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CPO Pool Math Workbook

Math Calculation Formulas
Disinfectants
Pool Volume
Turnover & Flow Rates
Water Balance
Chemical Adjustment
Breakpoint Chlorination

MATH CALCULATION FORMULAS

Amount Conversions

Ounces to Pounds =	Ounces ÷ 16 = Pounds
Fluid Ounces to Gallons =	Fluid Ounces ÷ 128 = Gallons

Distance Conversions

Yards to Feet =	Yards x 3 = Feet
Meters to Feet =	Meters x 3.28 = Feet

Surface Areas **Radius = Diameter ÷ 2*

Rectangle or Square =	Length x Width = Square Feet
Circle =	3.14 x Radius x Radius = Square Feet

Pool/Spa Volume **Average Depth = (Shallow + Deep) ÷ 2*

Rectangle =	Length x Width x Average Depth x 7.5 = Gallons
Circle =	3.14 x Radius x Radius x Average Depth x 7.5 = Gallons

Turnover Rate

Hours =	Pool Volume ÷ Flow Rate ÷ 60 = Hours

Flow Rate

Gallons Per Minute (GPM) =	Pool Volume ÷ Turnover Rate ÷ 60 = GPM

Filter Surface Area

Square Feet =	Flow Rate ÷ Filtering Rate = Square Feet

Heater Sizing

British Thermal Units (BTU) =	Pool Volume x 8.33 x Temperature Adjustment = BTU

Spa Water Replacement Frequency

Replacement Internvals (Days) =	Spa Gallons ÷ 3 ÷ Average Users Per Day = Days

CHARACTERISTICS OF DISINFECTANTS

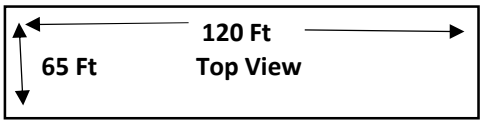
Disinfectants inactivate or kill the vast majority of microorganisms that can cause disease (pathogens). Pathogens include bacteria, fungi, viruses, and protozoan parasites. In addition, disinfectants are effective at killing algae.

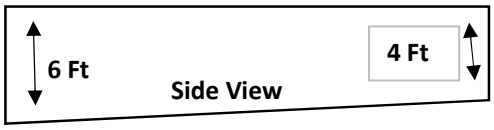
	Sodium Hypochlorite	Calcium Hypochlorite	Lithium Hypochlorite	Gas Chlorine	Trichlor	Dichlor	BCDMH (Bromine)
% Available Chlorine	10-12%	47-78%	35%	100%	90%	56-63%	27%
% Active Strength	10-12%	47-78%	29%	100%	>99%	>99%	95.50%
pH in 1% Solution	9-14	8.5-11	10.8	0	2.8-3.5	6.5-6.8	4.8
pH Effect in Water	Raises	Raises	Raises	Lowers	Lowers	Neutral	Lowers
Physical Appearance	Liquid	Granular, Tabs, Briquet	Granular	Gas	Granular, Tabs	Granular	Granular, Tabs

POOL & SPA VOLUME

Pool Volume **Average Depth = (Shallow + Deep) ÷ 2*

Rectangle = Length x Width x Average Depth x 7.5 = Gallons





Your pool is 120 ft long by 65 ft wide. The shallow end is 4 ft and the deep end is 6 ft.

What is the volume in gallons?

Length_____ x Width____ x Average Depth____ x 7.5 = Gallons____

Length 120 x Width 65 x Average Depth____ x 7.5 = Gallons____

*(Shallow 4 + Deep 6) ÷ 2 = *Average Depth 5*

Length 120 x Width 65 x Average Depth 5 x 7.5 = Gallons 292,500

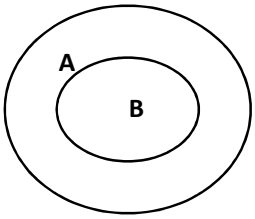
EXAM AREA:

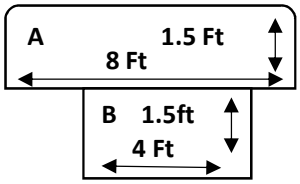
Length_____ x Width____ x Average Depth____ x 7.5 = Gallons____

Length_____ x Width____ x Average Depth____ x 7.5 = Gallons____

Spa Volume **Diameter ÷ 2 = Radius*

Circle = 3.14 x Radius x Radius x Depth x 7.5 = Gallons





Your spa diameter is 8 feet, your seating depth is 1.5 feet. The footwell diameter is 4 feet and has a depth of 1.5 ft.

What is the spa volume?

TOTAL SPA VOLUME = A VOLUME + B VOLUME

A 3.14 x Radius ___ x Radius ___ x Depth ___ x 7.5 = Gallons ___

3.14 x Radius 4 x Radius 4 x Depth 1.5 x 7.5 = Gallons 565.2

B 3.14 x Radius ___ x Radius ___ x Depth ___ x 7.5 = Gallons ___

3.14 x Radius 2 x Radius 2 x Depth 1.5 x 7.5 = Gallons 141.3

TOTAL SPA VOLUME___ = A VOLUME___ + B VOLUME____

TOTAL SPA VOLUME 94.2 OR 94 Gallons = A VOLUME 75.36 + B VOLUME 18.84

EXAM AREA:

A 3.14 x Radius ___ x Radius ___ x Depth ___ x 7.5 = Gallons ___

B 3.14 x Radius ___ x Radius ___ x Depth ___ x 7.5 = Gallons ___

TOTAL SPA VOLUME___ = A VOLUME___ + B VOLUME____

TURNOVER RATE (TR) & FLOW RATES (FR)

Turnover Rate (TR) - When the total volume of a pool is passed through its filter within a 6-hour period, the pool has had one turnover per 6 hours or 4 turnovers per 24 hours. Codes require that the entire volume of pool water be circulated through the filter in a certain time period. Rates for some water park and speciality pools may vary due to unique conditions, and turnover requirements vary by jurisdictional codes.

Turnover Rate Standards: The following turnover rates are considered standard in most jurisdictions. Use these values to calculate the minimum required flow rate for your facility:

- ·Swimming Pools - 6 Hours
- ·Spas - 30 Minutes
- ·Wading Pools - 1 to 2 Hours
- ·Waterparks/specialty pools - 3 to 4 Hours
- ·Hospital.Health Club Pools - as low as 3 Hours
- ·Therapy Pools - 2 Hours

Flow Rate (FR) - The flow rate is the number of gallons per minute passing a given point in the ciruculation system. Find the required flow rate in gallons per minute (gpm) with a known turnover rate and pool volume.

Formula: Pool Volume (in gallons) ÷ Turnover Time (in hours) ÷60 (min./hour) = Flow Rate (FR in gpm)

Relationship Between Turnover Rate and Flow Rate:

Pool volume (in gallons), FR is the Flow Rate of the pump (in gpm), 60 is the conversion for minutes per hour, and TR is the Turnover Rate

Flow Rate

Pool Volume ÷ TR (in hours) ÷ 60 min = FR in GPM

Example: In a 200,000 gallon pool at a 6 hour turnover rate, what is your flow rate?

Pool Volume _____ ÷ TR _____ (in hours) ÷ 60 min = FR _____ in GPM
Pool Volume 200,000 ÷ TR 6 (in hours) ÷ 60 min = FR 555.56 in GPM

Turnover Time

Pool Volume ÷ FR ÷ 60 min/hr = TR in Hours

Example: In a 185,000 gallon pool with a FR of 550 gpm has a turnover rate of?

Pool Volume _____ ÷ FR _____ ÷ 60 min/hr = TR_____ in Hours
Pool Volume 185,000 ÷ FR 550 ÷ 60 min/hr = TR 5.6 in Hours

EXAM AREA:

FR Formula Pool Volume _____ ÷ TR _____ (in hours) ÷ 60 min = FR _____ in GPM

TR Formula Pool Volume _____ ÷ FR _____ ÷ 60 min/hr = TR_____ in Hours

WATER BALANCE - SATURATION INDEX

SI =	pH +	Tf +	Cf +	Af -	TDSf
Saturation Index	pH as Tested	Temperature Factor	Calcium Factor	Alkalinity Factor	TDS Factor

Example:

You are the operator of 100,000 gallon pool. The water tests give you the following readings:
Total alkalinity is 75 ppm. pH 7.4 Calcium hardness 125 ppm. Temperature is 84.
Total dissolved solids is 500 ppm. What is your saturation index?

Saturation Index Factors

Temperature		Calcium Hardness (Expressed as CaCO3)		Total Carbonate Alkalinity	
F	Tf	ppm	Cf	ppm	Af
32	0.0	25	1.0	25	1.4
37	0.1	50	1.3	50	1.7
46	0.2	75	1.5	75	1.9
53	0.3	100	1.6	100	2.0
60	0.4	125	1.7	125	2.1
66	0.5	150	1.8	150	2.2
76	0.6	200	1.9	200	2.3
84	0.7	250	2.0	250	2.4
94	0.8	300	2.1	300	2.5
105	0.9	400	2.2	400	2.6
		800	2.5	800	2.9

Total Dissolved Solid Factors

TDS	Factor
≤ 800	12.1
801 - 1,500	12.2
1,501 - 2,900	12.3
2900 - 5,500	12.4
> 5,500	12.5

	Value	*Factor*
pH	7.4	+7.4
Temperature	84	+0.7
Calcium Hardness	125	+1.7
Carbonate Alkalinity	75	+1.9
Sub-Total		11.7
Total Dissolved Solids	500	-12.1
Saturation Index		-0.4

EXAM AREA:

	Value	*Factor*
pH		
Temperature		
Calcium Hardness		
Carbonate Alkalinity		
Sub-Total		
Total Dissolved Solids		
Saturation Index		

CHEMICAL ADJUSTMENTS

Pool Volume _____ ÷ 10,000 x ppm change _____ x Chemical Used _____ ÷ Essential Conversion_____ = _____

Increase Chlorine	**1 ppm**
Chlorine Gas	1.3 oz
Calcium Hypochlorite (67%)*	2 oz
Sodium Hypochlorite (12%)	10.7 fl oz
Lithium Hypochlorite	3.8 oz
Dichlor (62%)	2.1 oz
Dichlor (56%)	2.4 oz
Trichlor	1.5 oz

Decrease Chlorine	**1 ppm**
Sodium Thiosulfate	2.6 oz
Sodium Sulfite	2.4 oz

Increase Calcium Hardness	**1 ppm**
Caclium Chloride (100%)	1.44 oz
Calcium Chloride (77%)	1.92 oz

Increase Total Alkalinity	**1 ppm**
Sodium Bicarbonate	2.24 oz
Sodium Caronate	1.4 oz
Sodium Sesquicarbonate	2 oz

Decrease Total Alkalinity	**1 ppm**
Muriatic Acid (31.4%)	2.6 fl oz
Sodium Bisulfate	3.36 oz

Increase Stabilizer	**1 ppm**
Cxyanuric Acid	1.3 oz

***Appendix B-2 in Pool & Spa Operator Handbook*

Essential Conversions: Always convert to pounds or gallons

Converting Ounces to Pounds: Total Ounces ÷ 16 = Pounds

Converting Fluid Ounces to Gallons: Total Fluid Ounces ÷ 128 = Gallons

Example:

You operate a 15,000 gallon pool with a calcium hardness level of 150 ppm. How much calcium chloride (77%) would be required to increase this pool to 220 ppm?

Pool Volume _____ ÷ 10,000 x ppm change _____ x Chemical Used _____ ÷ Essential Conversion_____ = _____

Pool Volume 15,000 ÷ 10,000 x ppm change 70 x Chemical Used 1.92 ÷ Essential Conversion 16 = 12.6 lbs

Example:

How much sodium thiosulfate would you need to lower the free chlorine from 16 ppm to 2 ppm in a 60,000 gallon pool?

Pool Volume _____ ÷ 10,000 x ppm change _____ x Chemical Used _____ ÷ Essential Conversion_____ = _____

Pool Volume 60,000 ÷ 10,000 x ppm change 14 x Chemical Used 2.6 ÷ Essential Conversion 16 = 13.65 lbs

Example:

How many gallons of sodium hypochloite will be needed to raise the free chlorine from 2 ppm to 4 ppm in a 250,000 gallon pool?

Pool Volume _____ ÷ 10,000 x ppm change _____ x Chemical Used _____ ÷ Essential Conversion_____ = _____

Pool Volume 250,000 ÷ 10,000 x ppm change 2 x Chemical Used 10.7 ÷ Essential Conversion 128 = 4.18 gallons

Exam Area:

Pool Volume _____ ÷ 10,000 x ppm change _____ x Chemical Used _____ ÷ Essential Conversion_____ = _____

Pool Volume _____ ÷ 10,000 x ppm change _____ x Chemical Used _____ ÷ Essential Conversion_____ = _____

Pool Volume _____ ÷ 10,000 x ppm change _____ x Chemical Used _____ ÷ Essential Conversion_____ = _____

BREAKPOINT CHLORINATION

The term breakpoint chlorination is used to describe the process of adding free chlorine (FC) to treat, oxidize or remove combined chlorine. To achieve breakpoint, the free chlorine (FC) in the water must be raised to about 10 times the amount of combined chlorine (CC).

TC -	FC =	CC
		Combined
Total Chloine	Free Chlorine	Chlorine

#1 TC_____ - FC_____ = CC _____

#2 CC _____ x 10 = Breakpoint Chlorination (BPC) _____

#3 BPC _____ - FC _____ = PPM Change _____

#4 Pool Volume _____ ÷ 10,000 x PPM Change _____ x Chemical* _____ ÷ Conversion _____ = _____

**(See Appendix B-2 for chemical)*

Essential Conversions: Always convert to pounds or gallons

Converting Ounces to Pounds: Total Ounces ÷ 16 = Pounds

Converting Fluid Ounces to Gallons: Total Fluid Ounces ÷ 128 = Gallons

Example: You have a 65,000 gallon pool that has a free chlorine (FC) reading of 1.5 ppm and total chlorine (TC) reading of 3 ppm. How much calcium hypochorite is needed to reach breakpoint?

#1 TC 3 - FC 1.5 = CC 1.5

#2 CC 1.5 x 10 = Breakpoint Chlorination (BPC) 15

#3 BPC 15 - FC 1.5 = PPM Change 13.5

#4 Pool Volume 65,000 ÷ 10,000 x PPM Change 13.5 x Chemical* 2 ÷ Conversion 16 = 10.97 lbs

**(See Appendix B-2 for chemical)*

Exam Area:

#1 TC_____ - FC_____ = CC _____

#2 CC _____ x 10 = Breakpoint Chlorination (BPC) _____

#3 BPC _____ - FC _____ = PPM Change _____

#4 Pool Volume _____ ÷ 10,000 x PPM Change _____ x Chemical* _____ ÷ Conversion _____ = _____

**(See Appendix B-2 for chemical)*