[406].

Contact Dermatitis

Chloramines have also been implicated in contact dermatitis *(rashes)*. The number of rashes that occurs among BATHERS in treated recreational water is not known. One cross-sectional study of Australian school POOLS retrospectively examined the incidence rate of rashes in three POOLS. The three POOLS treatment types were 1) CHLORINE alone *(hand*

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400 Hlavsa MC, et al. Outbreaks of Illness Associated with Recreational Water — United States, 2011–2012. MMWR Morb Mortal Wkly Rep. 2015;64(24):668-72.
401 CDC. Ocular and respiratory illness associated with an indoor swimming pool--Nebraska, 2006. MMWR Morb Mortal Wkly Rep. 2007 Sep 14;56(36):929-32.
402 Massin N, et al. Respiratory symptoms and bronchial responsiveness in lifeguards exposed to nitrogen trichloride in indoor swimming pools. Occup Environ Med. 1998 Apr;55(4):258-63.
403 Goodman M ,et al. Asthma and swimming: a meta-analysis. J Asthma. 2008 Oct;45(8):639-47.
404 Schoefer Y, et al. Health risks of early swimming pool attendance. Int J Hyg Environ Health. 2008;211(3-4):367-73.
405 Weisel CP, et al. Childhood asthma and environmental exposures at swimming pools: state of the science and research recommendations. Environ Health Perspect. 2009 Apr;117(4):500-7.
406 Schoefer Y, et al. Health risks of early swimming pool attendance. Int J Hyg Environ Health. 2008;211(3-4):367-73.

dosing), 2) CHLORINE plus ozone *(automatic dosing and control)*, and 3) bromine *(sodium bromide plus ozone using automatic dosing and control)*. This study reported 14.4% of the BATHERS in the hand-dosed CHLORINE POOLS experienced rashes[407]. This and anecdotal reports strongly suggests that rashes are the most common RWI.

The greatest number of rashes appears to be among hydro-therapists *(aquatic physical therapists)*. A survey of 190 professional hydro-therapists in Israel reported that 45% developed skin disease after beginning work. Symptoms reported included itchiness, redness, dry skin. The areas affected were the extremities, the face and trunk, and folds in the skin. The authors concluded: 1) exposure to water influences development of irritant contact dermatitis; 2) cumulative exposure of low-potency irritants may be cause of contact dermatitis; 3) contact dermatitis is an occupational disease of hydro-therapists[408]. In these and similar reports, the exact chemical species inducing the contact dermatitis has not been identified but the collective opinions of the investigators is that halogenated organic compounds is the cause. One conservative estimate places the number of halogenated DISINFECTION byproducts *(DBPs)*, including organic chloramines, in swimming POOLS at greater than 200. The clinical significance of these is likely to vary with the concentration of specific chloramine and BATHER specific factors *(length of exposure, underlying health conditions, and cumulative previous exposure)*.

Maximum Concentration

After considerable discussion the MAHC decided to recommend an action level concentration of 0.4 ppm *(mg/L)* for combined CHLORINE in all recreational waters. As stated in MAHC 5.7.4.4.2, 0.4 ppm is an action level, not an absolute limit that would result in a violation. That is because the combined chorine measurement made in standard test kits is actually a measure of all organic and inorganic combined chlorine compounds in the water, not just the inorganic chloramines, dichloramine and trichloramine, that are well documented to cause many of the health effects discussed above. Most of the organic chlorine compounds measured have little to no information about short or long-term health effects. This means that the combined chlorine measured is a variable mixture of irritant compounds and other chlorine compounds not known to have these effects. As a result, similar combined chlorine levels could vary significantly in the amount of irritating inorganic chloramines in the mix. This makes it difficult to set a regulatory level for combined chlorine or other related chemical measures until a test is available to differentiate the irritating inorganic chloramines from the remainder of the combined chlorine mixture currently measured. The MAHC's interim solution decision was to move to an action level until such tests are available. The action level is then used to minimize the potential for both respiratory and dermal disease that is known to be associated with exposure to chloramines. The action level is intended to drive pool operators to conduct regular combined chlorine testing and use exceedances of the action level to implement a chloramine reduction plan. That means that failure to conduct regular combined chlorine testing or exceeding the action level and having no plan for reducing the value would be the violation cited by inspectors rather than the actual

407 Fitzgerald DA, et al. Spa pool dermatitis. Contact Dermatitis. 1995 Jul;33(1):53.
408 Rycroft RJ, et al. Dermatoses associated with brominated swimming pools. Br Med J (Clin Res Ed). 1983 Aug 13;287(6390):462.

exceedance of the combined chlorine action level. The MAHC recognizes that the 0.4 ppm combined chlorine concentration chosen is arbitrary and that it has not been substantiated by adequate human clinical studies. In the absence of an adequate human study, the MAHC has opted for a conservative value rather than a more lenient value of 0.5 ppm *(mg/L)* preferred by some operators. The key is that regulators start enforcing regular testing for combined CHLORINE so that POOL operators work towards keeping levels low by responding to this action threshold.

Levels of chloramines and other volatile compounds in water can be minimized by reducing introduction of CONTAMINANTS that lead to their formation *(e.g., urea, creatinine, amino acids and personal care products)*, as well as by use of a shock OXIDIZER *(e.g., potassium monopersulfate)* or supplemental water treatment. Effective filtration, water replacement, and improved BATHER hygiene *(e.g., showering, not urinating in the POOL)* can reduce CONTAMINANTS and chloramine formation.

Shock dosing with CHLORINE can destroy inorganic chloramines that are formed. Some research shows that non-CHLORINE shock OXIDIZERS reduce the propensity to develop chloramines. However, this research has not been peer-reviewed to date. The U.S. EPA has determined that manufacturers of “shock OXIDIZERS” may advertise that their “shock OXIDIZER” products “remove,” “reduce,” or “eliminate” organic CONTAMINANTS

- For more information, see: http://www.epa.gov/oppad001/shock_ltr.htm.

Secondary Disinfection

SECONDARY DISINFECTION SYSTEMS such as ozone and UV light may effectively destroy inorganic chloramines. As this also has a public benefit and can assist in meeting the MAHC requirements for combined CHLORINE, it is strongly recommended that any installation utilizing UV or ozone as a SECONDARY DISINFECTION SYSTEM consider the positive impact the equipment may have on reducing combined CHLORINE levels in addition to achieving DISINFECTION goals.

To improve chloramine control strategies, future research should be aimed at:

- Defining the fundamental chemistry of DISINFECTION byproducts including, organic and non-organic chloramine formation from precursor compounds that are common to swimming POOLS;
- Defining relationships between levels of combined CHLORINE in water and air of AQUATIC VENUES and the adverse effects on POOL attendees, to include inhalation, ingestion, and contact;
- Documenting efficacy of water treatment technologies to reduce chloramine levels;
- Improve testing for combined CHLORINE in air and water; and
- Testing for the components of combined CHLORINE.

5.7.4.4.3 Calcium Hardness

Calcium hardness is the amount of dissolved calcium *(plus some other minerals like magnesium)* in the water. High calcium is not healthy for swimming since it can cause burning of the mucous membranes, as well as skin irritation on sensitive people. Calcium hardness of 200 - 400 ppm *(mg/L)* is preferred for proper calcium carbonate saturation and for avoiding soft-water scale found in SPAS and hot tubs when other water parameters are near their nominal levels. For venues with water temperatures greater than 90º F *(32oC)*, the range should be 100 to 200 ppm.

Too much calcium causes cloudiness and scale formation. It also reduces the effectiveness of disinfectants. Too little calcium, especially when combined with low pH or low Total Alkalinity can also lead to "aggressive water," which can dissolve calcium carbonate from plaster, as well as metallic parts of the POOL *(walls, floor, handrails, ladders, light fixtures, and equipment)*, and also cause discolored water or stains on the POOL walls and floor.

The maximum permissible concentration of 1000 ppm *(mg/L)* may not be appropriate for regions with particularly hard source water. In such regions local CODES should reflect the specialized practices needed for source waters containing more than 1000 ppm *(mg/L)* total hardness.

Minor deviations from the calcium hardness levels stated in the CODE do not in themselves present imminent health threats to the BATHERS. As such, minor deviations in hardness levels do not require the immediate closure of the facility. Rather, deviations from permissible hardness levels indicate poor management of the water balance and should indicate a need for a thorough inspection of the entire facility.

5.7.4.4.4 Algaecides

In practice, most algaecides are reasonably effective when applied according to their US EPA accepted label directions and the application is coupled with frequent and thorough brushing.

CHLORINE and bromine can be registered and used as algaecides, but must be used in accordance with EPA label directions.

Bromine and bromamine have been demonstrated to be algaecidal[409].

Common Types

The two basic types of non-halogen algaecides are copper based algaecides and quaternary ammonia compounds *(QACs)*, often referred to as "quats". Some algaecides contain a mixture of a quat and a copper compound.

Copper-based algaecides can be used to treat against all types of algae, but are especially effective against mustard and green types of algae. These will not cause foam to appear in a swimming POOL as is common with simple quaternary ammonia types of algaecides. There is however a problem with stains on the surface of the swimming POOL

409 Kott Y, et al. Algicidal effect of bromine and chlorine on Chlorella pyrenoidosa. Appl Microbiol. 1966 Jan;14(1):8-11.

if the product is not used properly. Proper pH control is very important to minimize staining potential when using copper-containing algaecides.

The other most common types are quaternary ammonium. These algaecides will not stain a swimming POOL. There are two types of quats: simple and polymeric *(more commonly called "polyquats")*. Simple quats are mixtures of various alkyl dimethyl benzyl ammonium compounds *(ADBACs)* or didecyl dimethyl ammonium compounds *(DDACs)*. There are numerous variations of these. The technical name for the active ingredient in polyquats is "Poly[oxyethylene (dimethylimino) ethylene (dimethylimino) ethylene dichloride]". Neither type of quat will cause staining. When overdosed, simple quats tend to cause foam, especially in POOLS with water features *(e.g. fountains, waterfalls)*. Polyquats do not cause foaming, even when used repeatedly at the maximum label dose in POOLS with water features.

EPA-Registered Algaecides

In selecting a quat, it is vital that the product has been registered by the U.S. EPA for use in swimming POOLS. The vast majority, but not all, of the products on the market have current US EPA REGISTRATIONS. All products registered by the U.S. EPA will have a registration number on the label (usually it will state "EPA Reg. No." followed by a series of numbers). This registration number can be verified by using the EPA National Pesticide Information Retrieval System which is managed for the EPA by Perdue University. As part of their registration process the U.S. EPA does not distinguish between public and private facilities.

- To access the EPA National Pesticide Information Retrieval System: (http://ppis.ceris.purdue.edu/#)

Registered Process

The U.S. EPA registration process for algaecides is substantially different than the registration process used for disinfectants. As part of the development of the product, the U.S. EPA requires companies to conduct efficacy studies on the product. The U.S. EPA does not consider algae in POOLS or SPAS to be pathogenic and thus not a direct threat to public health. Since algae are not a public health issue, the US EPA does not require companies to submit their efficacy package for an agency data review. Thus, in the registration process the U.S. EPA looks carefully at the toxicology of the product but not the efficacy. The state of California does require detailed efficacy studies prior to registration. Products sold in the state of California must have the state registration number on the label. Products registered in California but sold outside of the state usually do but are not required to have the California registration number on the label. Any local agency concerned about the efficacy of a particular algaecide could request the producer supply the California registration number and then verify the status of the product with the California Department of Pesticide Regulation.

5.7.4.5 Source (Fill) Water

Most public recreational water venues use the PUBLIC WATER SUPPLY as the fill water source. In instances where this is not possible, it is important that the fill water not be a potential source of illness to BATHERS. Since requirements governing water quality vary by jurisdiction, it is not possible to specify every test that might be required by a jurisdiction. Therefore, facilities need to insure that the fill water complies with the jurisdictional requirements. Examples of potential tests that a jurisdiction may require include, but are not limited to the following: bacteria, nitrates, nitrites, iron, manganese, sulfur, and turbidity. It is also recommended that this testing be conducted on an annual basis.

5.7.4.6 Water Balance for Aquatic Venues

Water balance is an important part of proper AQUATIC VENUE operation and maintenance. As such, the Langelier SATURATION INDEX *(LSI)* is a useful tool for MONITORING the CORROSIVE or scale-forming tendencies of AQUATIC VENUE water. Although there is little scientific literature on the LSI and AQUATIC VENUE water, it is common industry practice to use this index.

The LSI formula is: LSI = **pH + TF + CF + AF – TDSF**

- **pH** Obtained by testing the POOL or SPA water.
- **TF** Temperature Factor - using MAHC Annex Table 5.7.4.6 *(below)*, look up the actual AQUATIC VENUE water temperature at the time of sampling, in order to obtain the appropriate TF value.
- **CF** Calcium Hardness Factor - determine the ppm *(mg/L)* of calcium hardness *(CH)* in the water sample. Using the MAHC Annex Table 5.7.4.6 *(below)*, use the appropriate calcium hardness *(CH)* reading, in order to obtain the appropriate CF value.
- **AF** Total Alkalinity Factor - determine the ppm *(mg/L)* of total alkalinity (TA) in the water sample. Using the MAHC Annex Table 5.7.4.6 *(below)*, use the appropriate total alkalinity *(TA)* reading, in order to obtain the appropriate AF value.
- **TDSF** Total Dissolved Solids Factor – If the TDS of the water is less than 1,000 ppm *(mg/L)*, use the factor of 12.1. If the TDS of the water is greater than 1,000 ppm *(mg/L)*, use the factor of 12.2.

Note: Use the TF, CF, and AF factors closest to your actual reading.

Total Dissolved Solids

A generally accepted level for TDS in AQUATIC VENUES is 1,500 ppm *(mg/L)* above the TDS level in the fill water. For AQUATIC VENUE using CHLORINE GENERATORS, startup TDS level should be measured on the initial fill after adding the salt for the CHLORINE generator. Additional research needs to be done to determine TDS in salt water AQUATIC VENUE, and its impact on water quality.

TDS is a measure of the overall quantity of matter in the AQUATIC VENUE that is not water. This matter includes such things as minerals *(calcium, magnesium, etc.)*, chemicals, body oils, sunscreen, etc. that are not removed by filtration.

There is only one state that has a maximum required TDS level *(2,500 PPM (mg/L))*. However, there is no known scientific data that substantiates any value as a maximum level. The 1,500 ppm *(mg/L)* level is utilized based on the fact that as the concentration of these materials increases in the AQUATIC VENUE they can result in staining, cloudy water, decreased effectiveness of disinfectants *(by up to 50%)*, and an enhanced environment for the growth of algae. Excessively high TDS levels *(greater than 5000 ppm (mg/L))* may require more drastic measures such as a complete AQUATIC VENUE drain and refill, or additional water filtering, as a complete water drain may damage some AQUATIC VENUE.

It is also important to note that the salt required by saltwater chlorination systems will substantially increase the TDS level. Therefore, in saltwater AQUATIC VENUE, it is best to consider the TDS level after the required amount of salt has been added to a freshly filled AQUATIC VENUE as the baseline level.

Table 5.7.4.6 Langelier Index Conversion Chart

TF		***CF***		***AF***	
Temp °F/°C	***TF***	***CH ppm (mg/L)***	***CF***	***TA ppm (mg/L)***	***AF***
32°F / 0°C	0.0	5	0.3	5	0.7
37°F / 3°C	0.1	25	1.0	25	1.4
46°F / 8°C	0.2	50	1.3	50	1.7
53°F / 12°C	0.3	75	1.5	75	1.9
60°F / 16°C	0.4	100	1.6	100	2.0
66°F / 19°C	0.5	150	1.8	150	2.2
76°F / 24°C	0.6	200	1.9	200	2.3
84°F / 29°C	0.7	300	2.1	300	2.5
94°F / 34°C	0.8	400	2.2	400	2.6
105°F / 41°C	0.9	800	2.5	800	2.9
128°F / 53°C	1.0	1000	2.6	1000	3.0

Water balance should fall within the range of –0.3 to +0.3, as determined by the Langelier SATURATION INDEX.

A Low Langelier Index *(a value less than –0.3)* can result in corrosion, BATHER irritation, and discomfort. AQUATIC VENUE water may cause etching, pitting, dissolving, and staining of walls, grouting, and plumbing.

LSI Decreases as:

- Stabilizer Increases, and

- Total Dissolved Solids Increase.

A High Langelier Index *(a value greater than +0.3)* can lead to scale formation, cloudy water, filtration problems, heater problems, loss of CHLORINE efficiency, and BATHER discomfort. AQUATIC VENUE water may deposit excess minerals on the POOL and equipment. Scale generally appears as white or lightly colored rough blotches on the AQUATIC VENUE walls. It also adheres to other objects in the POOL, piping and filter system. Scale can restrict water flow, shortening filter runs and reducing filtration efficiency.

LSI Increases as:

- Temperature Increases,
- Total Alkalinity Increases,
- pH Increases, and
- Calcium Hardness Increases.

A small positive value is preferred over a negative value because a slight scale layer provides some protection, and is less harmful than corrosion, which causes permanent damage to mechanical and structural components.

Langelier Indexes can be adjusted to the -0.3 to +0.3 range by:

- Adjusting the pH to 7.2 to 7.6, and
- Adjusting the total alkalinity to 60 to 180 ppm *(mg/L)*, and
- Adjusting the calcium hardness to
    - 200 to 400 ppm *(mg/L)* for a masonry POOL or SPA, or
    - 80 to 200 ppm *(mg/L)* for a vinyl or fiberglass unit.

While it is always possible to lower the pH, it is not as simple with the total alkalinity or calcium hardness. Lowering the total alkalinity will usually lower the pH as well. Lowering the calcium hardness is not always possible, given the variation in hardness of the fill water. In situations where the calcium level is high, attention should be paid to lowering the pH and / or total alkalinity in order to improve the LSI.

It is not always possible to get the pH and total alkalinity within the proper range, due to the nature of the dissolved minerals. pH is the more important parameter, and should be maintained within the proper range.

If the AQUATIC VENUE is outdoors, and uses stabilized CHLORINE, in order to get a more accurate reading of the LSI, it is recommended that 30% of the CYA reading be deducted from the total alkalinity test result.

5.7.4.7 Water Temperature

Specialized populations may require specific water temperatures for safe and effective programming.

Some general guidelines are as follows:

- Cold water can affect both mental and bodily functions, possibly preventing clear thinking and restricting normal physical activity. It is uncomfortable and can be painful, and puts a strain on the body as you try to rewarm. By definition, water below 70°F *(21°C)* is considered cold, due to the fact that body heat is absorbed twenty-five times faster in water than air.
- Multi use AQUATIC VENUES are usually kept at 83°F – 86°F *(28°C – 30°C)*, while competitive AQUATIC VENUES are usually maintained at cooler temperatures between 78°F – 82°F *(25.5°C – 27.5°C)*. Depending on the target population, instructional and THERAPY POOL water temperatures usually range between 86°F – 94°F *(30°C – 34°C)*.

The following table adapted from USA Swimming provides guidelines for water temperatures based on activity and population:

Table 5.7.4.7: Water Temperature Guidelines Based upon Activity and Population

Bather Type	Temperature Range	Notes
Swim Team & Lap Swim	78°-82°F *(25.5°-27.5°C)*	Slightly warmer may be workable
Resistance Training	83°-86°F *(28°-30°C)*	---
Therapy & Rehab	91°-95°F *(33°-35°C)*	Can be as low as 87°F *(30.5°C)* for many types of therapy
Multiple Sclerosis	80°-84°F *(26.5°-29°C)*	Warmer water can cause adverse effects
Pregnancy	78°-84°F *(25.5°-29°C)*	Warmer water can cause adverse effects
Arthritis	84°-90°F *(29°-31°C)*	Arthritis Foundation min/max
Arthritis	86°-90°F *(28°-32°C)*	ATRI low function program
Fibromyalgia	86°-96°F *(30°-35.5°C)*	ATRI
Aerobic Activity	84°-88°F *(29°-31°C)*	---

Older Adults – Vertical	83°-86°F *(28°-30°C)*	Moderate to high intensity
Older Adults – Vertical	86°-88°F *(30°-31°C)*	Low intensity
Children, Fitness	83°-86°F *(28°-30°C)*	---
Children's Swim Lessons	82°F *(27.5°C)*	Varies with age and class length
Obese	80°-86°F *(26.5°-30°C)*	---

There are no definitive temperatures that are applicable for all uses of an AQUATIC VENUE. The suggested AQUATIC VENUE water temperature is dependent on the person's activity in the POOL. For example, individuals participating in competitive swimming prefer cooler water *(70°-80°F or 21°-27°C)* than individuals participating in water fitness for arthritis *(83°F or 28°C, minimum)* (http://www.uswfa.com/suggested_pool_temps.asp). Water ranging in temperature from 79°-86°F *(26°-30°C)* is comfortable for most swimmers throughout prolonged periods of moderate physical exertion.[410]

However, there are maximum temperatures that can and do have an effect on the health of the PATRON using the facility. Water temperature between 83°-86°F *(28°-30°C)* is the most comfortable temperature for typical recreational water usage. Water temperature may need to be adjusted based upon specific uses of the facility.

The WHO recommends that water temperatures in hot tubs be kept below 104°F *(40°C)*. High temperatures *(above 104°F or 40°C)* in SPAS or hot tubs can cause drowsiness, which may lead to unconsciousness and, consequently, drowning[411]. The CPSC has received reports of several deaths from extremely HOT WATER *(approximately 109°F or 43°C)* in hot tubs. In addition, high temperatures can lead to heat stroke and death[412]. Further examination of data on the health impact of high temperature water on pregnancy, particularly in the first trimester, is needed.

Minimum temperature requirements are not included in this CODE. Water that is too cold, simply will not be utilized for any extended period of time, and will not be used by individuals seeking a recreational water experience.

410 WHO. Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments. 2006. WHO Press, Geneva, Switzerland. Available at http://www.who.int/water_sanitation_health/bathing/bathing2/en/. Accessed on April 24, 2016.
411 Press E. The health hazards of saunas and spas and how to minimize them. Am J Public Health. 1991 Aug;81(8):1034-7.
412 USCPSC. Spas, hot tubs, and whirlpools: Document # 5112. Available at http://www.poolsafely.gov/wp-content/uploads/5112.pdf. Accessed on April 24, 2016.

Even though minimum temperatures are not included in the CODE, it is important to remember that cold-water basins, such as plunge POOLS, can present health concerns due to water temperature extremes.

These small, deep POOLS generally contain water at a temperature of 46-50°F (*7°-10°C)* and are used in conjunction with saunas or steam baths. Adverse health outcomes that may result from the intense and sudden changes in temperature associated with the use of these POOLS include immediate impaired coordination, loss of control of breathing and, after some time when the core body temperature has fallen, slowed heartbeat, hypothermia, muscle cramps, and loss of consciousness. In general, exposure to temperature extremes should be avoided by pregnant women, users with medical problems, and young children.[413]

Spa Temperature Maximum

SPA temperature maximum was based on the preponderance of state CODES that currently use this temperature and it is widely accepted and practiced in the industry. See discussion below in MAHC Annex 5.7.4.7.2 that recommends further evaluation.

Comfortable

Water varying from 83°-86°F *(28°-30° C)* is the most comfortable temperature for typical water fitness classes. This allows the body to react and respond normally to the onset of exercise and the accompanying increase in body temperature. Cooling benefits are still felt and there is little risk of overheating. Program modifications will be required for water temperature outside the recommended range. Aquatic Fitness Professionals should know the water temperature and modify the program accordingly based upon the population and the program format.

Below Recommendation

Water temperature below the recommended range requires modifications in programming. The primary focus of the warm up should be large, lower impact, rhythmic movements that gradually elevate core temperature of the body and should last for at least 9-15 minutes. The main segment must be of adequate intensity to maintain proper body temperature and prevent injury. Participants may find it necessary to wear specialized clothing to maintain body heat. The cool down and post-stretch must be adjusted, in overall length as well as activity, according to the environmental conditions. Water temperature above the recommended range also requires modifications in programming. The intensity and length of the main segment should be adjusted to prevent overheating. Encourage proper hydration and apparel *(e.g. avoid swimming caps that prevent heat dissipation)*. An extended cool down with emphasis on stretching and relaxation is appropriate.

5.7.4.7.2 Maximum Temperature

413 WHO. Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments. 2006. WHO Press, Geneva, Switzerland. Available at http://www.who.int/water_sanitation_health/bathing/bathing2/en/. Accessed on April 24, 2016.

SPA temperatures of 104°F *(40°C)* are routinely used in SPAS and hot tubs across the United States. The MAHC is not aware of data that suggests this is too high for use by healthy individuals. Higher temperatures mimic a high fever in the human body and may not be healthy, particularly for prolonged use. However, the high temperature used in SPAS and hot tubs *(MAHC sets it at 104°F / 40°C maximum)* necessitates strong signage to alert users about alcohol use and alert vulnerable groups about the risks potentially associated with use of SPAS and hot tubs. Review of the existing data *(or collection of new data)* is needed to inform the MAHC about whether a maximum length of time in a SPA should be set.

Ethanol Use and Solo Use

Ethanol use may contribute to the likelihood of drowning[414]. Low to moderate doses of ethanol did not appear to significantly impact body temperature or thermoregulatory response systems in healthy males at 104°F *(40°C)*[415,416]. However, there did appear to be increased risk of cardiac hypotension and fainting when users stood up that could result in slips or falls, the most common cause of SPA-related injury in the United States[417]. Several studies of sauna-related deaths in Scandinavia find a high percentage of alcohol use and that users were alone[418,419]. Signage to restrict alcohol use, not to use SPAS when alone, and to exercise caution and use handrails to exit is warranted.

Pregnant Women

Maternal hyperthermia has been shown to be associated with birth defects[420]. Some studies have shown an increased risk of birth defects and miscarriages associated with hot tub or SPA use during early pregnancy[421,422,423,424]. Pregnant women, particularly during the first trimester, should consult their healthcare provider before using hot tubs or SPAS. If women in later pregnancy choose to use hot tubs or SPAS, they should keep exposure to a minimum, and ensure the temperature is at or below recommended STANDARDS. Signage should alert pregnant women about the potential risks of hot tub or SPA use and the need to consult with their physician before use. Further expert review of the data is warranted to see if the data support reducing the water temperature and, if so, what

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414 Howland J, et al. Why are most drowning victims men? Sex differences in aquatic skills and behaviors. Am J Public Health 1996;86:93--6.
415 Allison TG, et al. Thermoregulatory, cardiovascular, and psychophysical response to alcohol in men in 40 degrees C water. J Appl Physiol. 1992 Jun;72(6):2099-107.
416 Mekjavic IB, et al. Cardiovascular responses during 70 degrees head-up tilt: the effect of elevated body temperature and high alcohol blood levels. Physiologist. 1987 Feb;30(1 Suppl):S56-7.
417 Alhajj M, et al. Hot tub, whirlpool, and spa-related injuries in the U.S., 1990-2007. Am J Prev Med. 2009 Dec;37(6):531-6.
418 Rodhe A, et al. Sauna deaths in Sweden, 1992-2003.Am J Forensic Med Pathol. 2008 Mar;29(1):27-31.
419 Kenttämies A, et al. Death in sauna. J Forensic Sci. 2008 May;53(3):724-9.
420 Moretti ME, et al. Maternal hyperthermia and the risk for neural tube defects in offspring: systematic review and meta-analysis. Epidemiology. 2005 Mar;16(2):216-9.
421 Milunsky A, et al. Maternal heat exposure and neural tube defects. JAMA. 1992 Aug 19;268(7):882-5.
422 Duong HT, et al; National Birth Defects Prevention Study. Maternal use of hot tub and major structural birth defects. Birth Defects Res A Clin Mol Teratol. 2011 Sep;91(9):836-41.
423 Chambers CD. Risks of hyperthermia associated with hot tub or spa use by pregnant women. Birth Defects Res A Clin Mol Teratol. 2006 Aug;76(8):569-73.
424 Li DK, et al. Hot tub use during pregnancy and the risk of miscarriage. Am J Epidemiol. 2003 Nov 15;158(10):931-7.

temperature should be adopted to proactively protect women of childbearing age who may not know if they are pregnant.

Young Children

Few studies exist looking at the impact of high temperature on young children although older children do appear to be able to control their temperature as well as adults[425] but the high temperatures in saunas do put great demands on the circulatory system[426]. However, infants cannot control their body temperature as effectively as their older siblings and parents. This is because babies have a small body mass compared to body surface area. Being in water even a few degrees different from normal body temperature *(98.6°F/37°C)* can affect a baby's body temperature. Being in very warm or HOT WATER found in hot tubs/SPAS can cause hyperthermia, a dangerously high body temperature. Signage for SPAS and hot tubs should caution users about bringing infants and young children into SPAS or hot tubs, particularly for prolonged use.

5.7.5 Water Quality Chemical Testing Frequency

Table 5.7.5: Water Testing Frequency Reference Chart

	*Start-up**	*Manual Testing*	*Automated Controllers*	*Closing**
Free Chlorine	Yes	2 hrs.	4 hrs.	Yes
Combined Chlorine	Yes	2 hrs.	4 hrs.	Yes
pH	Yes	2 hrs.	4 hrs.	Yes
TA	Yes	-	-	-
CH	Yes	-	-	-
CYA	Yes†	-	-	-
TDS	Yes	-	-	-
Microbiological	*Testing shall be conducted after a fecal incident.*			
** Manual testing to be done at these times.*				
† Unless TriChlor (trichloro-s-triazinetrione) or DiChlor (sodium dichloro-s-triazinetrione) are used for daily sanitizer or shock, then weekly.				
Note: Manual testing should be done after a significant weather event for outdoor facilities.				

425 Rowland T. Thermoregulation during exercise in the heat in children: old concepts revisited. J Appl Physiol. 2008 Aug;105(2):718-24.
426 Jokinen E, et al. Children in sauna: cardiovascular adjustment. Pediatrics. 1990 Aug;86(2):282-8.

5.7.5.1 Chemical Levels

When using colorimetric testing methods, combined CHLORINE testing consists of measuring free CHLORINE, measuring total CHLORINE, and subtracting the free CHLORINE from the total CHLORINE. When using titrimetric methods, it is easiest to perform a direct measure. The analyst should simply count each drop of titrant and multiply by the correct factor to attain the combined CHLORINE level.

A properly calibrated automatic chemical MONITORING system which maintains records and can be monitored remotely via a secure website could be acceptable for daily testing, if the system allows for the health department to have access to view a read-only log which monitors the chemistry at a facility.

5.7.6 Water Clarity

Water clarity is a useful measure of general water quality. Visual observation of main drains is important for BATHER SAFETY to avoid drowning incidents and injury prevention *(for BATHER visibility)*. For POOLS, the use of a Secchi disk is not recommended. If a marker tile of suction outlet is not available, an alternate such as a submersible manikin or shadow doll could be placed at the deepest point of the POOL/attraction to check clarity.

For more information about the limitations of Secchi disks, see:

- NOAA Technical Memorandum ERL PMEL-67, *Eyeball Optics of Natural Waters: Secchi Disk Science*, Rudolph W. Preisendorfer, Pacific Marine Environmental Laboratory,Seattle, WA, April 1986.

5.8 Decks and Equipment

5.8.1 Spectator Areas

ANSI defines where a trip hazard is considered as a level change that is greater than ¼ inch *(6.1 mm)*. Other definitions include an abrupt or unexpected level change in surfaces.

5.8.1.2.3 Tripping Hazards

Over time changes may occur in deck elevation, or equipment added to or removed from the deck surface. The deck should be inspected to ensure any changes in deck elevation or the addition or removal of deck equipment does not cause a tripping hazard.

5.8.2 Diving Boards and Platforms [N/A]

5.8.3 Starting Platforms

See MAHC Annex Section 4.8.3 for discussion.

5.8.4 Pool Slides [N/A]

5.8.5 Lifeguard and Safety Related Equipment

5.8.5.1 Equipment Inspection and Maintenance

The absence of this required equipment can adversely affect the effectiveness of a rescue and the SAFETY of the lifeguard. It could also hinder the response from emergency services. For this reason, it is the responsibility of the owner/operator to make sure this equipment is in place prior to opening the AQUATIC FACILITY to the public.

The equipment should be working so it can be used when needed. The word "safe" denotes the equipment is not modified to be in working condition and thus pose a risk to the user.

5.8.5.2 Safety Equipment Required at All Aquatic Facilities

5.8.5.2.1 Emergency Communication Equipment

5.8.5.2.1.1 Functioning Communication Equipment

As stated in the design section, emergency communication devices should be part of the design but also required to be present in the operation.

5.8.5.2.1.2 Hard Wired Telephone for 911 Call

- The AQUATIC FACILITY must be provided with the tools necessary for rapid and effective emergency communication. These tools might include a telephone, emergency band radio or other effective means of communication.
- Having a reliable telephone available during an emergency is important. Frequently cellular telephones, cordless telephones, and other self-powered devices are not ready for use. Having a hard wired telephone provides that reliability.
- The telephone must be available to all AQUATIC VENUE users for use in an emergency, anytime the AQUATIC VENUE is open for use. Pay telephones must be able to dial 911 without the use of coins or cards and maintained in an operable condition.
- The communication device should be placed in a manner where BATHERS can see and reach the device within about one minute and be placed so there are no obstructions to reaching it. The response time by the proper emergency agency has been shown to make a difference in patient outcome[427].

5.8.5.2.1.4 Alternate Communication Systems

The intent is that an emergency phone or alternate communications system or device is immediately available to PATRONS from all AQUATIC VENUES within an AQUATIC FACILITY. Some alternate communication systems might include a handset or intercom system to a location that is constantly manned whenever the AQUATIC VENUE is open for use *(e.g. a*

427 EMS World Response Time Standards: http://www.emsworld.com/article/10324786/ems-response-time-standards.

front desk at a hotel, the check in desk at a fitness club, or other continuously manned location); a commercial emergency contact device that connects to a MONITORING service, or directly to 911 dispatch; or devices that alert multiple staff on site when activated *(e.g. pagers systems, cellular telephone systems and radio communication alert systems)*. For larger facilities, this could include internal communication processes such as two-way radio use to a central phone to facilitate emergency communications to outside EMS in place of hard wired publicly accessible phones.

5.8.5.2.2 First Aid Equipment

5.8.5.2.2.1 Location for First Aid

This is stated in the design section but also stated in the MAHC operations section to require the operator to designate a first aid location for existing facilities. The supplies should be provided at locations where they can be quickly accessed by staff responding to emergencies.

5.8.5.2.2.2 First Aid Supplies

The first aid supply list is based on the ANSI/ISEA Z308.1-2009 STANDARD for a Workplace First Aid Basic Kit. The listed contents are based on the items needed, but the quantities are not specified to allow for flexibility based on the size of the AQUATIC FACILITY, the anticipated BATHER COUNT, anticipated number and types of injuries, and the number of first aid locations. Topical supplies such as antibiotic cream, burn gels, and antiseptics were removed because this poses a scope of practice issue for the level of training typical to lifeguarding.

The operator should provide enough supplies that the kit does not need continuous restocking. There should be enough supplies to last between first aid kit supply inspections, plus the time needed to obtain and replace the supplies. The contents should be inspected and resupplied often enough to maintain the supplies in good condition.

The supplies must be stored in such a manner as to protect them from moisture and extremes of heat and cold that will cause deterioration. Supplies must be periodically checked for expiration dates and replaced as needed.

A biohazard cleanup kit was included as lifeguards often deal with body fluids on surfaces such as vomit, feces, and blood. According to OSHA[428], "Generally, lifeguards are considered to be emergency responders and, therefore, would be considered to have occupational exposure. Emergency response is generally the main responsibility of lifeguards, therefore, such duties could not be considered collateral. Although it is the employer's responsibility to determine which, if any, of the employees have occupational exposure, employers of lifeguards should examine all facets of the lifeguard's emergency response duties, not just "retrieval from deep water." As a result, lifeguards are covered under OSHA 29 CFR 1910.1030 Bloodborne Pathogens STANDARD, which speaks to having contact with individuals that may be injured and bleeding. As a result, employers

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428 OSHA. Coverage of Lifeguards under 29 CFR 1910.1030. July 9, 1993. Corrected 08/16/2007. Accessed July 6, 2016 at https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=21197.

are required to offer all the protections of the Bloodborne Pathogens STANDARD. Management should also consider how bloodborne pathogen training is integrated with training for environmental and/or water-based clean-up of feces and other body fluids *(See MAHC 6.5)*.

The MAHC chose to compile this list after reviewing the contents of several kits that were commonly available.

One complete bloodborne pathogen spill kit is needed at the AQUATIC FACILITY. Example of minimum suggested contents:

- Disposable gloves*;
- Disposable gown or apron, facemask, shoe covers;
- Face Shield;
- Anti-microbial wipes;
- Biohazard Bag;
- Disinfectant *(ex. calcium hypochlorite packet – 1 oz.)*;
- Absorbent materials or fluid solidifier *(~20 gm)*;
- Scoops for solidified material;
- Scraper; and
- Instructions for use.

***** Do not use latex gloves. Gloves should be single use, vinyl or nitrile, and non-powdered. Gloves should be disposed of after one use. Fit is important. It is recommended that 4 to 6 mil. gloves be used.

****** It is suggested that a kit be assembled, put in a container and sealed to assure the contents are still intact when needed. After use, a new kit is provided or the container is restocked and resealed.

In addition to the AQUATIC FACILITY kit, lifeguards should carry basic PPE for immediate use during initial exposure to feces, vomit, and small amounts of blood until the full kit arrives at the treatment scene.

AEDs were considered to be included in this list, but due to the requirement for medical direction for AED use by trained rescuers, it was not included as it may not be within the AHJ's authority to mandate such equipment. However, AEDs are widely used and can be used for submersion events and any cardiac incident. If local protocols can be established, it is recommended to have an AED.

5.8.5.2.3 Signage

5.8.5.2.3.1 Sign Indicating First Aid Location

Effective signage must communicate where first aid assistance can be obtained. This is especially important in smaller AQUATIC FACILITIES and at AQUATIC FACILITIES not requiring lifeguards where the first aid station might be outside the immediate AQUATIC VENUE area.

Signage is also important at very large AQUATIC FACILITIES where the first aid station might be harder to find. Effective signage should follow the STANDARDS established by ICC A117.1-2009 and ADA Accessibility Guidelines including sign height, raised or Braille lettering, and placement.

Emergency telephones or communication devices are usually in conspicuous locations; however, those locations should be communicated so BATHERS and staff alike know where they are and can rapidly locate them.

5.8.5.2.3.2 Emergency Dialing Instruction

Signage must be posted at the telephone or approved communication system or device with emergency contact number*(s)* or procedures and the address of the AQUATIC FACILITY. Often a person in an emergency situation can be confused, so having the address of the AQUATIC FACILITY, emergency number*(s)*, and special instructions, if any, at the telephone makes responding easier.

5.8.5.2.3.3 Management Contact Info

An owner/operator contact number must be provided for notification of water quality and SAFETY concerns. At AQUATIC FACILITIES where QUALIFIED OPERATORS are not present at all times, it is important for PATRONS to be able to contact the owner/operator when water quality has been compromised *(e.g. cloudy water, fecal matter in the water, and/or other issues of concern related to water quality or SAFETY)*.

5.8.5.2.3.4 Hours of Operation

Operating hours for an AQUATIC FACILITY should be posted and clearly visible at the AQUATIC FACILITY, especially when the AQUATIC FACILITY is not attended at all times by an operator or lifeguard.

5.8.5.3 Safety Equipment Required at Facilities with Lifeguards

5.8.5.3.1 UV Protection for Chairs and Stands

In MAHC 4.8.5.3.3, permanently installed chairs and stands are required to be designed with UV protection. In MAHC 5.8.5.3.1, chairs and stands are required to have the UV protection present. Regardless of when the chair or stand was constructed, UV protection is required to protect the lifeguard from an occupational exposure.

5.8.5.3.2 Spinal Injury Board

Spinal injury boards facilitate immobilization of a person with a suspected spinal injury. Because these boards are often used in or around the water, their construction should be of materials that can withstand the environment and be easily SANITIZED/disinfected between uses. Boards must be properly maintained and in good repair. An example is using a wooden backboard that is worn so the wood is exposed and no longer cleanable. In this case, refinishing it with a waterproof finish should again make it cleanable. The head immobilizer and straps are commonly used in lifeguard training programs and these tools assist in the immobilization of a person on the board and should be present during operation. Deciding which straps to be included should consider how to best immobilize the person to the board. Common locations for straps are at the upper torso, the hips, and legs.

The number of spine boards available at the AQUATIC FACILITY should be dependent on the size of the AQUATIC FACILITY. It would be difficult to determine the exact number but a general consideration should be to have a spine board reach the location it is needed within a couple of minutes. There should not be a delay: the person needing to be extricated from the water will need to be held in an immobile position in the water. To extricate without a spine board can cause more damage to the person.

5.8.5.3.3 Rescue Tube Immediately Available

The 50th percentile adult is at least 64 inches *(1.6 m)* tall. The rationale is that the average adult BATHER'S head would be above the static water line and they could use the AQUATIC VENUE without difficulty. Due to buoyancy considerations at chest level, a short lifeguard could have difficulty doing a rescue safely without equipment. For this reason, the rescue tube is required unless there is less than 3 feet *(0.9 m)* of depth in which their chest would likely be above the static water line.

Lifeguard training agencies have determined that the use of a rescue tube makes rescues safer for both the victim and the rescuer. The rescue tube provides a BARRIER between the victim and the rescuer as well as a handhold for both during a rescue.

In very shallow water, the rescue tube may not be as effective so the language in the CODE is flexible to allow for the rescue tube to be available immediately, but is not required to be worn. However, as stated above, the rescue tube provides protection for the lifeguard so the operator should determine the level of risk and requirement for wearing the rescue tube based on the AQUATIC VENUE depth, activities, and frequency of rescue.

5.8.5.3.4 Rescue Tube on Person

Being properly prepared to respond to an emergency requires wearing the harness strap attached to the rescue tube and keeping the rescue tube in a position and location where it can be immediately used.

It is important to wear the rescue tube in a rescue ready position. Wearing the strap and sitting with the tube at the lifeguard's feet, or in any other position except held against the body, can lead to situations where a lifeguard is injured or cannot respond because the tube's strap is wrapped around handrails, chair pedestals or other catch points. Management should reinforce through pre-service, in-service, and employment policy that the lifeguards are expected to hold the rescue tube in a manner taught and accepted by the lifeguard training agency.

5.8.5.3.5 Identifying Uniform

There should be no delay in care because a PATRON is unable to find a member of the AQUATIC FACILITY SAFETY TEAM. Distinct uniforms are a STANDARD in most industries to identify workers and their assigned tasks.

5.8.5.3.6 Signal Device

The most basic communication method used by lifeguards is a combination of whistle blasts and hand signals to communicate with each other, PATRONS, and management. Whistle signals can communicate when to clear the POOL, get another lifeguard's or supervisor's attention, and communicate emergencies.

The devices and their use can vary depending on the AQUATIC FACILITY and its management. Because of inherent background noise, whistles, hand signals, emergency buttons, radios, and telephone handsets are used to provide more effective communication.

5.8.5.3.7 Sun Blocking Methods

Protection from direct sun exposure is a necessary part of lifeguarding at AQUATIC FACILITIES. Gone are the days when the objective of the lifeguard was to get as deep a tan as possible. Today, sun exposure, especially when the skin becomes burned, increases significantly the risk of skin cancers.

In a recent study of melanoma, it was noted that the melanoma DNA contained 33,000 mutations, many of which may have come from UV light exposure[429].

The best sunscreens available at the present time are broad spectrum or full spectrum and are usually so labeled. More will probably become available as new Food and Drug Administration rules are implemented[430]. These protect against both UVA and UVB rays as long as re-application is conducted periodically. Because SPF ratings only measure UVB effectiveness there is a lot of variability in UVA protection in sunscreens. The CDC recommends a sunscreen with an SPF of at least 15[431].

There are some questions about the health effects of some of the screening chemicals, but the benefits seem to outweigh the hazards. To minimize exposure to these chemicals, lifeguards should also wear protective clothing, hats, use sun-blocking umbrellas, or any other means to avoid exposure to UV light. Protection is also needed from reflected exposure. Light-skinned individuals can be particularly sensitive to both direct as well as indirect exposure to the sun's UV rays[432]. Employers should educate lifeguards about the

429 Pleasance ED, et al. A comprehensive catalogue of somatic mutations from a human cancer genome. Nature. 2010;463;7278;191-6.
430 21 CFR Parts 201 and 310, Labeling and Effectiveness Testing; Sunscreen Drug Products for Over-the-Counter Human Use.
431 CDC/NIOSH. UV Radiation [online]. [cited 2014 Feb 6.] Available from: http://www.cdc.gov/niosh/topics/uvradiation/.
432 IARC monographs on the evaluation of carcinogenic risks to humans. Solar and ultraviolet radiation. IARC Monogr Eval Carcinog Risks Hum. 1992;55:1-316. PMID:1345607.

risk and protection options but are exempted from requirements to pay for sunscreen as PPE according to OSHA 1910.132(h)(4)(iii)[433].

5.8.5.3.8 Polarized Sunglasses

Glare and reflected sunlight off the water surface can cause significant visibility problems for lifeguards and potentially impact job performance. Lifeguards working at outdoor AQUATIC VENUES are required to wear polarized eye wear to reduce the risk of glare causing reduced visibility. This polarized eyewear should also be a part of any sun exposure awareness training since it also potentially reduces the harmful short- and long-term effects of UV on eyes that include increased risk for cataracts and macular degeneration[434435,436,437,438,439,440]. However, employers are exempted from requirements to pay for sunglasses as PPE according to OSHA 1910.132(h)(4)(iii)[441].

Polarized eyewear can assist with glare indoors as well but should be tested so it does not impede visibility due to lower light levels.

Polarized 3-D glasses must not be used as they can be disorienting and can disrupt normal vision.

5.8.5.3.9 Personal Protective Equipment

Appropriate PPE must be provided to all employees that have possible occupational exposures. Lifeguards should carry or have immediately available basic PPE *(disposable gloves and resuscitation mask with one-way valve)* for immediate use during initial exposure to feces, vomit, and small amounts of blood until the full facility bloodborne pathogen kit arrives at the treatment scene. This could be in a small pouch to be carried on the lifeguard, a pouch associated with the rescue tube, or at a location near the lifeguard position. The intent is that the lifeguard does not need to leave the immediate area to find PPE nor will it create a delay in response.

OSHA Blood borne Pathogen Regulations[442], require that the employer shall provide, at no cost to the employee, appropriate PPE such as, but not limited to, gloves, gowns, face shields or masks and eye protection, and mouthpieces, resuscitation bags, pocket masks, or other ventilation devices. PPE will be considered "appropriate" only if it does not permit blood or other potentially infectious materials to pass through to or reach the employee's

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433 OSHA. Personal Protective Equipment standard 1910.132 Accessed March 1, 2014 at https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9777.
434 Krutmann J, et al. Towards standardization of UV eye protection: what can be learned from photodermatology? Photodermatol Photoimmunol Photomed. 2013 Nov 8. doi: 10.1111/phpp.12089.
435 Glickman RD. Ultraviolet phototoxicity to the retina. Eye Contact Lens. 2011 Jul;37(4):196-205.
436 Roberts JE. Ultraviolet radiation as a risk factor for cataract and macular degeneration. Eye Contact Lens. 2011 Jul;37(4):246-9.
437 Glickman RD. Phototoxicity to the retina: mechanisms of damage. Int J Toxicol. 2002 Nov-Dec;21(6):473-90.
438 McCarty CA, et al. A review of the epidemiologic evidence linking ultraviolet radiation and cataracts. Dev Ophthalmol. 2002;35:21-31.
439 Roberts JE. Ocular phototoxicity. J Photochem Photobiol B. 2001 Nov 15;64(2-3):136-43.
440 Taylor HR. Ultraviolet radiation and the eye: an epidemiologic study. Trans Am Ophthalmol Soc. 1989;87:802-53.
441 OSHA. Personal Protective Equipment standard 1910.132 Accessed March 1, 2014 at https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9777.
442 29 CFR 1910.1030, Toxic and Hazardous Substances – Blood borne Pathogens.

work clothes, street clothes, undergarments, skin, eyes, mouth, or other mucous membranes under normal conditions of use and for the duration of time which the protective equipment will be used.

5.8.5.3.10 Rescue Throwing Device

If the single lifeguard is engaged in a rescue and another person is in distress, the rescue throw device allows for an untrained individual to assist the distressed person.

5.8.5.3.11 Reaching Pole

If the single lifeguard is engaged in a rescue and another person is in distress, the reaching pole allows for an untrained individual to assist the distressed person.

5.8.5.4 Safety Equipment and Signage Required at Facilities without Lifeguards

5.8.5.4.1 Throwing Device

A rescue throwing device is a throw bag, buoyant life ring, torpedo buoy or other easily thrown buoyant device that is designed for a person on the DECK to throw to a person in distress in the AQUATIC VENUE. Fifty feet *(15.2 m)* minimum of ¼ inch *(6.4 mm)* rope securely attached to the device is required. It has been found that untrained individuals have a reasonable ability to reach 30 feet *(9.1 m)* with a rescue throw device. A 50 foot *(15.2 m)* rope would accommodate that distance. The 1.5 times the width of the POOL allows for a SAFETY factor to overthrow the device and pull the rope back toward the person in distress. This also allows for extra rope to hold on to. The device must be kept ready for use, and the rope must be coiled to prevent tangles and to facilitate throwing the device.

5.8.5.4.2 Reaching Pole

The pole is intended to reach out to a swimmer in distress and to allow them to grab hold of the pole. The pole should be submerged when introducing it to the swimmer to prevent injury. In some cases the “hook” can be used to encircle a non-responsive swimmer to draw them to the side. Use of the device involves reaching out to the swimmer and then pulling the pole straight back to the side, along with the swimmer. The pole cannot be swung around to the side as the strength required exceeds that of most people, and the pole is not that durable.

Since the pole is pulled back to the side, a telescoping pole is not appropriate as it can pull apart. Ideally the pole can reach to the middle of many smaller POOLS making the entire POOL reachable from the side with the pole.

The pole must be equipped with a “life-hook” or “shepherd’s crook”. For SAFETY, the hook must be a looped frame-type hook, not the single metal hook. The hook protects the swimmer from being injured by the pole, as well as allows a non-responsive swimmer to be pulled in. To prevent injury, use only the hook attachment bolts supplied by the manufacturer. This will prevent hooks and snags, caused by using the improper bolts, which can injure the swimmer.

5.8.5.4.3 CPR Posters

CPR performed by bystanders has been shown to improve outcomes in drowning victims[443]. CPR started immediately on a drowning victim instead of waiting until emergency responders arrive will have a significant effect on the potential for brain damage in the victim. Posters of CPR explaining basic procedures can be reviewed in seconds and give the provider enough knowledge to assist the victim until emergency responders arrive.

Posters can educate PATRONS to recognize potential causes of, prevention, and spread of RWIs. PATRONS need to be educated to what RWIs are, how they are spread, and how they can be prevented.

Resources for RWI education can be found at http://www.cdc.gov/healthyswimming. There are many resources for CPR posters that can be found online.

5.8.5.4.4 Imminent Health Hazard Sign

A sign indicating reasons requiring closure especially at AQUATIC FACILITIES where a QUALIFIED OPERATOR or QUALIFIED LIFEGUARD is not present should be posted listing specific incidents which would require the AQUATIC FACILITY to immediately close. Examples of such incidents include fecal incidents, broken/missing drain grates, water clarity, water quality issues, and lightning. A contact number should be provided to notify the owner/operator of conditions considered an IMMINENT HEALTH HAZARD.

5.8.5.4.5 Additional Signage

MAHC 6.3.2 outlines the conditions that require a QUALIFIED LIFEGUARD. For AQUATIC FACILITIES that do not have lifeguards, PATRONS should be informed that no lifeguard is provided so they can comply with any requirements and understand the identified risk. For instance, at a hotel POOL that requires key entry, the sign would notify hotel guests that no lifeguard is provided and persons under the age of 14 are not allowed in without adult supervision.

5.9 Filter/Equipment Room

In a review of POOL chemical incidents documenting 400 incidents, 221 reported two contributing factors. Of the 221 secondary factors, 39.8% listed improper chemical mixing as one of the contributing factors[444].

5.9.1 Chemical Storage

5.9.1.1 Local Codes

All chemical containers must be labeled with the following information:

- Chemical identity,

443 Kyriacou DN, et al. Effect of immediate resuscitation on children with submersion injury. Pediatrics. 1994;94 (2):137-142.
444 Anderson AR, et al. The distribution and public health consequences of releases of chemicals intended for pool use in 17 states, 2001-2009. J Environ Hlth 2014;76:10-15.

- Manufacturer's name and address,
- Physical hazards,
- Health hazards, and
- Degree or type of risk.

The label should explain necessary precautions to take; how to handle, store, and dispose of chemicals; and sometimes indicate hazard potential with a number from 0 to 4. This number indicates the degree of risk, with the number 4 representing the greatest risk, and shows the hazard categories (see NFPA 704: *Hazard Identification System*).

5.9.1.2 OSHA and EPA

Chemicals should never be pre-mixed with water by hand before adding the chemical to the AQUATIC VENUE unless specified by the manufacturer.

If a dissolution or feed tank is used to dissolve product for feeding into the AQUATIC VENUE, the tank must be equipped with a mechanical mixer, dedicated to a single chemical, and clearly labeled to prevent the introduction of incompatible chemicals to the tank.

Chemicals should be added to water, water should never be added to chemicals.

Pre-mixing in containers that are not clean can result in the generation of heat and toxic gases and may result in fire or explosion.

OXIDIZERS such as calcium hypochlorite, monopersulfate or bleach shall not be mixed with any other chemicals.

5.9.1.3 Safety Data Sheets (SDS)

An SDS is a form containing data, potential hazard information, and instructions for the safe use of a particular material or product. An important component of product stewardship and workplace SAFETY, it is intended to provide workers and emergency personnel with procedures for handling or working with that substance in a safe manner, and includes information such as physical data *(melting point, boiling point, flash point, etc.)*, toxicity, health effects, impact on the environment, first aid, reactivity, STORAGE, disposal, protective equipment, and spill handling procedures. The exact format of an SDS can vary from source to source. It is important to use an SDS that is supplier-specific as a product using a generic name *(e.g. OXIDIZER)* can have a formulation and degree of hazard which varies between different manufacturers.

Filed

SDSs should be filed anywhere chemicals are being used. An SDS for a substance is not primarily intended for use by the general consumer, focusing instead on the hazards of working with the material in an occupational setting.

OSHA

In the U.S., OSHA requires that SDSs be available to employees for potentially harmful substances handled in the workplace under the Hazard Communication regulation. The

SDS is also required to be made available to local fire departments and local and state emergency planning officials under Section 311 of the Emergency Planning and Community Right-to-Know Act.

Hazard Ratings

The SDS will typically contain the hazard ratings according to either the NFPA or HMIS systems. The NFPA system may be found in *NFPA 704: Standard System for the Identification of the Hazards of Materials for Emergency Response*. In the NFPA system, the chemicals are rated according to their health, flammability, instability, and special hazards. The degree of hazard is indicated by a number from 0 to 4, with 0 being the least hazardous and 4 being the most hazardous. Either HMIS or NFPA ratings are useful to include on product labels. Most fire CODES require these ratings to be posted on CHEMICAL STORAGE ROOM doors.

5.9.1.5 Protected

In addition to the requirements listed in MAHC 5.9.1.5, the following BEST PRACTICES are recommended:

- Place all chemical containers, drums, boxes, and bags on pallets to raise them off the floor.
- Containers should not be stacked so that they will easily fall over. A general rule of thumb is that they should not be stored more than three high.
- Containers of chemicals shall be closed securely to prevent contamination.
- Any shelving units used to store chemicals should be sturdy enough to support the weight of the chemicals being stored.

5.9.1.6 No Mixing

Particularly keep chlorinated cyanurates, hydantoin bromine, and calcium hypochlorite away from other chemicals, paper, water, petroleum products, or other organic compounds to avoid possible cross-contamination.

No liquids should be stored above solids.

Chemicals must be stored in the original manufacturers' labeled container. STORAGE containers that held other chemicals previously are unacceptable. Chemicals may be transferred from the original container to a new container if that container was manufactured for the STORAGE of that chemical and properly labeled.

Aquatics staff should read and consider findings and recommendations developed from investigations related to POOL chemical-related injuries.

- See "CDC Recommendations for Preventing Pool Chemical-Associated Injuries" at: http://www.cdc.gov/healthywater/swimming/pools/preventing-pool-chemical-injuries.html

5.9.1.7 Ignition Sources

NFPA, HMIS, or equivalent hazard rating systems may be used.

5.9.1.9 Lighting

Horizontal-plane illumination must be adequate for SAFETY and navigation, as well as for reading documents.

The IESNA recommends a 30 footcandle *(323 lux)* minimum for Motor & Equipment Observation.

5.9.1.10 Personal Protective Equipment

Common components of PPE for chlorinated AQUATIC VENUE chemicals are as follows:

- **Respiratory Protection:** Wear a NIOSH approved respirator if levels above the exposure limits are possible.
- **Respirator Type:** A NIOSH approved full-face air purifying respirator equipped with combination CHLORINE/P100 cartridges. Air purifying respirators should not be used in oxygen deficient or IDLH atmospheres or if exposure concentrations exceed ten times the published limit.
- **Skin Protection:** Wear impervious gloves to avoid skin contact. A full impervious suit is recommended if exposure is possible to a large portion of the body. A SAFETY SHOWER should be provided in the immediate work area.
- **Eye Protection:** Use chemical goggles. Emergency eyewash should be provided in the immediate work area.
- **Protective Clothing Type:** Neoprene, Nitrile, Natural rubber *(This includes: gloves, boots, apron, protective suit)*.

5.9.2 Chemical Handling

5.10 Hygiene Facilities

5.10.1 General [N/A]

5.10.2 Location [N/A]

5.10.3 Bathhouse Design [N/A]

5.10.4 Plumbing Fixture Requirements

5.10.4.1 General Requirements

Toilets and SHOWERS should appear clean and ready to use to attract BATHERS to use them[445].

445 PWTAG. Swimming pool water; Treatment and quality standards for pools and spas. 2nd edition, 2009. Micropress Printers Ltd.

Although the MAHC is not aware of any work in this particular setting, studies in child care settings, schools, long term care facilities and food service establishments all support the importance of surface cleaning. The MAHC feels that daily cleaning at a minimum in this setting is reasonable for aesthetics as well as health and SAFETY.

5.10.4.3 Rinse Showers

Soap is not needed at RINSE SHOWERS because it can have a negative effect on water chemistry.

5.10.4.5 Diaper-Changing Stations

It is the responsibility of PATRONS to clean diaper changing surfaces after each use. This is consistent with practice in other public settings where diapering takes place. However, staff should keep an eye on stations and clean when necessary.

5.10.4.6 Non-Plumbing Fixture Requirements

Associations between AQUATIC VENUES and disease outbreaks have been well documented in the literature. Though an outbreak has never been connected to the materials used specifically, wood and other porous materials have been shown to have bacterial growth on them that can be hard to remove.

Non-porous materials used as matting at AQUATIC FACILITIES were found to be contaminated with bacteria and biofilm scum layers, although conventional cleaning was documented to remove the contamination[446].

Biofilms are a complex collection of microbes that attach to a wet surface and form a scum layer that harbors bacteria and other microbes that could cause illness. Once established, biofilms provide a home for a variety of microbes such as *Pseudomonas* and are hard to remove. Biofilm-associated bacteria are much more resistant to HOCl compared with free swimming microbes. Design options to reduce biofilm formation as well as sanitizing systems with effective validation, could be useful for reducing biofilm formation.

5.10.5 Provision of Suits, Towels, and Shared Equipment

5.10.5.1 Towels

The drying temperature is more important than the wash temperature when destroying potential infectious pathogens.

- See CDC recommendations for laundering entitled, “Environmental Cleaning & Disinfecting for MRSA” at: http://www.cdc.gov/mrsa/community/enviroment/.

446 Davis TL, et al. Bacteriological analysis of indoor and outdoor water parks in Wisconsin. J Water Health 2009;7(3):452-463.

5.10.5.4 Shared Equipment Cleaned and Sanitized

Research has demonstrated that play features, mat materials, and other shared equipment found at AQUATIC FACILITIES and water parks can harbor bacteria, even while submerged in chlorinated water. Damp materials that were not submerged in water contained the highest populations of bacteria. Damp play features designed for infants and toddlers were found to be likely vehicles for transference of gastrointestinal bacteria.[447]

Sanitization is defined as reducing the level of microbes that are considered safe by public health STANDARDS. This may be achieved through a variety of chemical or physical means including chemical treatment, cleaning, or drying.

Associations between swimming POOLS and disease outbreaks have been well-documented in literature. Though an outbreak has never been connected to play features or the type of play feature material specifically, the possibility could exist due to biofilms found on these materials. Outbreaks may be more likely if the AQUATIC FACILITY is not maintained properly.

Biofilms are structured communities of microorganisms encapsulated within a self-developed polymeric matrix that adhere to a living or inert surface. In AQUATIC VENUES, biofilms form readily in water distribution and recirculation lines, filters, collector tanks, and swimming POOLS. Biofilms form when bacteria begin to excrete a slimy, sticky substance that allows them to adhere to surfaces. The biofilm mass usually consists of many species of bacteria, and can also include fungi, algae, and protozoa. Biofilms are resistant to CHLORINE and are difficult to remove once initial adhesion occurs. The biofilm slime shelters disease-causing microorganisms, protecting them from CHLORINE DISINFECTION. In addition, biofilms exert an oxidant demand, consuming CHLORINE residuals in the distribution line and requiring higher doses at the treatment station for residual maintenance at the end of the line. Design options to reduce biofilm formation as well as sanitizing systems with effective validation, could be useful for reducing biofilm formation.

Contact

Shared equipment that contact mucous, saliva, eyes, or ears require sanitizing to prevent transmission of potential disease causing pathogens.

5.10.5.5 Other Equipment

Shared equipment which is hand held or used as a flotation device used in aquatic therapy or play have also been found to harbor potential harmful microorganisms, even while submerged in properly chlorinated water. Bacteria found in these environments are most likely from biofilms that have attached to these surfaces. Soaking in disinfectants may not be enough to penetrate the biofilm; so to control biofilm growth, it is recommended to physically remove the slimly film by scrubbing equipment on a routine basis. The array of

447 Davis TL, et al. Bacteriological analysis of indoor and outdoor water parks in Wisconsin. J Water Health 2009;7(3):452-463.

organisms isolated from damp features suggests that features need to be cleaned, SANITIZED, and thoroughly dried on a routine basis using a combination of chemical and physical methods, preferably as recommended by the manufacturer[448].

5.11 Water Supply/ Wastewater Disposal [N/A]

5.12 Special Requirements for Specific Venues

5.12.1 Waterslides

Weight is a key variable in the operation of WATERSLIDES. ASTM 2376 Standard Practice for Classification, Design, Manufacture, Construction, and Operation of Water Slide Systems contains STANDARDS for manufacturer and operator responsibilities regarding WATERSLIDE systems. Manufacturer's responsibilities include specifying the maximum number of riders that are to ride in the FLUME at one time and rider weight requirements. Owner/operator responsibilities include specific WATERSLIDE operation policies and procedures including signage addressing maximum/minimum height and weight. See further Annex discussion at MAHC 6.4.2.2.3 on sign messages

5.12.2 Wave Pools

5.12.3 Moveable Floors

5.12.4 Bulkheads

5.12.5 Interactive Water Aquatic Venues

5.12.6 Wading Pools

5.12.7 Spas

5.12.7.2 Drainage and Replacement

For example, a 600 gallon SPA divided by 3 yields 200 divided by 25 *(the average users per day)* produces an 8 day water replacement interval.

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