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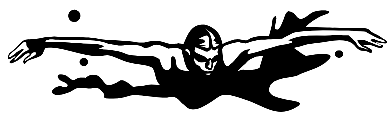


The Aquatic Facility Newsletter for Pool Operators

Inside this issue:

Respiratory Illness Associated with an Indoor Swimming Pool --- Nebraska, 2006

Below is a summary of an article from Center for Disease Control's *Morbidity and Mortality Weekly Report* which describes an outbreak likely associated with exposure to toxic levels of chloramines. The entire article can be reviewed at www.cdc.gov/mmwr/preview/mmwrhtml/mm5636a1.htm

On December 26, 2006, the Nebraska Department of Health received a report of a child hospitalized in an intensive care unit for a severe illness after swimming in an indoor motel swimming pool. The pool was inspected the same day and immediately closed by the Department of Health because of multiple state health code violations. The Department initiated an outbreak investigation to identify additional cases and the cause of the illness. The results of the investigation, which indicated that 24 persons became ill, concluded the outbreak likely was the result of exposure to toxic levels of chloramines that had accumulated in the air in the enclosed space above the swimming pool. Chloramines are disinfection by-products formed when free chlorine, a common disinfectant used in swimming pools, combines with nitrogenous human wastes (e.g. sweat, urine or feces) in pool water. This outbreak highlights the potential health risks from chemical exposure at improperly maintained pools and the need for properly trained pool operators to maintain water quality.

The index patient was an otherwise healthy boy aged 6 years. The boy and his family attended a gathering with relatives at the motel on December 25, 2006, and he spent approximately 3 hours swimming in the pool. During this time, he had onset of coughing and difficulty breathing. He stopped playing in the pool but continued to cough, with one or two episodes of vomiting due to coughing. During a period of 5 hours, the boy's condition worsened and he was taken to a local emergency department. The parents told the physician that multiple persons in their group had developed burning eyes, nasal burning, congestion, and cough. He was transferred to the pediatric intensive care unit in stable condition for observation, with a guarded prognosis and a diagnosis of upper airway obstruction from chemical irritation. The boy's condition gradually improved, and he was discharged the next morning. The attending physician recorded chlorine irritation as the cause of illness.

Investigators learned that the motel belonged to a national chain. The indoor, heated pool measured 40 × 32feet and had a maximum capacity of 70 persons. The immediate pool area was contained within a larger enclosed courtyard area with a single exhaust fan for ventilation in the ceiling directly above the pool. Adjacent guest rooms opened directly into the enclosed courtyard.

Nebraska health code regulations require clean and clear public swimming-pool water with a clearly visible main drain. Acceptable water-chemistry values for swimming pools are as follows: free chlorine, 2--10 ppm; pH, 7.2--7.8; and chloramine (measured as combined chlorine[†]), $\leq$0.5 ppm. Inspection of the motel pool on December 26 revealed multiple state health code violations, including cloudy water, a free chlorine level (0.8 ppm) less than half the minimum, a chloramine level (4.2 ppm) eight times the maximum, and a pH (3.95) approximately half the minimum. Less severe violations included low alkalinity, inadequate daily logs, and an inoperable flow meter. Review of operator logs indicated deterioration of the pool's water quality during the weeks preceding the outbreak.

Before pool closure, the operator recorded inadequate combined chlorine levels for 26 consecutive days. Each log entry for combined chlorine on these days was at least three times higher than the acceptable limit of 0.5ppm, ranging from 1.8--7.0 ppm. During this same period, the operator also recorded pH levels below the lowest acceptable limit of 7.2 on 14 of 26 days and free chlorine levels below the lowest acceptable limit of 2.0 ppm on 5 of 26 days. In addition to improper management of the water chemistry, the ceiling exhaust fan was turned off at the time of the outbreak, and the outside windows of the enclosed courtyard were closed because of cold outdoor air temperatures.

The pool was closed on December 26 and subsequently drained. It reopened February 7, 2007, and no additional illnesses have been reported.

Chloramines can remain in the water or evaporate into the air above the pool, causing a pungent smell. Trichloramine is more volatile than monochloramine and dichloramine and is released into the air more readily. In addition, trichloramine causes more severe irritation and forms more rapidly in water with a low pH, such as the water in this pool. Methods to test chloramine levels in the air exist but are neither routine nor rapid. Therefore, environmental air sampling was not performed as part of this outbreak investigation, and the outbreak could not be specifically linked to elevated levels of chloramines in the air. However, several factors strongly suggest that high chloramine levels in the air were the cause of illness. First, the water's combined chlorine level of 4.2 ppm (at least eight times the acceptable level), together with the water's extremely low pH (3.95), was favorable for formation of high levels of chloramines, particularly trichloramine. Second, all 24 ill persons reported that their symptoms began after they entered the pool courtyard environment, and 70% of ill persons who entered the immediate pool area reported illness onset within 2 hours of entering the area. Finally, ventilation was inadequate during the outbreak; the windows of the pool enclosure were closed, and the ceiling exhaust fan had been turned off, presumably to retain a warmer temperature in the enclosed courtyard.

Chloramines are not considered health hazards in outdoor swimming pools. However, in the enclosed space around indoor pools, they can reach dangerous concentrations and pose a substantial health risk. High concentrations cause acute eye and respiratory tract irritation in swimmers and other persons in the indoor pool environment and might also contribute to asthma and respiratory disease.

In 2004, two similar outbreaks associated with exposure to indoor motel swimming pools were reported in Illinois. Within minutes of entering the indoor pool environments, 72 persons, predominantly children, reported illness with high attack rates and symptoms consistent with chloramine exposure. Water-chemistry abnormalities and inadequate pool maintenance were cited as contributing factors; the investigators suggested that standard education be mandatory for all public pool operators.

Pre-Swim Hygiene

In most jurisdictions, it is common to shower before a swim. Thorough showering will help to remove much of the sweat, urine, fecal matter, dead skin cells, cosmetics, suntan oil and other potential water contaminants that add to the total dissolved solids (TDS) and bacteria load of the pool water. British studies of school age swimmers have shown that pre swim showering removes up to 2/3 of the sweat and 1/3 of the bacteria off the body that would otherwise end up in the pool.[5]

Where pool users normally shower before swimming, pool water is cleaner, easier to disinfect with smaller amounts of chemicals and thus more pleasant to swim in.

Money is saved on chemicals, filter changes or backwashing and drainage and refilling of the pool to reduce the build up of TDS which has an negative effect on the water purification process.

Pollutants combine with the chlorine in the pool water to become chloramines in the water and air. Chloramines are a much poorer disinfectant than chlorine. The production of chloramines can result in an inadequately disinfected swimming pool. Swimming pools, which are not properly disinfected, have been proven to serve as vehicles for the transmission of human disease.

The most appropriate setup for showers is private shower stalls to encourage nude showering and adequate removal of fecal matter from the perianal (rear end) area. Most people have small amounts of fecal material on their perianal region, which can transfer pathogens into the water. Appropriate signage in change rooms and toilets can encourage patrons to adopt more hygienic behaviours. The average adult has 0.14 grams of fecal material on their perianal area and the average child between 1 to 10 grams of fecal material. 1 gram of feces contains 10^{11} microbes.[4]

The role of footbaths and showers in dealing with foot infections is under question. However, it is generally accepted that there must be some barrier between outdoor dirt and the pool in order to minimize the transfer of dirt into the pool. A foot spray is probably the best of the alternatives to footbaths. Where outdoor footwear is allowed poolside (e.g. some outdoor pools), separate poolside drainage systems can minimize the transfer of pollutants to the pool water.[4]

It is also important for pool operators to ensure that they have adequate hygiene facilities available for patrons. Hand washing facilities, including soap dispensers and hand-dryers or disposable hand towels, should be available at hand basins. Shower facilities should have warm water available and be provided with soap. Sanitary diaper changing facilities and diaper bins should be provided in the change rooms. Hygiene facilities should be situated close to the pool to allow easy access, and be well stocked and maintained. Regular inspections and cleaning should be part of routine management, and operators should plan to increase the frequency of these according to patron volume.

"In May of 2004, Opinion Research Corporation (ORC) conducted a survey of nearly 1,000 people over the age of 18. Among the findings:

About 60% said that it is "not likely at all" or "possible but not likely" that a person could get sick from pool water.

Still, 88% agreed you should use soap and water after using the bathroom if you plan to jump back in the pool. Nearly 75% said they shower before going in.

Nearly 94% said a "poop" accident should be reported immediately.

75% pointed the finger at diapered children (although Beach says adults who don't "wipe" thoroughly add 3 to 4 pounds of "solid" matter to the average water park).

One-fifth said if you could smell the chlorine, the pool was safe (chlorine does kill germs, but some organisms die a slow death, lasting in a dangerous state for days). Also, a heavy odor means harmful chemicals have formed.

One-fifth said a little urine never hurt anyone (urine, in fact, does not contain germs, but you can decide how you feel about that statement). [6]

The Centers for Disease Control – healthy swimming campaign is now using the six "P-L-E-As" for protection against recreational water illness which includes the following: [1]

Please do not swim when you have diarrhea … this is especially important for kids in diapers.

Please don't swallow the pool water

Please practice good hygiene. Take a shower before swimming and wash your hands after using the toilet as germs on your body end up in the water.

Please take your kids on bathroom breaks often

Please change diapers in a bathroom and not at poolside

Please wash your child thoroughly (especially the rear end) with soap and water before swimming.

There is no question that the best and simplest way to improve pool water quality is for pools to encourage all customers to use toilets and showers before entering the pool.

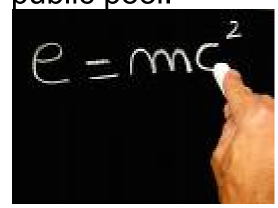
"By reducing this pollution, it is also possible to lower the amount of disinfectant needed to maintain water quality standards leading to a healthier and more pleasurable swimming experience."[3]

References:

1. Castor ML, Beach M. Prevention of recreational water illnesses. Infection diseases in Children website. Available at: www.cdc.gov/healthyswimming/pdf/Prevention%20of%20RWIs_Slack.pdf. Accessed December 17th 2008.
2. CDC. Notice to readers: revised recommendations for responding to fecal accidents in disinfected swimming venues. MMWR website. Available at: http://www.cdc.gov/mmwR/preview/mmwrhtml/mm5706a5.htm. Accessed December 17th 2008
3. Beach MJ. Recreational water illness prevention and swimming pool operation: moving beyond the basics. *J Environl Health.* 2007;69(9).
4. CDC. Surveillance data from swimming pool inspections —selected states and counties, United States, May-September 2002. *MMWR.* 2003;52(22):513-516
5. http://www.swimfit.com/article.asp?ArticleID=31
6. http://www.medicinenet.com/script/main/art.asp?articlekey=50298 - 45k

Important Pool Calculations

The following is a brief summary of calculations that can be used for day-to-day operations at your swimming pool. All of these calculations are covered in more detail during the Saskatchewan Swimming Pool Operator's Course administered by your local Health Region. The manual provided at this course covers these calculations and is an important resource for every public pool.



Area and Volume Equations (section II):

Area of a rectangle (m^2) or (ft^2) = Length x Width
Volume of a cube (m^3) or (ft^3) = Length x Width x Depth
Area of a circle (m^2) or (ft^2) = $\pi \times r^2$
Volume of a circular pool (m^3) or (ft^3)= $\pi \times r^2 \times h$(depth) where $\pi = 3.14$ and r = radius*
* radius is ½ the diameter of a circular pool

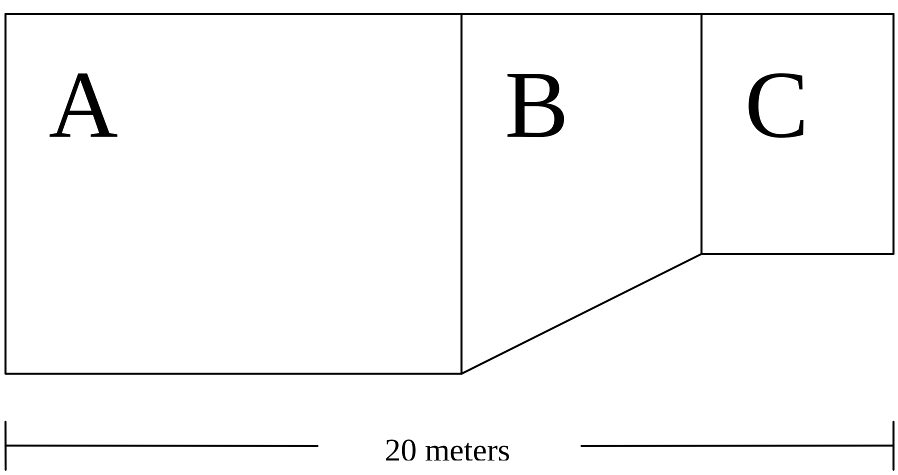
When calculating volume in m^3, multiply your answer by 1000 in order to get the number of litres. When calculating volume in ft^3, multiply your answer by 6.23 to get the number of gallons.

Question 1:

Calculate the volume of a pool that is 20 meters long and 10 meters wide. The depth at the deep end is 5 meters while the shallow end is 1 meter. The length of the shallow end is 5 meters, the deep end 10 meters and the transition area 5 meters.

Solution:

Start by splitting the pool up into sections as shown in the figure where A is the deep portion of the pool, B is the transition area, and C is the shallow portion. The diagram is a side view of an average rectangular swimming pool.



First, determine the volume for each portion separately:

Volume (A) = Length x Width x Depth
= 10m x 10m x 5m
= $500m^3$

Volume (B) = Length x Width x [(D1 + D2) / 2]*
= 5m x 10m x [(5m + 1m) / 2]
= 5m x 10m x 3m
= $150m^3$

* The depth in the transition zone (B) changes so we take the average depth of this portion.

Volume (C) = Length x Width x Depth
= 5m x 10m x 1m
= $50m^3$

To get the volume of the swimming pool, add the volumes of each section together:

Volume = A + B + C
= $500m^3$ + $150m^3$ + $50m^3$
= $700m^3$

To determine the volume in litres or gallons a multiplication factor must be used. There are 1000 litres or 220 imperial gallons per m^3. So to determine the volume in litres or gallons we use the following conversion calculations:

Volume (litres) = $700m^3$ x 1000litres/m^3
= 700,000 litres

Volume (gallons) = $700m^3$ x 220gallons/m^3
= 154,000 gallons

Flow Rate (section II):

The flow rate is the rate at which water is moving through the recirculation system in a pool. A sufficient flow rate will ensure the pool water is filtered and disinfected in a sufficient manner.

Question 2:

The entire pool volume must move through the recirculation system at least 4 times per day. Using the pool volume from Question 1, what flow rate is needed to attain the required 4 turnovers per day?

Solution:

Flow rate = $\frac{\text{Water passing through (litres/day)}}{\text{24 hours/day x 60 minutes/hour}}$

Flow rate = $\frac{\text{700,000 litres x (4 turnovers/day)}}{\text{24 hours/day x 60 minutes/hour}}$

Flow rate = 1944 litres/minute

Therefore, our 700,000 litre swimming pool requires a flow rate of 1944 litres/minute in order to achieve the required 4 turnovers/day. Flow rate is always in litres/minute or gallons/minute.

Number of Turnovers (section II)

If you have a flow meter installed in your pool's recirculation system, the number of turnovers per day can be determined using the following equation. Flow meters will often give both metric (litres/minute) and imperial (gallons/minute) measurements.

Question 3:

Using the values from questions 1 & 2, calculate the number of turnovers per day.

Solution:

\# of turnovers = $\frac{\text{flow rate x 60min/hr x 24hrs/day}}{\text{Volume of pool (litres)}}$

= $\frac{\text{1944 litres/minute x 60 min/hr x 24 hrs/day}}{\text{700,000 litres}}$

= 4 turnovers/day

Adjusting Alkalinity/Calcium Hardness (section V):

When using chemicals to adjust the various aspects of water chemistry in your pool, it is very important to always refer to product label for proper dosing instructions. In this example, we will calculate the required amount of hydrochloric acid required to adjust the total alkalinity in pool water.

Question 4:

An operator of a 500,000 litre swimming pool has measured the total alkalinity at 160mg/l. The desired alkalinity in Saskatchewan is between 80 – 120mg/L. We will use 100mg/l as our desired concentration. Normally, 1.5L of the standard 30-31% hydrochloric (muriatic) acid will lower alkalinity by 10mg/L in 100,000L of water.

Solution:

Litres of Chemical Required =

= Litres of Product x $\frac{\text{Pool Volume}}{\text{Volume from Label}}$ x $\frac{\text{mg/L change required}}{\text{mg/L change from label}}$

= 1.5L x $\frac{500{,}000\text{L}}{100{,}000\text{L}}$ x $\frac{160\text{mg/L} - 100\text{mg/L}}{10\text{mg/L}}$

= 1.5L x 5 x 6

= 45L of acid needs to be added to decrease the total alkalinity from 160mg/L to 100mg/L. Always refer to the Saskatchewan Swimming Pool Operators Course book from instructions on proper acid application.

Saturation Index (section V):

The Saturation Index, also known as the Langelier's Index, is used to determine is pool water is balanced, over saturated, or under saturated. Over saturated water can be scale forming while under saturated water can be corrosive to pool components. This index uses pH, temperature, calcium hardness, alkalinity, and total dissolved solid (TDS) measurements. Each measure is assigned a factor shown in the table below and these factors are be used in the equation. pH is not assigned a factor, rather we use the pH value as it is measured. The factor for TDS is 12.1 if the TDS level is below 1000mg/L and 12.2 is the TDS level is above 1000mg/L.

Saturation Index = pH + TF + CF + AF – TDS factor

Temperature F ° = **TF**	Calcium Hardness = **CF**	Total Alkalinity = **AF**
32° = **0.0**	5 = **0.3**	5 = **0.7**
37° = **0.1**	25 = **1.0**	25 = **1.4**
46° = **0.2**	50 = **1.3**	50 = **1.7**
53° = **0.3**	75 = **1.5**	75 = **1.9**
60° = **0.4**	100 = **1.6**	100 = **2.0**
66° = **0.5**	150 = **1.8**	150 = **2.2**
76° = **0.6**	200 = **1.9**	200 = **2.3**
84° = **0.7**	300 = **2.1**	300 = **2.5**
94° = **0.8**	400 = **2.2**	400 = **2.6**
105° = **0.9**	800 = **2.5**	800 = **2.9**
128° = **1.0**	1000 = **2.6**	1000 = **3.0**

Question 5:

A pool operator wishes to determine if her swimming pool water is balanced. After testing, she determines the pH to be 7.8, temperature to be 80ºF, calcium hardness is 300mg/L, alkalinity is 175mg/L, and the total dissolved solid concentration is 1500mg/L.

Solution:

First step is to find the appropriate factors using the table.

pH - the pH value of **7.8** is used in our equation

Temperature (TF) - an 80ºF temperature is halfway between 0.6 and 0.7 so we will use a factor of **0.65**.

Calcium (CF) - the calcium hardness concentration is 300mg/L so our calcium factor is **2.1**

Alkalinity (AF) - the total alkalinity concentration is 175mg/L so our factor is **2.25**

Total dissolved Solids (TDS) - A TDS value of 1500mg/L requires a factor **12.2**.

Subtract 12.1 if TDS is less than 1000mg/L and subtract 12.2 if TDS is greater than 1000mg/L

SI = pH + TF + CF + AF – TDS factor
= 7.8 + 0.65 + 2.1 + 2.25 – 12.2
= 0.7

If answer is ±0.5, water is balanced
If answer is > +0.5 water is over saturated
If answer is < -0.5 water is under saturated

Our value of +0.7 is greater than +0.5 and therefore the water is over saturated. This condition will cause scale formation within the pool basin and recirculation system. To correct this, we need to adjust certain parameters. Consulting the Saskatchewan Swimming Pool Standards we will see that the alkalinity and calcium concentrations are too high. The alkalinity needs to be lowered to 80 – 120mg/L while the calcium hardness should be within the range of 125 – 275mg/L. Please refer to the relevant section in the Swimming Pool Operator's Course manual on how to adjust these parameters.

Another **Factor Table** for this index can be found on page V-19 of the manual.

Chlorine Dosage Equation (section VI):

On a hot, sunny day, the chlorine concentration in a public swimming pool can drop quickly. It is important to know how to make measured adjustments in order to minimize downtime. This chlorine dosage equation is useful for adjustments made using a liquid or granular chlorine product.

Question 6:

An operator, about to open a public swimming pool for the day, tests the free available chlorine and finds the concentration to be 0.6mg/L. Saskatchewan's Swimming Pool Regulations require the minimum concentration to be at least 2.0mg/L. The operator has a container of "HTH" chlorine, also known as calcium hypochlorite, which he can use to adjust the chlorine. Our pool is 700,000 litres and the calcium hypochlorite concentration is 65%.

Solution:

We already have a little bit of chlorine in the pool so we need to determine the amount of chlorine necessary in order to bring the concentration up to the necessary level.

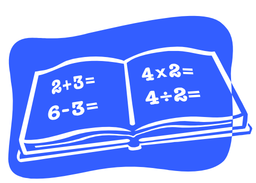
$$\begin{aligned}\text{Chlorine dosage} &= 2.0\text{mg/L} - 0.6\text{mg/L} \\ &= 1.4\text{mg/L}\end{aligned}$$

We need to add enough chlorine into the pool to raise the chlorine concentration by 1.4mg/L. To determine the amount of calcium hypochlorite we need we use the following formula:

$$\begin{aligned}\text{Chlorine required} &= \frac{\text{Litres of Water x Dosage (mg/L) x 1kg/L}}{\text{Strength of Chlorine x 10,000}} \\ &= \frac{\text{700,000 L x 1.4mg/L x 1kg/L}}{\text{65 x 10,000}} \\ &= \text{1.5 kg}\end{aligned}$$

Therefore we need to add 1.5kg of "HTH" or 65% calcium hypochlorite to our pool water in order to raise the free chlorine concentration from 0.6mg/L to the minimum of 2.0mg/L. Feel free to increase the free chlorine residual 1 – 2 mg/L above the minimum level to ensure there is a sufficient amount of free chlorine to meet the demand on hot, busy days!

This summary covers many of the necessary pool calculations but is by no means comprehensive. If further information is needed, consult your Swimming Pool Operator's Course manual or contact your local Public Health Inspector. Contact information for the inspector in your area is provided in this newsletter.



For information regarding upcoming Provincial Swimming Pool Operators Courses please contact your local public health office for details.

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Regina Qu'Appelle Health Region
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