ENVH 440
December 9, 2009

Charles Easterberg
Lecturer, DEOHS

Swimming Pools and Spas

We must learn enough to **OUT-THINK** swimming pools and spas. Must know enough to be helpful.

1. Know regulations (a history of mistakes)
2. Understand how pools work
3. Know human nature

RESOURCES

WAC 246 - 260 WATER RECREATION FACILITIES regulations
Chapter 246-260 WAC (October 31, 2004)

Pool Operator's Manual:
WSPHA / WSEHA; 1997

Recommended Practice for Design, Equipment & Operation of Swimming Pools and Public Bathing authored by the APHA, CDC, NSPI jointly

- NSPI **Certified Pool Operator** certification class and materials
- Gabrielsen: **Swimming Pools** latest edition
- Pool sales companies and installers
- Citizen/professional groups: April Pool's Day

Public health basis for regulation:

1. Swimming is major recreational activity with high potential for lethal consequences
    - Drowning
    - Serious, long term injury: para-and quadraplegia
    - Disease morbidity
2. Pool sales and installations are increasing
3. Other water activities are increasingly popular

State Regulations

Define: public, semi-public, private pool
Cover: water quality, disinfection, sanitation and safety
Basic requirements:
Permit from health department and city
Plan review
Potable water
No connection with sewer

State Requirements (continued)

No cross connections
Materials: impervious, cleanable, light-colored
Hydrostatic relief
Water circulation:
shallow: deep
bottom; top except in diving tank
turnover: 100% of volume must circulate every 6 hrs or less
Filtration
Chemical minimums and maximums
Chlorine rooms (if gas chlorine used)
Monitoring & record keeping
Lifeguards
Lighting
Depth markings
Emergency equipment
Barriers
Bather loads

Hazards: natural water (in US)

Schistosome cercarial dermatitis (swimmers' itch)
Encephalopathies*Naegleria & Acanthamoeba:* fatal meningioencephalitis-causing amoebas
Leptospirosis from wild and domestic animal urine
Protozoans: giardiasis, *Cryptosporidium*

Hazards: natural fresh water elsewhere in world

- Schistosomiasis (snail fever)

Hazards: swimming pool

1. Skin rashes:
   Staphylococcus aureus
   Pseudomonas aeruginosa
   Mycobacterium granuloma
   MRSA
2. Enteric pathogens:
   Salmonella
   Shigella
   Norovirus?
   Worse?
3. Eye infections; conjunctivitis
4. Ear infections (*Pseudomonas*)

POOL BASICS

All pools must have certain components:

Water-holding space (the swimming part)
Pump (to move the water around)
Hair strainer (to remove the big things)
Filter (s) (to remove the tiny things)
Disinfection regulating system (to add disinfectant when needed)
pH regulating system (to govern chlorine's bactericidal action)
Temperature control (for comfort)
Flow meter(s) (to know whether the water is being treated)

RECIRCULATION = TURNOVER RATE

Washington State regulations require 1 turnover every 6 hours to assure that disinfection and filtration are occurring.

Turnover Rate

$$\frac{\text{the pool's volume (gallons)}}{360} = \text{minimum legal flow in gallons per minute}$$

Example: IMA pool holds 260,000 gallons

$$\frac{260{,}000}{360} = 723 \text{ gpm minimum recirculation rate}$$

IMA pool= 260,000 g = 723 GPM
Hutchinson pool = 84,000 g = 234 GPM
Pavilion pool = 180,000 g = 500 GPM

Water flow determinants:

Gutter + main drain(s) water volume capacity
Filter area: the area in inches^2 which will allow water to pass
Pump size: determines the maximum rate at which water can be *propelled* (pushed or sucked; not merely flow)
Circulation pipe interior:

1. size (diameter in inches)
2. condition (smooth or lumpy [tubercled]) determines interior dimension and friction which limits the maximum flow at which water can move

WATER REMOVAL

a) Main drains:
   1. remove water
   2. must prevent enough suction to entrap swimmers, especially children
      - 2 main drains
      - Deepest place in pool
      - Grates must be at least 4x exit pipe diameter
      - Grates must limit maximum water velocity to 1.5 fps max

b) Gutters = must remove at least 60% of exiting water
      - Like having multiple drains all around the pool perimeter

- Evaporation: the warmer the water the faster this happens
- Swimmers: carry water away on their bodies and suits

FILTERS

1. Slow rate sand
2. Rapid sand
3. Diatomaceous earth (DE)
   - Pressure
   - Vacuum
4. CARTRIDGE (small pools)

BACKWASH or replace all filters when resistance reaches 14 psi.

FILTER AIDS sometimes help lengthen the time between backwashes

a) Alum + bicarbonate alkalinity = floc
   Sand & anthracite filters only

b) Wood fiber pre-coat: DE filters only

WATER PARAMETERS

PHYSICAL:

Smell : it shouldn't
Color: blue, blue-gray
Clarity: high
Turbidity: < 0.5 TU; 1 TU peak use
Temperature: comfortably cool

CHEMICAL:

pH = 7.4 - 7.6
Disinfectant concentration as applicable
Chloramines: low; $\leq$ 50% of free disinfectant value
Alkalinity: 80 - 120 mg/l
Hardness: 100 - 200 mg/l
Corrosivity: none

ADEQUATE DISINFECTION

- Protects health by killing pathogens
- Usually by chlorine in one form or another
- Prevents algae growth
- May oxidize organic compounds
- Produces "polished" water

BACTERIAL STANDARDS

Heterotrophic plate count (HPC)

#200 / ml in 2 consecutive tests

Total coliforms

Millipore Filter Test: < 1/100 ml in 2 consecutive tests

MPN Test: < 1+ tube in 2 consecutive tests

What is the best indicator organism?

E. coli?

Fecal coliforms?

Pseudomonas?

HPC?

A good bacterial indicator organism must have most of these attributes:

- not a pathogen
- Indicative of pollution
- present when pathogens present
- absent " " absent
- Dependable
- Durable: outlive pathogens
- Easily and quickly culturable
- Cheap to test for

Non-chlorine disinfectants

- Iodine
- Bromine
- Ozone
- Copper-silver ions
- Ultraviolet

CHLORINE: the commonest disinfectant

HYPOCHLOROUS ACID is produced when Cl2 dissociated in water and **does the disinfecting:** $Cl^{2-} + H_2O \rightarrow H_2^+ + OCl_2^-$

Chlorine in both hypochlorite forms is fed by a hypochlorinator

1. Calcium hypochlorite = 65% available chlorine; a solid
   - Erosion brick or cartridge (small pools, spas)
   - Basket with pellets or cake
2. Sodium hypochlorite = 5¼% - 14½% available chlorine (bleach)
   - Liquid fed by a pump
3. Chlorine gas (increasingly rare today because of hazard to swimmers)

   "1% of my business produces 99% of my risk."

   -Anonymous chlorine gas distributor

   - **INJECTOR**

     Under continuous pressure

     Non-code today
   - **EJECTOR**

     ejection from tank only under vacuum; gas must be sucked out of tank into pool recirculation pipe. Hazardous because it is under **constant pressure** in the tank and piping system as well as highly toxic.
4. **Hidden hazard** if suction can be created somehow sufficient to release gas due to unforeseen factors

   If gas used, its chlorinator room must be:
   - Above grade (not downstairs in a basement)
   - Open to exterior
   - Door opening out
   - Have a mask / SCBA in immediate vicinity
   - Exhaust fan with automatic sensor or switch operable from **outside** Cl^2 room
   - Gas alarm

Disinfectants: Washington State Health Department Regulations

pH ranges	7.2-7.5	7.5-7.8	7.8-8.0	Maximum
Cl_2 (gas, hypo)	1.0	1.4	1.8	6
Cyanurate	1.5	2.0	2.8	6
Bromine	2.0	3.5	3.5	6
SPA (Cl_2)	2.5	2.9	3.3	10

BREAKPOINT CHLORINATION: the addition of sufficient chlorine to oxidize chloramines until the free residual chlorine rises **proportionally** to chlorine added.

OZONE

►Neither system produces a germicidal residual

Europe uses: corona discharge principle generators
- total column vs. sidestream
- totally de-ozonate vs. leaving some in water
- professional pool operators vs. unskilled operators in US

US: uses UV light treatment generators; very uncommon
- Small output compared to corona discharge systems (*das Mickey Maus*)
- 0.05 ppm max: animal tests
  - 0.08 - 0.12: collagen in lungs
- Offgassing: 0.4 - 0.5 ppm
  - Scratchy throat at rest
- Leaking generators; ozonator room required for separation

ALKALINITY

- Pool's ability to neutralize H+
- Buffering agent: stabilizes pH
- Expressed as BICARBONATE at pH 7.0 - 7.9
- Ideal: 80 - 120 mg/l

→Alkalinity is consumed by Cl_2 so must be replaced regularly

Added as:
1. Caustic soda NaOH = 0.8 ppm
2. Soda ash Na_2CO_3 = 1.1 ppm
3. Baking soda $NaHCO_3$ = 1.7 ppm

HARDNESS

- Pool water's dissolved minerals
- Causes or prevents corrosion of metal pipes, pumps
- Ideal : 120 - 180 mg/l
- Expressed as ppm $CaCO_3$
- Added as calcium chloride

Pool Water Testing

Note: a well-trained pool operator is essential. Also: assuredly not colorblind

Essential tests:
- pH
- Disinfectant
- Alkalinity
- Hardness
- Temperature
- OPTIONAL TEST: Langelier Saturation Index for water corrosivity

►DISINFECTANT: several times daily or whenever pool is operating
►pH: equally often as disinfectant
►Alkalinity, hardness, any other parameters: weekly
►Langelier SI: whenever you want to know if water is corrosive or scale-forming

LANGELIER SATURATION INDEX

Assesses water's **corrosivity:** whether it will form scale on pipes or dissolve them. In soft-water areas like Western Washington, soft water dissolves pipes and pump impellors.

Using Langelier's tables, insert a pool's values as done below:

pH=	7.5
+TF=	+0.7
+CF=	+1.7
+AF=	+2.2
-- 12.1	-- 12.1
0.0 ± 0.5 = OK; ALLOWABLE	00.0 = **PERFECT BALANCE**

GOAL= ±0.5 = **BALANCE**
A negative value > -0.5 indicates the pool water is **corrosive** to piping
A positive value > +0.5 indicates the pool water is **scale-forming**

Testing Equipment

Meters

- Black Box Theory again
- Cost
- Calibration

Kits

Black Box Theory: any instrument or kit will always give an answer. How do we know it is correct?

- Liquid
- Powder or tablet
- Light used to measure color
- Note: ~5% of males have red-pink color blindness; cannot measure fine color differences when reading test kit results

VENTILATION

- Negative pressure
- Removes chloramines
- Removes humidity
- Prevents rust, corrosion, odors
- Air should hit surfaces, not people
- Energy efficiency concerns today

LIGHTING

- Allows lifeguards to see into water
- Illuminates walkways, decks, pool bottoms
- Prevents slips, falls
- Aids cleaning

SPAS and HOT TUBS

Same as swimming pools but consider them MINIATURE SEWAGE TREATMENT PLANTS because:

- Small water volume; lots of bodies = high bather : volume ratio
- High temperature = sweat, bacterial growth
- Constantly circulating water = distributes bacteria, nutrients, disinfectant
- SPAS: must have complete turnover every 30 minutes
- Nutrient buildup: salts, dirt, slime
- Should run 24/7 to produce constant disinfection to prevent bacterial growth followed by water being forced into pores by pump; a grand bacterial infection opportunity

A perfect bacterial infection opportunity environment

- Ear, Eye infections: *Pseudomonas spp; Staphylococcus spp.*
- Legionnaire's disease: organisms breed in filters, pipes, become aerosolized
- Bacterial dermatoses:
  Pseudomonas aeruginosa
  Staphylococcus aureus
  Mycobacterium granuloma

BATHERS:

Showered; pre-bathed, clean
No skin infections

Maintain disinfectant levels
Maintain filters
Keep clean
Drain / refill:

$$\frac{V}{3} = \frac{500}{3} = 8.3 \text{ days per run}$$

- V = spa volume in gallons
- 3 = average number of daily users of this particular spa. If more, shorter run time; if fewer, then a longer run time.

Temperature maximum in Washington: 104°F because of possibly pregnant women.

No alcohol because of possible inebriation-induced drowsiness which has led to drowning.