Cyanuric Acid Change Requests in the MAHC

11-13-20

The Model Aquatic Health Code (MAHC) is being updated, and voting on the change requests (CRs) will open November 13. To join the Council for the Model Aquatic Health Code (CMAHC) and vote, please go to www.cmahc.org.

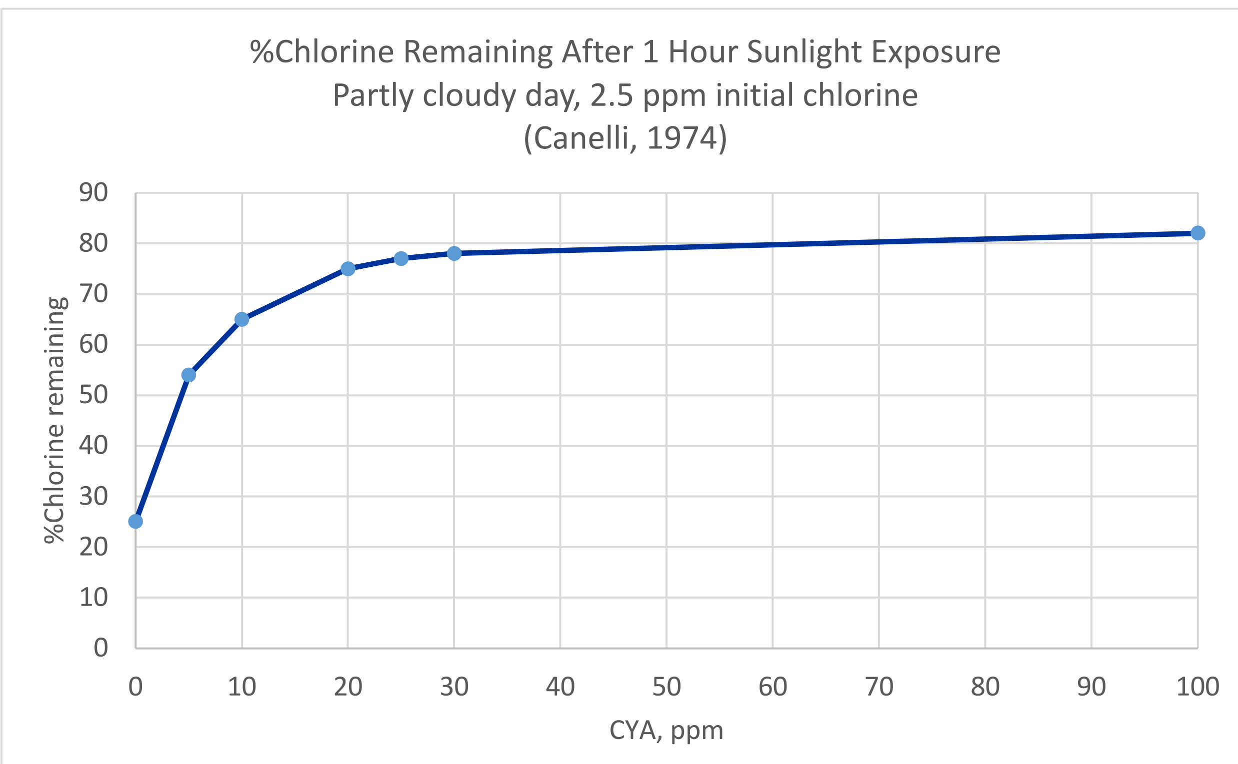
One of the most controversial topics for the current revision cycle has been cyanuric acid (CYA). The variety of CRs in the MAHC regarding cyanuric acid (CYA) can be confusing. Following is a short guide to the CYA CRs and the technical facts behind them. This guide has been updated to include the changes made to CRs after the CMAHC conference.

Background

Before getting into the details of the CRs, the following technical summary provides background information and data to help understand the reasoning behind the requests.

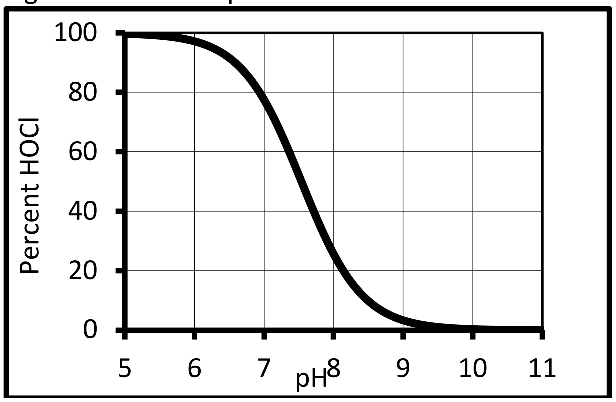
First it is important to understand why CYA may be beneficial in operating pools. The following graph shows that chlorine residuals are resistant to degradation by sunlight in the presence of CYA.

Figure 1. Effect of CYA on chlorine stability



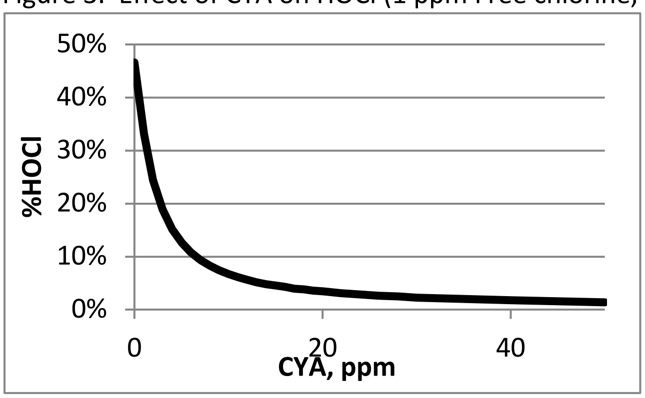
Next it is important to understand the effects of CYA on disinfection. In chlorine pools, the primary disinfectant is hypochlorous acid (HOCl). Figure 2 is the familiar graph showing the effect of pH on HOCl concentrations, which points to the importance of controlling pH to ensure proper disinfection.

Figure 2. Effect of pH on HOCl



Likewise, Figure 3 shows that increasing concentrations of CYA decrease the HOCl concentration.

Figure 3. Effect of CYA on HOCl (1 ppm Free chlorine, pH 7.5)



The following table shows the HOCl concentrations with increasing CYA and 1 ppm free available chlorine as measured by DPD[1] (DPD-FC) at pH 7.5. The last column shows the relative increase in kill time based on the Chick-Watson concept of CT value (i.e. CT = concentration x time needed to achieve inactivation). For instance, if the HOCl concentration is cut in half, then it will take twice as long to kill the organism.

Table 1 HOCl concentrations with 1 ppm DPD- FC and the relative increase in pathogen kill times

CYA, ppm	HOCl, ppm	Relative increase in kill time vs 0 ppm CYA
0	0.486	
10	0.040	12 times longer
15	0.026	19 times longer
20	0.020	24 times longer
30	0.013	37 times longer
45	0.0086	57 times longer
50	0.0077	63 times longer
90	0.0043	113 times longer

100	0.0038	128 times longer

So for an organism that was killed within a minute with no CYA, the kill time would increase to about half an hour with 20 ppm CYA, about an hour with 45 ppm CYA, and about 2 hours with 90 ppm CYA.

The CMAHC Chlorine Stabilizers Ad Hoc Committee (the Committee) published a paper showing the increase in risk of infection with increasing CYA concentrations[2]. As expected, increasing the CYA concentration, decreases the HOCl concentration, increases the time it takes to kill pathogens, and increases the risk of infection.

The Change Requests

Following is a list of the CRs grouped by category:

Definitions
3.2-0033: This CR from the Committee provides a definition for DPD-FC. This is important because DPD measures CYA-bound chlorine as free chlorine, and does not provide a measure of the true sanitizer, HOCl.

Managing CYA and DPD-FC together as a ratio

<u>5.7.3.1.1.2-0001 30:1 CYA:DPD-FC</u>
This CR from the Committee proposes that the CYA:DPD-FC ratio does not exceed 30:1. So if the CYA is 30 ppm, the minimum DPD-FC would be 1 ppm, and if the CYA is 60 ppm, the minimum DPD-FC would be 2 ppm. Since HOCl is fairly constant with constant CYA:DPD-FC ratio, a 30:1 ratio would be equivalent to a minimum HOCl concentration of 0.013 ppm (see Table 1 above).

This 30:1 ratio was a compromise value obtained after objections from manufacturers of stabilized sanitizers. According to the original recommendation from the Committee[2], using a 20:1 ratio would reduce the annual probability of *Giardia* infection by about a factor of 2 and *E. coli* infection by about a factor of five compared to current MAHC limits. The 20:1 ratio would provide a modest reduction in infection risk without imposing major changes to pool operations.

<u>5.7.3.1.1.2-0002 15:1 CYA:DPD-FC</u>
This CR proposes that the CYA:DPD-FC ratio does not exceed 15:1. So if the CYA is 30 ppm, the minimum DPD-FC would be 2 ppm. This ratio would be equivalent to a minimum HOCl concentration of 0.026 ppm.

Calculations outlined in the CR show that this would make free chlorine roughly equivalent to 1 ppm monochloramine for killing *Giardia*. Pool operator courses have taught for decades that pools should be sanitized with free chlorine because combined chlorine is not a sufficient sanitizer. If the CYA:DPD-FC ratio exceeds 15:1, then the sanitizer would be less effective than 1 ppm monochloramine, which is not acceptable.

A ratio of 15:1 is effective in achieving stabilization of chlorine from degradation by sunlight. For the data shown in Figure 1, a 15:1 ratio represents a 2.5 x 15 = 37.5 ppm CYA concentration. No significant increase in stabilization to sunlight occurs with ratios higher that 15:1.

Furthermore, if a pool is operating with a minimum 1 ppm DPD-FC and CYA at 15 ppm, then the pool would not need to be drained to perform the CDC diarrheal fecal accident response.

<u>5.7.3.1.1.2.2-0002 45:1 CYA: DPD-FC</u>
This CR proposes that the CYA:DPD-FC ratio does not exceed 45:1. So if the CYA is 90 ppm, the minimum DPD-FC would be 2 ppm. This ratio would be equivalent to a minimum HOCl concentration of about 0.0086 ppm.

The de-facto ratio currently in the MAHC is 45:1 (2 ppm minimum DPD-FC with 90 ppm maximum CYA).

All three of the ratio CRs (15:1, 30:1 and 45:1) change the minimum DPD-FC concentration when CYA is present from 2 ppm to 1 ppm. As such, all three would increase the risk for pools operating between 1 and 2 ppm DPD-FC compared to the current MAHC.

<u>5.7.3.1.1.2.2-0001 CYA and DPD-FC Table</u>
This CR does not change the minimum DPD-FC concentration required when CYA is present, but provides a means for increasing the required DPD-FC when CYA levels climb. The first two columns in the following table are from the CR. The last two columns show the resulting ratios and HOCl concentrations.

Minimum DPD-FC, ppm	Range of CYA, ppm	Maximum ratio	Minimum HOCl, ppm
2	1 to 30	15:1	0.027
3	31 to 60	20:1	0.020
4	61 to 90	22.5:1	0.018

Absolute limits for chlorine and CYA
5.7.3.1.1.2.1-0001: This CR proposes to change the **minimum DPD-FC for pools using CYA from 2 ppm to 1 ppm**.

5.7.3.1.3.1-0002: This CR proposes to **prohibit CYA in all indoor pools**.

5.7.3.1.3.1-0003: This CR proposes to **delete the prohibition of CYA for spas and therapy pools**.

5.7.3.1.3.2-0001: This CR proposes "if CYA level tests **above 90 ppm** (mg/L), the aquatic venue may remain open during its normal operating hours that day but when it is closed for the day the swimming pool may **not reopened until the CYA level is lowered to 75 ppm** or less. If a pool that operates 24 hours a day, the CYA level must be lowered to 75 ppm or less within 24 hours."

5.7.3.1.3.2-0002: This CR proposes a **40 ppm maximum for CYA**, based on the Committee's published 20:1 ratio and keeping the minimum DPD-FC of 2 ppm when CYA is used.

5.7.3.1.3.2-0003: This CR proposes **a 60 ppm maximum for CYA** and raising the minimum DPD-FC to 3 ppm when CYA is used.

5.7.3.1.3.2-0004: This CR proposes to **raise the CYA maximum to 180 ppm**. In addition to raising the risk of illness in pools, there are practical issues with this CR. The issue with performing dilutions to measure CYA concentrations >90 ppm is handled in the CR by requiring any operators running >90 ppm CYA to prove that they are capable of performing accurate measurements by using dilution techniques. However, the CR does not address the fact that CYA test kits that have the required certifications to NSF-50 are only required to be accurate to within + or – 50% (L3 kits), or require a photometer (L1 or L2 kits). At 180 ppm, +/- 50% represents a range from 90 to 270 ppm, and at 300 ppm, +/- 50 % represents a range from 150 to 450 ppm. So, using the current technology, a concentration of 300 ppm may appear to be below 180 ppm. The CR also does not account for the difficulty in using ORP to control chlorine feed with CYA concentrations as high as 180 ppm.

Testing frequency

5.7.5.8.2-0002: This CR proposes to require **daily** testing of CYA.

5.7.5.8.2-0003: This CR, submitted by the Committee, proposes to require **weekly** testing of CYA.

Training

6.1.2.1.1.5-0001: This CR proposes to add the impact of CYA concentrations on HOCl concentrations to pool operator courses.

Fecal accident response

6.5.3.1.1-0001: This CR proposes to change the formed stool remediation to ensure sufficient HOCl is present for inactivation of *Giardia*. The remediation times will vary depending on the CYA:DPD-FC ratio.

Imminent health threats requiring immediate correction or closure

6.6.3.1-0003: This CR proposes that **<1 ppm DPD-FC**, exceeding a **45:1 CYA:DPD-FC** ratio, or exceeding **300 ppm CYA** should be reason for closure. The 300 ppm value is a toxicity limit calculated by NSF using EPA's SWIMODEL[3]. This CR removes the requirement for pools with CYA to maintain >2 ppm DPD-FC.

6.6.3.1-0004: This CR proposes that exceeding **90 ppm CYA** should be reason for closure. Since the CR references the operational section of the code, if the CYA limit were raised to 180 ppm, then the limit for closure would also be 180 ppm.

6.6.3.1-0005: This CR proposes that **<1 ppm DPD-FC**, exceeding a **150:1 CYA:DPD- FC** ratio, or exceeding **300 ppm CYA** should be reason for closure. The 300 ppm value is a toxicity limit calculated by NSF using EPA's SWIMODEL. This CR removes the requirement for pools with CYA to maintain >2 ppm DPD-FC.

6.6.3.1-0001: This CR proposes that **<1 ppm FC for pools without CYA, <2 ppm DPD-FC for pools with CYA**, or exceeding **117 ppm CYA** should be reason for closure. The 117 ppm value is a toxicity limit calculated by the World Health Organization (WHO)[4]. <1 ppm FC for pools without CYA and <2 ppm

DPD-FC with CYA are already reasons for closure in the 2018 MAHC. This CR just spells out the minimum chlorine requirements in section 6.6.3.1 instead of referring to other sections of the code.

Recommendations

We would like to recommend the following CRs for a Yes vote. We believe that these CRs will provide a reduction in risk of infection compared to the current MAHC, without imposing major changes to pool operations.

Table 2. Vote Yes

<table>
<tr><td>3.2-0033</td><td>DPD-FC definition</td></tr>
<tr><td>5.7.3.1.1.2-0002
Or
5.7.3.1.1.2.2-0001</td><td>Maximum 15:1 CYA:DPD-FC ratio
Or
Table
<table>
<tr><td>Minimum DPD-FC, ppm</td><td>Range of CYA, ppm</td></tr>
<tr><td>2</td><td>1 to 30</td></tr>
<tr><td>3</td><td>31 to 60</td></tr>
<tr><td>4</td><td>61 to 90</td></tr>
</table></td></tr>
<tr><td>5.7.3.1.3.2-0001</td><td>If CYA> 90 ppm, drain to 75 ppm overnight</td></tr>
<tr><td>5.7.5.8.2-0003</td><td>Weekly testing of CYA</td></tr>
<tr><td>6.1.2.1.1.5-0001</td><td>Including CYA vs HOCl in operator training courses</td></tr>
<tr><td>6.5.3.1.1-0001</td><td>Formed stool remediation based on HOCl</td></tr>
<tr><td>6.6.3.1-0001</td><td>Closure for
> 117 ppm CYA
<1 ppm FC for pools without CYA
<2 ppm DPD-FC for pools with CYA</td></tr>
</table>

All of the CRs listed in this document, except those noted below in Table 3 will provide an overall decrease in the risk of illness transmission in pools. Because the CMAHC process does not require that you choose one option, it is possible to vote yes for every CR that will provide greater limitations on CYA. However, we believe that this particular set of CRs in Table 2 provides the optimal balance between chlorine efficacy and chlorine stabilization and so provides the best protection for public health.

We strongly recommend a No vote for the following CRs because they would provide an overall increase in the risk of infection compared to the current MAHC and the recommendations above.

Table 3. Vote No

5.7.3.1.1.2.2-0002	Maximum 45:1 CYA:DPD-FC ratio
5.7.3.1.1.2.1-0001	Change minimum DPD-FC for pools with CYA from 2 ppm to 1 ppm.
5.7.3.1.3.1-0003	Delete the prohibition of CYA for spas and therapy pools.
5.7.3.1.3.2-0004	Raise the CYA limit to 180 ppm.
6.6.3.1-0001	Closure for >150:1 CYA:DPD-FC ratio or >300 ppm CYA

Please let us know if you would like any further information.

---

[1] DPD = N,N-diethylphenylenediamine, a common test kit for free chlorine.

[2] Falk, R.A.; Blatchley, E.R., III; Kuechler, T.C.; Meyer, E.M.; Pickens, S.R.; Suppes, L.M. Assessing the Impact of Cyanuric Acid on Bather's Risk of Gastrointestinal Illness at Swimming Pools. Water 2019, 11, 1314, https://www.mdpi.com/2073-4441/11/6/1314. All of the calculations in this summary were produced using values from this reference.

[3] Cox, K., Hamilton, S. Cyanuric acid (CAS #108-80-5): Estimated maximum allowable concentration in pool water, NSF International, Study number NSF00001, May 28, 2019. This study is available in the attachments to CR 6.6.3.1-0005.

[4] WHO 2006 Guidelines for safe recreational water environments, V 2: Swimming pools and similar environments, https://www.who.int/water_sanitation_health/publications/safe-recreational-water-guidelines-2/en/