Facts, Formulas & Other Information

Swimming Pool Chemicals:

Chlorine:

Types of Chlorine	% of Chlorine	pH
Elemental Gas Chlorine	100%	Less than 1.0
Sodium Hypochlorite (Liquid)	12-15%	11.8
Calcium Hypochlorite	65%	13.0
Lithium Hypochlorite	35%	10.7
Sodium-dichlorite-s-triazinetrione (Di-Chlor)	55%	6.8-7.0
Triclhor-s-triazinetrione (Tri-Chlor)	90%	2.5-3.0
Liquid Bleach (1/3rd-1/2 the strength Sodium Hypo)	5-6%	High

Di-Chlor and Tri-chlor are both stabilized chlorine compounds. Cyanuric acid levels will increase over time with the use of these two types of chlorine.

All chlorine types make the same thing when added to water, Hypochlorous acid (HOCI) and Hypochlorite Ions (OCI). The Hypochlorous acid is the active sanitizer and the Hypochlorite ions are the less active sanitizer. Percentage of activity is predicated on pH. Sanitizing activity is a GOOD thing!

Never mix the different types of chlorine together!

Chlorine Dosage Chart

Chlorine Gas (100%) (Chlorine Gas NOT FOR HOMEOWNER USE)

Volume of pool / 120,000 x _____ ppm desired change = _____pounds

Sodium Hypochlorite (Liquid Chlorine)

Volume of pool / 120,000 x _____ ppm desired change = _____ gallons

Calcium Hypochlorite (Cal-Hypo @ 67%)

Volume of pool / 78,000 x _____ ppm desired change = _____ pounds

Lithium Hypochlorite (35%)

Volume of pool / 42,000 x _____ ppm desired change = _____ pounds

Trichlor (90%)

Volume of pool / 108,000 x _____ ppm desired change = _____ pounds

Dichlor (56%)

Volume of pool / 67,200 x _____ ppm desired change = _____ pounds

Dichlor (62%)

Volume of pool / 74,400 x _____ ppm desired change = _____ pounds

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To Neutralize Chlorine

Sodium Sulfate

Volume of pool / 67,250 x _____ ppm unwanted chlorine = _____ pounds

Sodium Thiosulfate

Volume of pool / 117,600 x _____ ppm unwanted chlorine = _____ pounds

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Chlorine Conversion/Comparison Chart

1 lb of gas chlorine = (1 gallon liquid chlorine) = (1 lb 8-1/2 oz Cal-Hypo) = (2lb 13-1/2 oz Lithium Hypo) = (1 lb 12-1/2 oz Sodium Dichlor) = (1 lb 2 oz Trichlor)

1 Gal Liquid Chlorine = (1 lb gas chlorine) = (1 lb 8-1/2 oz Cal-Hypo) = (2 lb 8-1/2 oz Lithium Hypo) = (1 lb 12-1/2 oz Sodium Dichlor) = (1 lb 2 oz Trichlor)

1 lb Calcium Hypochlorite = (10-1/2 oz gas chlorine) = (2/3 gallon liquid chlorine) = (1lb 13-1/2 oz Lithium Hypo) = 1 lb 2-1/2 oz Sodium Dichlor) = 11-1/2 oz Trichlor)

1 lb Lithium Hypochlorite = (5-1/2 oz gas chlorine) = (1/3 gallon liquid chlorine) = (8-1/2 oz Cal-Hypo) = (10 oz Sodium Dichlor) = (6 oz Trichlor)

1 lb Sodium Dichlor = (9 oz gas chlorine) = (½ gallon liquid chlorine) = (14 oz Cal-Hypo) = (1lb 9-1/2 oz Lithium Hypo) = (10 oz Trichlor)

1 lb Trichlor = (14-1/2 oz gas chlorine) = (9/10 gallon liquid chlorine) = (1 lb 6 oz Cal-Hypo) = (2 lb 9 oz Lithium Hypo) = (1 lb 9-1/2 oz Sodium Dichlor)

Other Pool Chemicals

Chemical	What they do	pH
Sodium Bicarbonate (Alkalinity Plus)	Increase's Total Alkalinity	8.3
Sodium Bisulfate (Dry Acid)	Decreases Total Alkalinity	8.3
Muriatic Acid	Decreases Total Alkalinity	0.1
Sulfuric Acid	Decreases Total Alkalinity	low
Sodium Carbonate (Ph Plus)	Increases pH	13.0
Sodium Bisulfate (Dry Acid)	Decreases pH	low
Muriatic Acid	Decreases pH	0.1
Sulfuric Acid	Decreases pH	low
Calcium Chloride	Increases Calcium Hardness	N/A
Sodium Thiosulfate	Neutralizes Chlorine	N/A
Cyanuric Acid (Stabilizer/Conditioner)	Stabilizes Chlorine	3.0

Simplified Total Alkalinity (TA) adjustment dosages

Lowering TA with Muriatic Acid

Volume of pool / 125,000 x _____ ppm desired change =_____quarts

Lowering TA with Sodium Bisulfate

Volume of pool / 47,056 x _____ ppm desired change = _____ pounds

Raising TA with Sodium Bicarbonate

Volume of pool / 71,425 x _____ ppm desired change = _____ pounds

Raising TA with Sodium Carbonate*

Volume of pool / 113,231 x _____ ppm desired change = _____ pounds

Raising TA with Sodium Sesquicarbonate

Volume of pool / 80,0000 x _____ ppm desired change = _____ pounds

* Only use Sodium Carbonate when both Total Alkalinity and pH need to be raised and TDS and calcium carbonate are low - otherwise a white calcium precipitate may be formed. Use care and caution when adding pool chemicals. Always add chemicals to water not water to chemicals. Dilute as required and follow all manufacturer recommendation and instructions. Wear safety equipment to protect yours eyes and skin. Do not inhale chemicals. Broadcast or pour around the pool in an even and consistent manner. It would always be better to add a little less chemical than is required and test later. Re-adjust as needed.

To Increase Calcium Hardness

Calcium Chloride (77%)

Volume of pool / 92,400 x _____ ppm desired increase = _____ pounds

Calcium Chloride (100%)

Volume of pool / 120,000 x _____ ppm desired increase = _____ pounds

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To Increase Cyanuric Acid

Cyanuric Acid (100% strength)

Volume of pool / 120,000 x _____ ppm desired increase = _____ pounds

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Conversions and Definitions

MEASUREMENT CALCULATIONS

1-inch = 0.0833 feet (12/10)
Surface Area of a rectangle = length X width
Surface Area of a circle = radius X radius X 3.14
Surface Area of an irregular shaped pool 2 widest sections added together X length X 0.45 (Common sense and limitations apply)
(Make-up water or water loss calculation would be surface area of pool X inches of loss X 0.0833)
Example 400 SQFT Pool losing 2 inches per week 400 X 2 X 0.0833 = 66.64 cubic feet of water loss. Now convert to gallons 66.64 X 7.5 =499.8 gallons

Circumference = Distance around a circle
Circumference = Diameter X 3.14
Diameter = Distance across a circle
Radius = ½ the diameter
Radius = diameter divided by 2

WEIGHTS

7.48 gallons in each cubic foot of water (You can use 7.5)
1 gallon of water weighs 8.33 pounds
1 cubic foot of water weighs 62.3 lbs
1 ton = 2000 lbs
An average 12,000 gallon residential pool water weighs 100,000 lbs
1 yard of shotcrete/concrete weighs APPROX 4200lbs
An average 18 yard residential swimming pool shell weighs 76,000 lbs
An average residential swimming pool and its water weighs 176,000lbs (88 tons)
(This would not include decking, interior finish, tile, boulders and or water feature's)

16 ounces dry weight = 1 pound dry weight
128 ounces liquid = 1 gallon
64 ounces = ½ gallon liquid
32 ounces = ¼ gallon or 1 quart liquid
16 ounces = 1/8 gallon or 1 pint liquid
8 ounces = 1/16 gallon or 1 cup liquid

ELECTRICITY & POOL PUMPS

1000 watts = 1 kilowatt
1,000,000 watts = 1 Megawatt
.000001 watt = 1 Microwatt
1 milliamp = 0.001 amp (30 milliamps will cause muscle contractions)
3/4 volt of 1 volt = 750 millivolts = 0.75 volts
1 Horsepower = 746 watts commonly calculated at 1000 watts or 1 kilowatt per HP
Ohms Law means E = IR - Voltage = Current X Resistance or I = E/R and R = E/I
(E=Voltage) (I=Current) (R=Resistance)
Power Formula - Watts = Voltage X Current (Watts Law)
Example (1000 watts = 120 AC Voltage X 8.33 amps)
Example (1000 watts = 240 AC Voltage X 4.165 amps)
Example (10 amps X 120 AC Voltage = 1200 watts)
Example (5 amps X 240 AC Voltage = 1200 watts)
Example (120 AC Voltage X 12 amps = 1440 watts)
Example (240 AC Voltage X 6 Amps = 1440 Watts)
NOTE: @ 240 Volts twice as much power is being delivered, this cuts the Amps in half A 1 HP
120 volt 10 amp pump would use the same amount of electricity as a 1 HP 240 volt 5 amp pump
(Always use caution with electricity, consult an electrician if you do not know what you are doing)
Approximate power usage by HP
1/3 HP = 246 watts per hour
½ HP = 373 watts per hour
¾ HP = 560 watts per hour
1 HP = 746 watts per hour
1-1/2 HP = 1120 watts per hour (Average size pool pump)
2 HP = 1492 watts per hour or approximately 1.5 kilowattsv 3 HP = 2238 watts per hour

Swimming pool pumps generally run @ 3450 RPM
2-Speed pumps run @ 3450 RPM (High Speed) and 1725 RPM (Low Speed)

Pump manufactures make many lines of pool pumps. Some will be more efficient than others. Efficient pumps generally use about 10% less electricity than standard pumps. This can add up quickly over time. The cost difference between an efficient model and a standard model is usually less than $50.00. An average pool pump will cost approximately (8 hours per day X 1120 watts = 8960 watts X .10 per kilowatt hour = 89.60 cents per day times 365 days = $327.00 per year. It would take about 18 months to pay for the upgrade. Your pool pump should last 5-10 years or more. It is worth the extra money. Cost per kilowatt-hour of electricity is something you can find on your electrical service provider bill.

Swimming pool pumps will use more electricity if there is too much resistance is your circulation system. I.E pump to big, filter to small, inadequate piping or piping to small, filter dirty, hair and lint pot dirty, skimmer full of debris etc… With pool pumps bigger is usually NOT better.

Spa Jets should be sized 1 jet per 1/3 HP of pool pump = 2HP = 6 jets / 1-1/2 HP = 4 jets

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SINGLE SPEED PUMP vs. 2-SPEED PUMP COMPARISAN

STANDARD FILTRATION COSTS:
A standard single speed pool filtration system operates on a time clock for approximately eight hours per day. A two horsepower pump consumes approximately 1.5kw per hour. Assuming an electric rate of $0.10 per kWh, the following equation would apply:
8 hours X 1.5kw per hour X the rate of $0.10 per kWh = $1.20 per day.
$1.20 per day X 30 days = $36.00 per month

TWO-SPEED SYSTEM COSTS:
A two-speed system can operate your pool's filtration system 24-hours per day; 4 hours per day on high speed (2 horsepower) and 20 hours per day on low speed (1/3 horsepower) is one consideration. For this comparison we will only consider equal water turnover and filtration. High-speed cost is the same as above per hour; low-speed cost is about 1/4th-1/6th of high-speed.
4 hours X 1.5 kWh per hour X the rate of $0.10 per kWh = $0.45 per day.
8 hours X 0.375 kWh per hour (1/4th the 1.5 kWh cost) X the rate of $0.10 per kWh = $0.30 per day. / $.75 per day X 30 days = $22.50 per month.
In this scenario we have turned over the same amount of water as above (standard filtration costs) yet saved about 33% in utility costs.

24 HOUR CIRCULATION:
4 hours X 1.5 kWh per hour X the rate of $0.10 per kWh = $0.45 per day.
20 hours X 0.375 kWh per hour X the rate of $0.10 per kWh = $0.75 per day.
$.75 per day X 30 days = $36.00 per month.

(These are the FAIR comparisons) The bottom line is this, for about the same money as running a single speed pump for 8 hours on high speed you can run a 2-speed pump 24 hrs a day and take advantage of all the items listed below. This does not even take into consideration time of use plans where you could save more money on utility bills. 2-Speed pumps make a lot of sense. Smaller pumps apply as well!

Benefits of the Two-Speed System

1. 24-hour per day filtration keeps your pool cleaner by circulating and filtering water 24/7. You turnover the water in the pool almost twice as many times - this results in healthier water conditions.
2. Chemical needs are reduced, as your pool remains cleaner because it is filtering all the time. Chemicals and temperature are evenly mixed throughout the pool.
3. Energy and chemical costs can be reduced.
4. This helps your pool remain clean, fresh and ready for swimming.

5. If you use an automatic cleaner, it will only work on high-speed. Since you would be running the pump in high-speed less than ½ the time of a single speed pump, you could effectively increase the life of your cleaner by twice as long. If you use an Electric cleaner – no worries

- A single speed two horsepower pump running at 3450 RPM with a flow rate of 140GPM @ 40 feet of TDH operating for 8 hours will filter 67,200 gallons of water. An average pool is 12,500 gallons - this gives us a turnover of 5.376 times. A two-speed pump running at 3450 RPM with a flow rate of 140 GPM @ 40 feet of TDH in high-speed for four hours and in low-speed for 20 hours at 1725 RPM with a flow rate of 70 GPM will filter 117,600 gallons of water. This will produce 9.408 turnovers.

HYDRAULICS (FLUIDS IN MOTION)

1-psi = 2.31 feet of head (resistance) (Pressure)
1-psi - 28 inches water column pressure (WCP)
1-inch of mercury = 1.13 feet of head (Vacuum)

You can check the resistance in a closed loop swimming pool circulation system by installing a vacuum gauge just prior to the pump or at the pump and a pressure gauge just after the filter. These two readings when combined will give you a Total Dynamic Head or Resistance reading for your system. Most residential systems are and should be designed for about 40 feet of TDH. There are exceptions and this is not meant to be dogmatic. Example system: Vacuum gauge reads 8.3 and pressure gauge reads 13.4.

8.3 X 1.13 = 9.379 + 13.4 X 2.31 = 30.03. Total system resistance is 9.37 + 30.03 = 39.409

The PVC Piping in a pool system is designed to carry fluid from one point to another in an efficient matter. When piping is to small velocities increase and performance decreases. Piping velocities should be kept at less than 6 feet per second (fps) on the suction side and no more than about 8 fps on the return side. By sticking to these recommendations the pool pump can operate in an efficient manner.

A swimming pool system should have a Hydraulic design that will take into account pool water volume, turn over rate, filtering rate, pump size and type, filter size and type, distance from pool to equipment and many other factors. A common mistake is a 1-1/2 inch to 2 inch single suction line (In many cases connected to BOTH the skimmer and main drain) with a pump larger than 1 HP. We see this constantly!

PVC plumbing is designed to carry water @ less than 100 degrees plus/minus
CPVC plumbing is designed to carry water above 100 degrees
Swimming pools should turn over the entire volume of water at least one time every 6 hours (minimum)
Spas should turn over every 30 minutes or less

FILTERS

Filters are by size, filtering rate and microns of effective filter capability. The lower number of microns the smaller the particulate a filter will catch. Following is some general filter information and guidelines.

1 micron = one-millionth of 1 meter = 0.0000394 inches (the human eye can detect objects a small as 35 microns)
1 grain of table salt = 100 microns

Sand Filters catch particulates to about 30-50 microns

(As SAND filters get dirty they catch smaller and smaller debris)

Most residential Sand Filters are rated @ 20 GPM per SQFT of filtering area
This means:
3.1 SAND Filter is rated @ 63 GPM (Gallons per minute)
4.9 SAND Filter is rated @ 98 GPM (Gallons per minute)
7.0 Sand Filter is rate @ 140 GPM (Gallons per minute)

DE Filters catch particulates to about 7-10 microns
(As DE Filters load up they catch smaller and smaller debris)

Most residential DE filters are rated @ 2 GPM per SQFT of filtering area
This means:
36 SQFT DE Filter is rated @ 72 GPM (Gallons per minute)
48 SQFT DE Filter is rated @ 98 GPM (Gallons per minute)
60 SQFT DE Filter is rated @ 120 GPM (Gallons per minute)
72 SQFT DE Filter is rated @ 144 GPM (Gallons per minute)

Cartridge Filters catch particulates to about 15-20 microns
(As Cartridge Filters load up they catch smaller and smaller debris)

For residential applications Cartridge filters are rated @ 1 GPM per SQFT of filter area for commercial applications they are rated at .375 GPM per SQFT of filtering area. You want to use the commercial rating.
This means:
320 SQFT Cartridge filter is rated @ 120 GPM (Gallons per minute)
420 SQFT Cartridge filter is rated @ 157.50 GPM (Gallons per minute)
520 SQFT Cartridge filter is rated @ 195 GPM (Gallons per minute)

NOTE: It is possible to backwash SAND and DE filters too much. By doing this you never really give the filter a chance to load up and catch the small debris. Most SAND and DE filters should not be backwashed until the pressure gauge on the filter rises 8-10 psi OR water quality starts to be compromised.

Approx gallons to backwash filters:

3.1 Sand Filter 300 gallons or until water is clear coming out of the backwash hose
4.9 Sand Filter 500 Gallons or until water is clear coming out of the backwash hose
7.0 Sand Filter 700 Gallons or until water is clear coming out of the backwash hose

36 SQFT DE Filter 180 Gallons or until water is clear coming out of the backwash hose
48 SQFT DE Filter 240 Gallons or until water is clear coming out of the backwash hose
60 SQFT DE Filter 300 Gallons or until water is clear coming out of the backwash hose
72 SQFT DE Filter 360 Gallons or until water is clear coming out of the backwash hose

1 pound of DE powder will coat 10 SQFT of DE Filter
36 SQFT DE filter requires 3.6 pounds of DE
48 SQFT DE filter requires 4.8 pounds of DE
60 SQFT DE filter requires 6 pounds of DE
72 SQFT DE filter requires 7.2 pounds of DE

DE Filters should be completely manually cleaned and inspected once a year. The grids in the filter are what need inspecting. Check for broken pieces and torn and worn grids.

SAND and DE Filters require a backwash valve for backwashing. Cartridge filter do not. DO NOT use the backwash valve to drain your pool any lower than the bottom of the skimmer throat. This can cause the pump to run dry and burn up your pump. The best way to drain a pool is with a submersible pump. They can be rented or purchased fairly inexpensively.

Cartridge Filters are manually cleaned as needed (Use hose and water). Clean cartridge

elements with (TSP) Tri-Sodium-Phosphate to degrease them. DO NOT use muriatic acid until AFTER you have done this. You can soak them in a mild solution of chlorine to turn them white again AFTER you have cleaned, decreased and rinsed them good.

Sand should be replaced in SAND Filter about every 3-5 years depending on manufacturer's specifications.

Sand Filter use #20 Silica sand and or predetermined amount of pea gravel. Consult your manufacturer's specifications.

HEATERS

1 BTU (British Thermal Unit) is the amount of heat required to raise 1 pound of water 1°F EXAMPLE: 800 gallon spa (800 X 8.33 = 6664 lbs) (If the spa temperature was 70 degrees and the desired temperature is 104 degrees) (6664 X 34 = 226,576 BTUs required) (400,000 BTU gas heater @ 82% efficiency) (400,000 X 82% =328,000 BTU output) (328,00 BTU output /226,576 BTU needed X 60 = 41 minutes to heat

1 therm (measurement of gas supply) = 100,000 BTU per hour
1 kilowatt = 3412 BTU
1 gallon of fuel oil = 140,000 BTU
1 ton (heat pump rating) = 15,000 BTU Example / 5-ton Heat pump = 75,000 BTU

Without a pool cover heat loss in a swimming pool can be 50% or more overnight

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OTHER INFO

- A typical bather displaces 3 cubic feet of water (Or about 20-25 gallons)
- One active swimmer in a pool produces about 1 pint of sweat
- Sweat and perspiration make ammonia
- One dog in a pool is equal to 50 people, Yes 50!
- 4 people in a 600 gallon spa are equal to 250 people in a 25' x 50' x 4' deep pool
- Your taste threshold for salt water is around 3500 ppm
- Ocean water is about 35,000 ppm
- 1 Yard of concrete will cover 75 SQFT 4" thick
- The diving board type should be used as a source for determining safe diving pool design. Bigger boards require longer deeper pools.
- Diving pools should be no less than 15' wide and 32-34' long minimum.
- Recommended max temperature for spas is no more than 104 degrees.
- Recommended max time in a spa @ 104 degrees is 15 minutes. Cool off and than go back in.
- A bucket can sometimes be used to determine if a leak is in a pool. Turn off water and the water-leveling device. Place bucket on the top step of the pool. Make sure the level in the bucket is equal to the level in the pool. Mark the level in the bucket. Check in 48 hours. Generally if there is a leak in the pool the water in the pool will be less than the water in the bucket. The evaporation rate should be the same.
- 8 gpm to fill pool with one hose (20,000 gallon pool would take 41.6 Hours to fill) 18 gpm to fill the pool with two hoses (20,000 gallon pool would take 18.5 hours to fill)