DRYDEN AQUA DISTRIBUTION
SUSTAINABLE WATER QUALITY

DRYDEN POOL ACADEMY
KNOWLEDGE IS POWER!

10 HIGH-LEVEL TRAINING SESSIONS

Live Zoom

Dryden Pool Academy
SESSION 7

OXIDATION

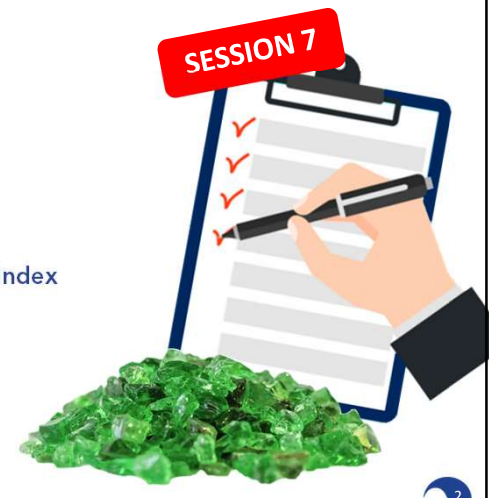
1

AGENDA 9:30 – 10:30

zoom

DRYDEN POOL ACADEMY
KNOWLEDGE IS POWER!

- Oxidation & Redox-reaction
- Free chlorine vs redox
- DA-GEN : The best disinfection with free radicals
- Problems with corrosion in swimming pools and the Langelier Index
- DAISY+ Case study
- Q&A : Questions / Réponses



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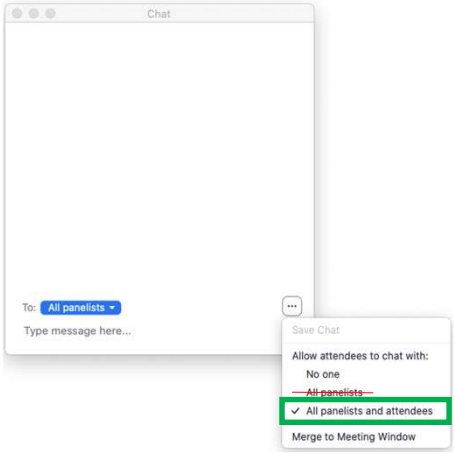
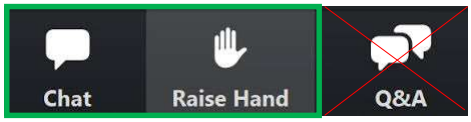
2

Questions & Answers

Prepare and send us your questions during the meeting using the chat!





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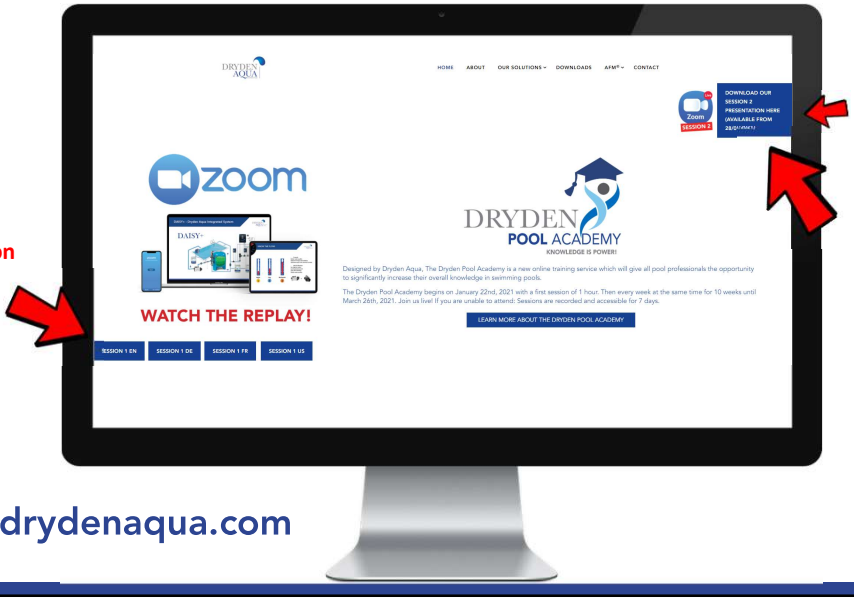
Dryden Pool Academy presentations and replays

Replay available for 7 days after each session (EN, DE, FR, US)



www.drydenaqua.com

Program

PDF Presentation available for download 24 hr before each session (every Thursday)

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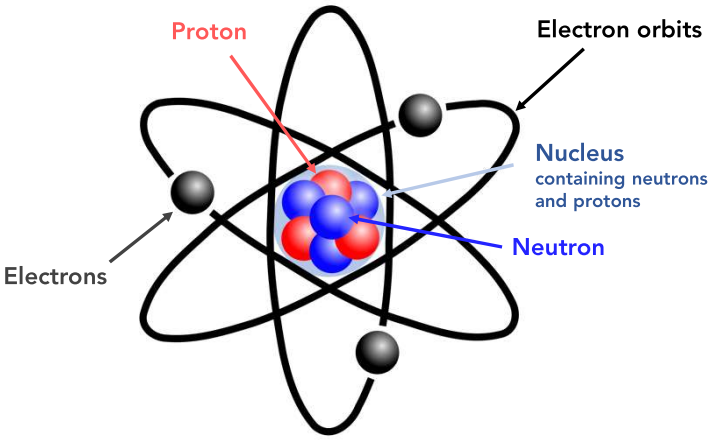
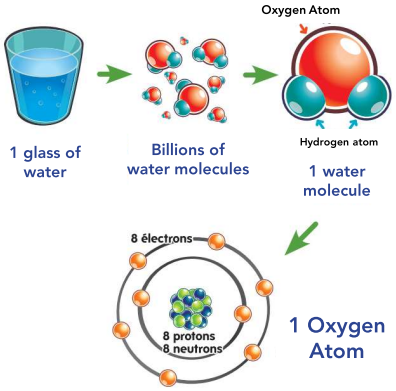
What is an atom?





The structure of Atom

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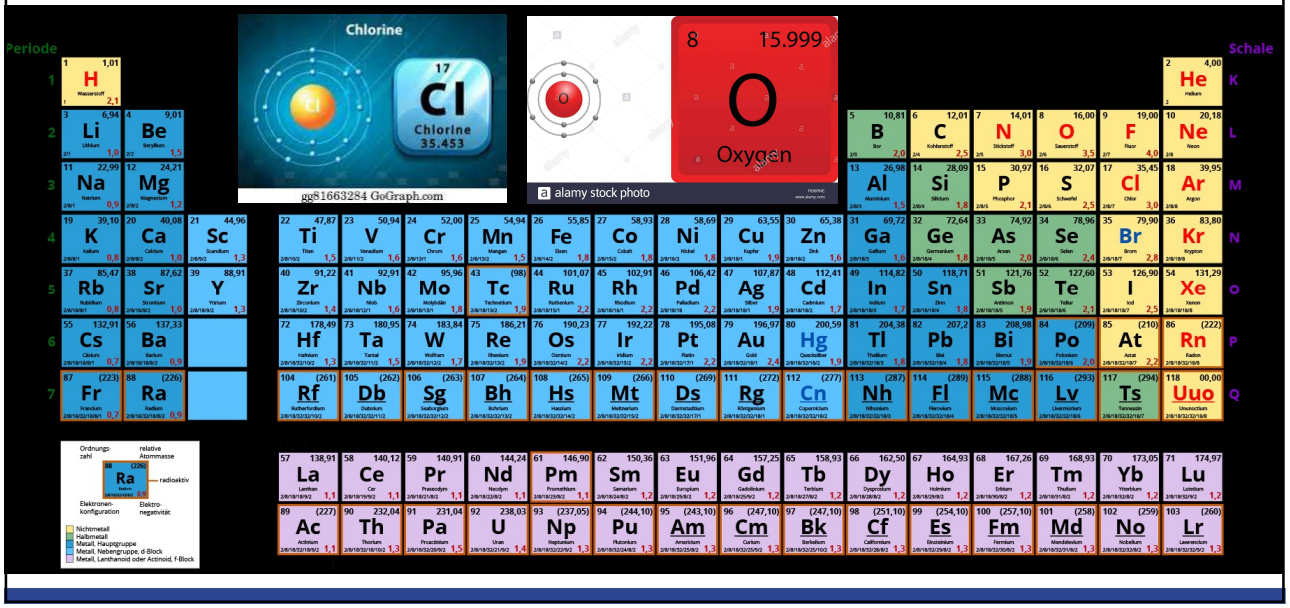
What is an Atom? The periodic table of the elements



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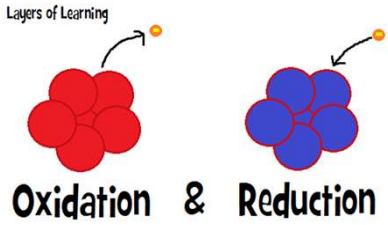
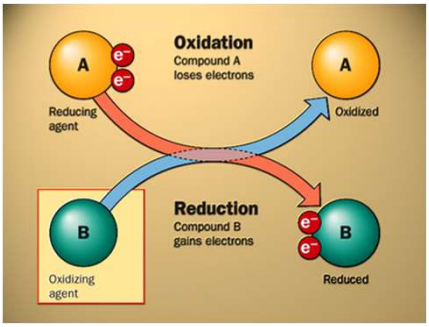
Oxidation: Transfer of electrons

The oxidizing agent takes the electrons.

The reducing agent is releasing electrons.

Definition:
Oxidation is a chemical reaction in which the reducing agent releases electrons and oxidizing agent is gaining electrones





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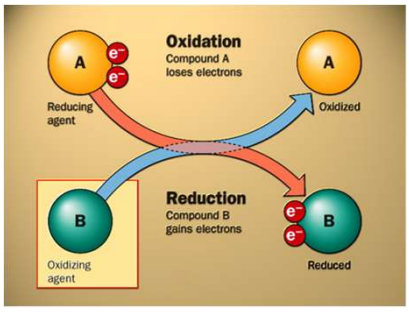
What is a REDOX reaction?

Oxidation is the opposite of reduction.
A reduction-reaction always comes together with an oxidation-reaction. Oxidation and reduction together are called REDOX (reduction and oxidation).



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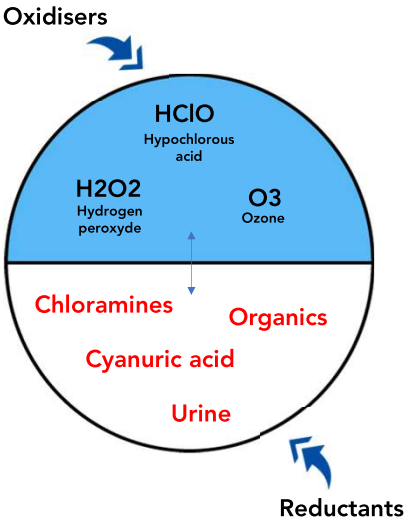
Oxidation-Reduction Potential: ORP

The unit of measurement of ORP is millivolts (mV).

The higher the millivolt reading, the more powerfully the oxidation process

Oxidisers increase the ORP and therefore increase disinfection . Typical oxidisers are hypochlorous acid, ozone, hydrogen peroxide, and potassium monopersulphate.

Reductants decrease the ORP and therefore decrease disinfection. Typical reductants are chloramines, cyanuric acid, organic matter, urine, micro-organisms, etc.



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ORP: The ideal hygiene parameter

ORP is an indicator of micro-organism kill time / kill rate.

Drinking water is adequately disinfected at an ORP of 650 mV.

In swimming pools, an ORP of 700 to 720 mV allows a quick disinfection.

Graph 6.1 Kill Time for a log 3 Reduction of E. coli as a Function of ORP

Source: Eutech Instruments Pty Ltd

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ORP varies with pH

ORP also depends on pH but also on water temperature and turbidity (Zeta Potential)

Redox	pH	Freies Chlor
650 mV	7.6	0.4 ppm
720 mV	7.0	0.4 ppm

ORP control always with pH control!

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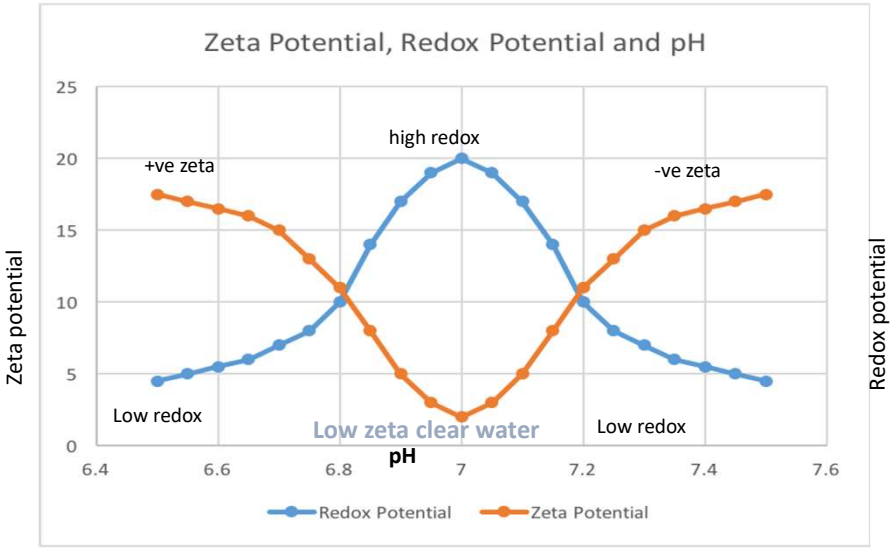
ORP varies with Zeta Potential



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Redox versus free chlorine?

ORP: The power of disinfection

- ORP measures oxidative disinfection power
- ORP is not measuring the concentration of free chlorine.
- Depends on the load, the water temperature, the pH and the Zeta potential (turbidity)

⇒ Ideal for residential pools

⇒ Perfect hygienic parameter

Free chlorine: Measures the absolute value

- Free chlorine measures the absolute concentrations of hypochlorous acid (HOCl) and the hypochlorite ion (OCl-)
- It does not measure the disinfection power
- Depends not on the load, the water temperature, the pH and the Zeta potential (turbidity)

⇒A legal must for public pools in most countries

⇒Ideally check disinfection power by ORP

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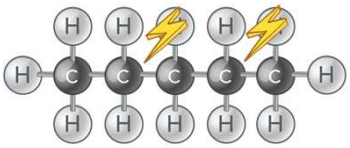
Oxidation: The electro-chemical potential in eV (Electronvolt)

The higher the eV: The more force to attract electrons, the stronger the oxidation

THE STRENGTH OF FREE RADICALS

	in eV
Hydroxyl radical (OH•)	**2.86**
Atomic Oxygen (O•)	2.42
Ozone (O3)	2.07
Persulfate (K2S2O8)	2.00
Percarbonate (2Na2CO3 · 3H2O2)	1.80
Hydrogen Peroxide (H2O2)	1.78
Chlorine (Cl)	**1.36**



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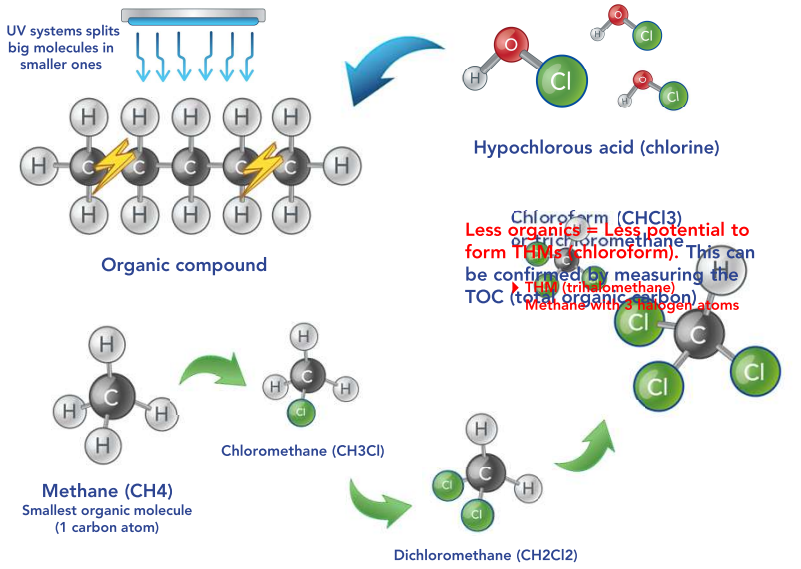
Chloroform (THMs) is formed in water when chlorine reacts with organics



Organic compounds are composed of mainly carbon and hydrogen.

Chlorine oxidizes organic molecules such as oil, lipids or protein

Organic compounds keep breaking down into smaller parts.

Chloroform (CHCl3) is a very volatile toxic by-products.

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STEP 4 : DAISY+: SWIMMING IN DRINKING WATER

0.1 MG/L

DAISY + DA-GEN = DAISY+

STEP 4

DA-GEN

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Pollet Pool Group
UK/IRELAND

DRYDEN AQUA
SUSTAINABLE WATER QUALITY

Swimming in Drinking Water

Free Chlorine 0.1mg/l

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Pollet Pool Group
UK/IRELAND

DRYDEN AQUA
SUSTAINABLE WATER QUALITY

Swimming in Drinking Water

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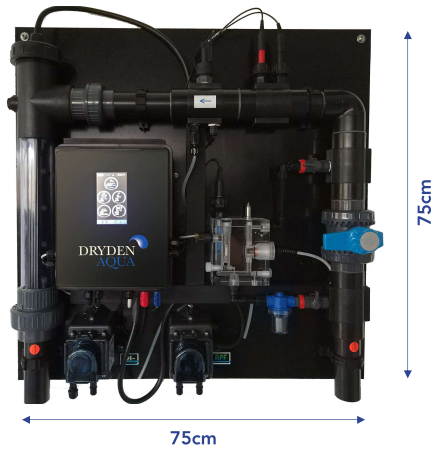
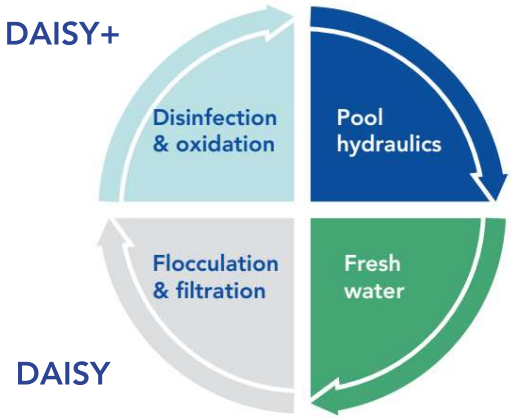
DA-GEN completes DAISY with a disinfection stage

DRYDEN AQUA

DAISY + DA-GEN = DAISY+





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What is DA-GEN and why free radicals ?

DRYDEN AQUA

DA-GEN is a Hydrolyser that generates free radicals and small amounts of chlorine.

- Free radicals for the main disinfection
- Chlorine for depot-disinfection

THE STRENGTH OF FREE RADICALS

	in eV
Hydroxyl radical (OH•)	**2.86**
Atomic Oxygen (O•)	2.42
Ozone (O3)	2.07
Persulfate (K2S2O8)	2.00
Percarbonate (2Na2CO3 · 3H2O2)	1.80
Hydrogen Peroxide (H2O2)	1.78
Chlorine (Cl)	**1.36**

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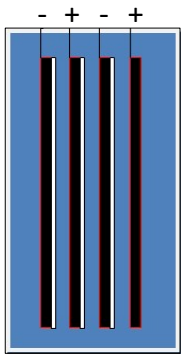
The best technology : Highly efficient electrodes (mono-polar)



15A

High amperage monopolar electrodes

- Can produce free radicals with a TDS concentration below 1200ppm => chlorides concentration under 600 ppm – the corrosion limit for V4A (316) stainless steel.
- Robust against scaling
- Better production performance
- Only 1g/l of salt (NaCl) or Magnesium chloride (MgCl2+) is usually needed

It is the Amps which give the performance

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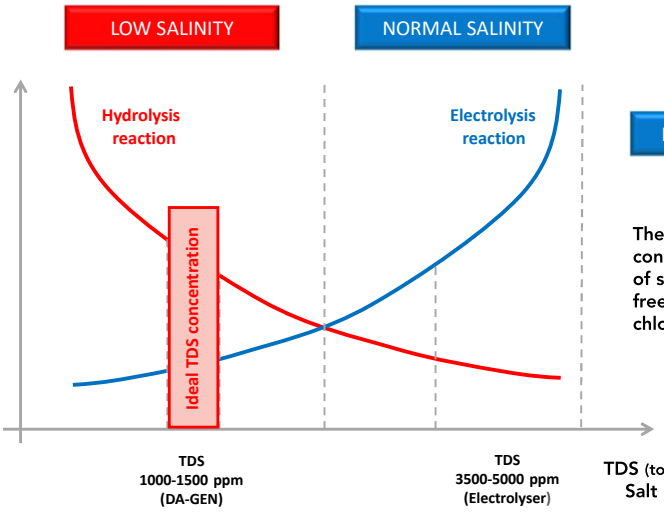
Hydrolysis vs Electrolysis

FREE RADICALS

We want to run the DA-GEN with a very low amount of salt (NaCl) or Magnesium Chlorine (MgCl2) to produce a maximum of free radicals (OH), and a small amount of chlorine for residual disinfection



FREE CHLORINE

The lower the concentration of salt (TDS), the more free radicals and the less chlorine is produced

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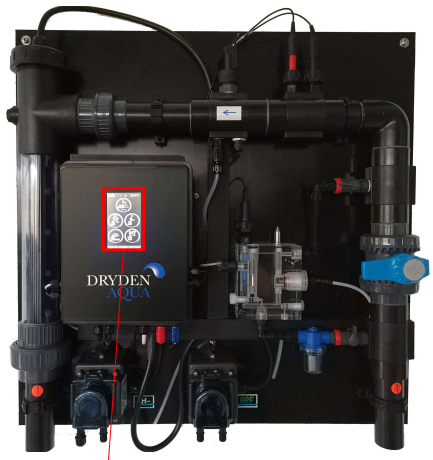
The best technology : Complete pool control



New Touchscreen

Wifi

LAN/Ethernet

DA-GEN app
www.da-gen.com

- pH measurement and automatic dosing
- Free chlorine (or Redox) measuring and control
- Temperature sensor
- Pump and backwash control (programmable)
- Automatic dosing of APF® for the best coagulation and flocculation
- Salinity probe (optional)
- Pool lights control
- Automatic dosing of ACO® (optional)

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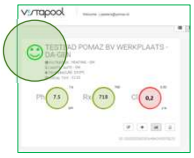
The best technology : Complete pool control

Monitor and control your customers



- Download your statistics in all available formats
- No limit of pools for each user
- No limit of users for each pool
- Configurable alarms by email

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Always in combination with DAISY®

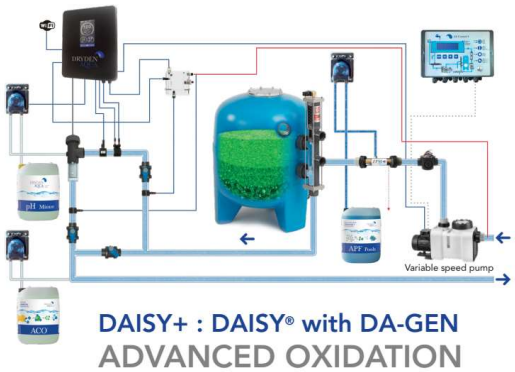
0.1 MG/L

Swim in drinking water!

With a properly sized DAISY: Free radicals and only 0.1 mg/l of free chlorine is necessary to ensure proper disinfection in private pools.

- Always with DAISY =>Only DAISY can lower oxidation demand in a pool by up to 80%
- Always with automated Free chlorine, pH + wifi control =>Only way to guarantee a healthy and beautiful water in drinking water quality.

Quality without compromise!



DAISY+ : DAISY® with DA-GEN
ADVANCED OXIDATION

PERFECT DOSING ▸ PERFECT CONTROL
PERFECT SOLUTION ▸ DRYDENAQUA.COM

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DA-GEN® Installation video

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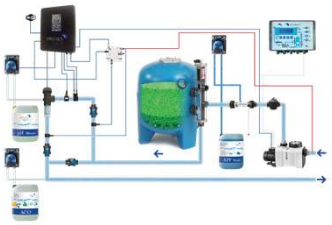
SWIM IN DRINKING WATER



DAISY+

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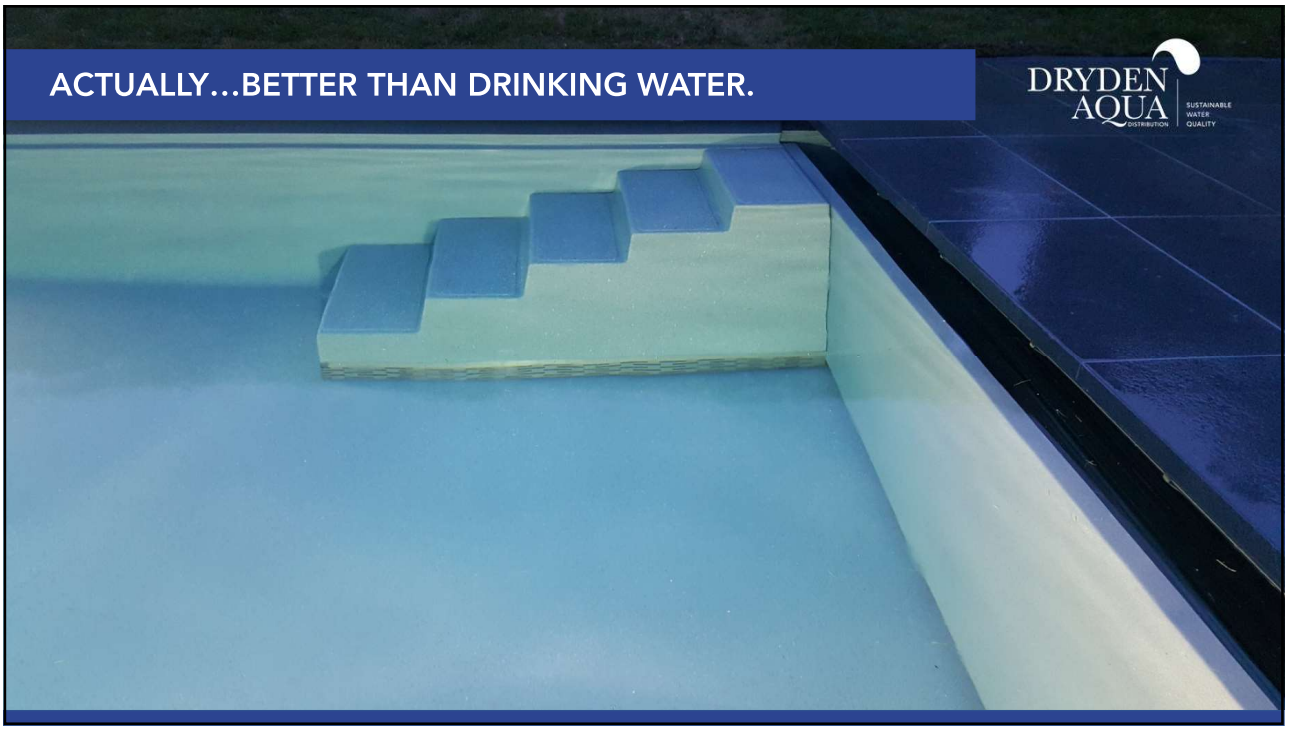
ACTUALLY...BETTER THAN DRINKING WATER.



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SUSTAINABLE WATER QUALITY

DRYDEN POOL ACADEMY

Chlorides, corrosion risk and Langelier Saturation Index LSI

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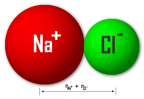
Chlorides

DRYDEN POOL ACADEMY

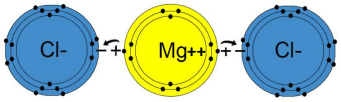
The chloride ion Cl- is a chlorine atom charged with an additional electron (negative ion).



Salt

Sodium chloride (NaCl) is the union of 1 sodium Na+ ion and 1 chloride Cl- ion

Magnesium chloride (MgCl2)
1 Mg2+ (magnesium) <=> 2 Cl- (chlorides)



Magnesium chloride

Chlorides are corrosive

Corrosion resistance depending on the type of stainless steel (max. values!):

- V4A – 316L: (1.4571): **600 mg / l of chlorides**
- V2A - 304: (1.4301): **200 mg / l of chlorides**
- 1.4539: **20 000 mg / l of chlorides**

=> austenitic stainless steel => excellent corrosion resistance

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TDS, conductivity and chlorides

TDS = Total Dissolved Solids (all ions in water)
Total concentration of substances dissolved in water expressed in mg/l (ppm)

Chlorides (mg/l) x ≈2 = TDS (mg/l)
TDS / 2 ≈ Chloride concentration (mg/l)
TDS * 1.6 ≈ conductivity in µS (microsiemens)
Conductivity / 1.6 = TDS

Example: 2000 µS ≈ 1200 TDS ≈ 600 chlorides (Cl-)

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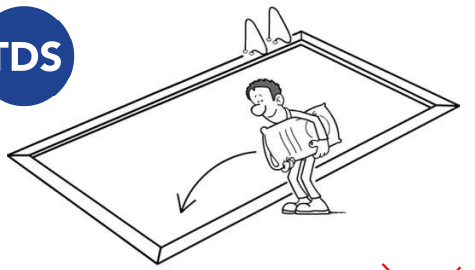
TDS, conductivity and chlorides

1kg of sodium chloride ($Na^{40\%}Cl^{60\%}$) per m3 of water
⇒ TDS increases by 1000 mg / l
⇒ 1 kg (1,000 g) of salt corresponds to 600 g of chloride and 400 g of sodium

1kg of magnesium chloride ($Mg^{25\%}Cl2^{75\%}$) per m3 of water
=> TDS increases by 500mg / l

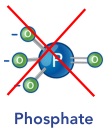


1kg / m3

TDS +1000ppm
600 ppm chloride
+400 ppm sodium

1kg / m3

TDS +500ppm
375 ppm chloride
+125 ppm magnesium



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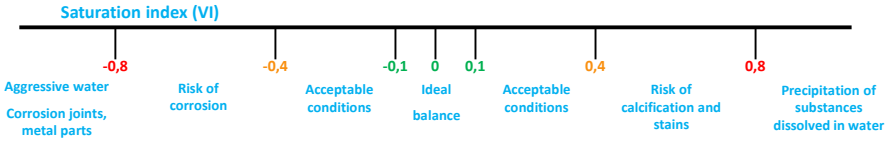
Corrosion: The Langelier index as a reference!
LSI : Langelier saturation index

$$VI = pH + TF + CF + AF - TDSF$$



pH : pH Value
TF : Temperature factor
CF : Total hardness factor
AF : Carbonate hardness factor (alkalinity)
TDSF : TDS Factor (Total Dissolved Solids)

LSI	Evaluation
-0,4 or less	Corrosive water
-0,4 to -0,2	Acceptable conditions
-0,1 to +0,1	Ideal balance
+0,1 to +0,4	Acceptable conditions
> +0,4	Scaling water

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Langelier index: Example
https://www.lenntech.com/calculators/langelier/index/langelier.htm

Table 1: Input table

pH *	7.4	
Conductivity / TDS *	1200	mg/L
$[Ca^{2+}]$ *	200	mg/L
$[HCO3^-]$ *	100	mg/L
Water temperature *	28	degree C

If you do not have a water analysis you can use the values in table 2. Click on a button at the bottom of table 2

Table 2 : Additional data

pH =	7.7	8	8.6	
TDS =	20	34483	273	mg/l
$[Ca^{2+}]$ =	5	400	49	mg/l
$[HCO_3^-]$ =	10	140	121	mg/l
T =	20	20	20	degree C

Example | Seawater | Tap water

Calculate the Langlier Saturation Index

Erase input values

Table 3: Results Langelier Saturation Index

pH_s	7.4
LSI	0.00036

TDS: 1200 mg/l
Total hardness: 200mg/l (=> 20°fH => 11°dH)
Alkalinity: 100mg/l (=>10°fH => 5.5°dH)
Temp.: 28°
pH neutral and balanced

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Langelier index: Example

https://www.lenntech.com/calculators/langelier/index/langelier.htm

DRYDEN POOL ACADEMY

Table 1: Input table

pH	7.4 *	
Conductivity / TDS	2200 *	mg/L
$[Ca^{2+}]$	200 *	mg/L
$[HCO_3^-]$	100 *	mg/L
Water temperature	28 *	degree C

Calculate the Langlier Saturation Index

Erase input values

If you do not have a water analysis you can use the values in table 2. Click on a button at the bottom of table 2

Table 2 : Additional data

pH =	7.7	8	8.6	
TDS =	20	34483	273	mg/l
$[Ca^{2+}]$ =	5	400	49	mg/l
$[HCO_3^-]$ =	10	140	121	mg/l
T =	20	20	20	degree C

Example | Seawater | Tap water

Table 3: Results Langelier Saturation Index

pH_s	7.5
LSI	-0.11

TDS: 2200 mg/l
Total hardness: 200mg/l (=> 20fH => 11dH)
Alkalinity: 100mg/l (=> 10fH => 5.5dH)
=> Temp. : 28°
LSI: -0.11 => balance pH: 7.5

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Langelier index: Example

https://www.lenntech.com/calculators/langelier/index/langelier.htm

DRYDEN POOL ACADEMY

Table 1: Input table

pH	7.4 *	
Conductivity / TDS	1200 *	mg/L
$[Ca^{2+}]$	200 *	mg/L
$[HCO_3^-]$	40 *	mg/L
Water temperature	28 *	degree C

Calculate the Langlier Saturation Index

Erase input values

If you do not have a water analysis you can use the values in table 2. Click on a button at the bottom of table 2

Table 2 : Additional data

pH =	7.7	8	8.6	
TDS =	20	34483	273	mg/l
$[Ca^{2+}]$ =	5	400	49	mg/l
$[HCO_3^-]$ =	10	140	121	mg/l
T =	20	20	20	degree C

Example | Seawater | Tap water

Table 3: Results Langelier Saturation Index

pH_s	7.8
LSI	-0.40

TDS: 1200 mg/l
Total hardness: 200mg/l => 20fH => 11dH
Alkalinity: 40mg/l => 4fH => 2.2dH
Temp.: 28°
LSI: -0.4 => balance pH: 7.8

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Langelier index: Example

https://www.lenntech.com/calculators/langelier/index/langelier.htm

DRYDEN POOL ACADEMY

Table 1: Input table

pH	7.4 *	
Conductivity / TDS	1200 *	mg/L
$[Ca^{2+}]$	200 *	mg/L
$[HCO3^-]$	100 *	mg/L
Water temperature	10 *	degree C

Calculate the Langlier Saturation Index

Erase input values

If you do not have a water analysis you can use the values in table 2. Click on a button at the bottom of table 2

Table 2 : Additional data

pH =	7.7	8	8.6	
TDS =	20	34483	273	mg
$[Ca^{2+}]$ =	5	400	49	mg
$[HCO_3^-]$ =	10	140	121	mg
T =	20	20	20	degree C

Example | Seawater | Tap water

Table 3: Results Langelier Saturation Index

pH_s	7.8
LSI	-0.39

Water temperature is also important

TDS: 1200 mg/l
Total hardness: 200mg/l => 20fH => 11dH
Alkalinity: 100mg/l => 10fH => 5.5dH
Temp.: 10°
LSI: -0.39 => Balance pH 7.8

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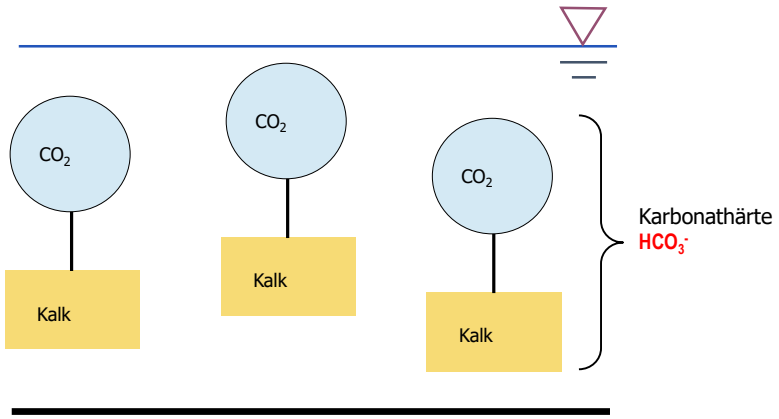
Alkalinity and pH



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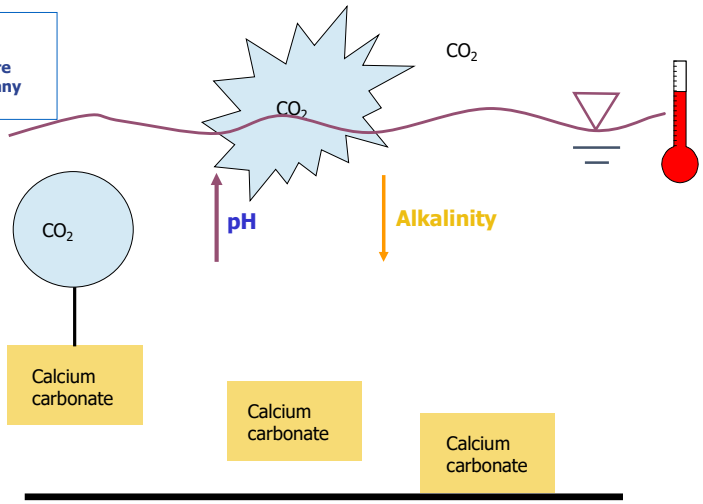
Alkalinity and pH

- Whirlpool baths
- High load
- Higher water temperature
- Swimming pools with many water attractions



High temperatures and/or water turbulence

=> calcium carbonate is precipitated and releases CO2 into the atmosphere

The pH rises

- Alkalinity decreases

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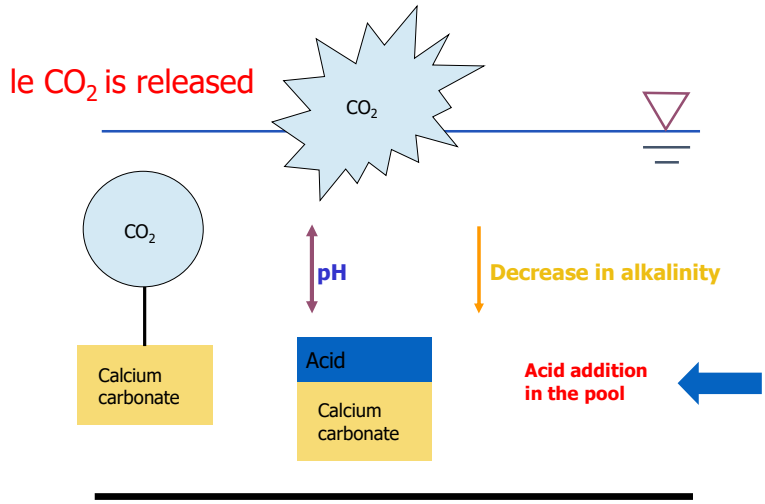
Alkalinity and pH



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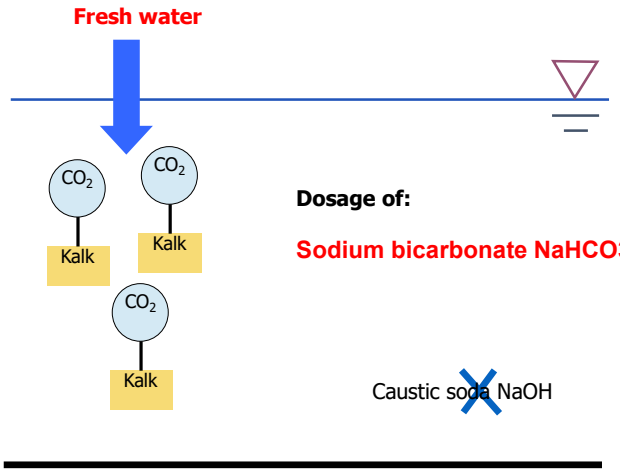
The solution...fresh water supply + Sodium bicarbonate



Dosage of:

Sodium bicarbonate NaHCO3

Caustic soda ~~NaOH~~

ALCA-Plus

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School indoor pool – Breitenbach, Switzerland

Volume : 180m3
500 school children every week

Energy consumption per week	Before
Filtration pumps (kWh)	1008
Backwash blower (kWh)	1.4
Room ventilation (kWh)	168
Water consumption (m^3)	50
Per bather (l)	100
Backwash water heating energy (kWh)	814

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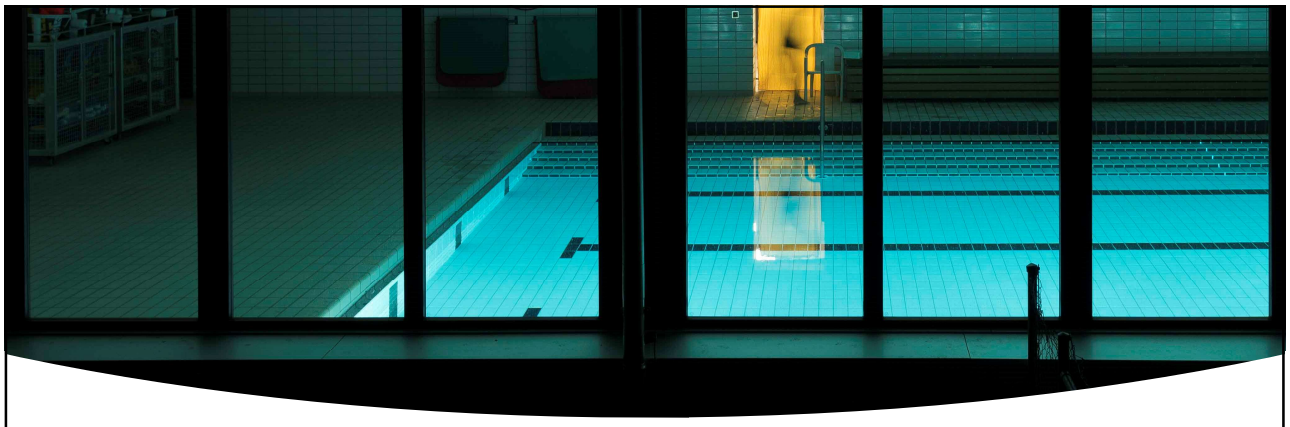
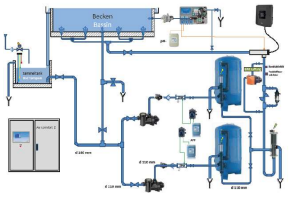


Main improvements



Installation of pump frequency controllers and flowmeters
⇒ 50% flow reduction at night, optimum filtration & backwash velocities

Sand filters replaced with new AFM Activated Filter Media
⇒ Improved air quality (trichloramines, THMs) and reduced backwash velocity

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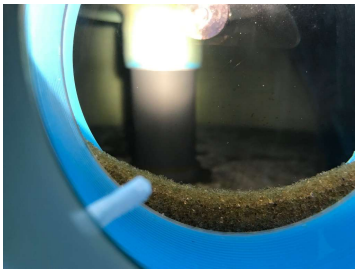
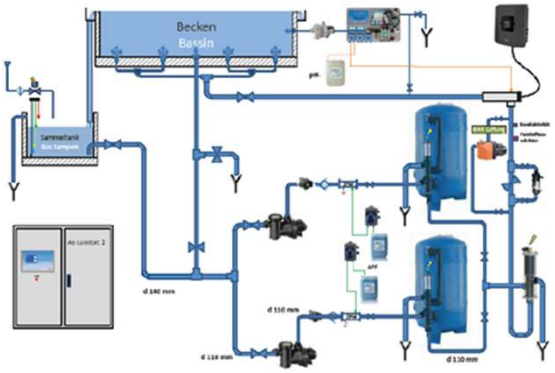
Public indoor pool Breitenbach
Aqua Solar, Switzerland





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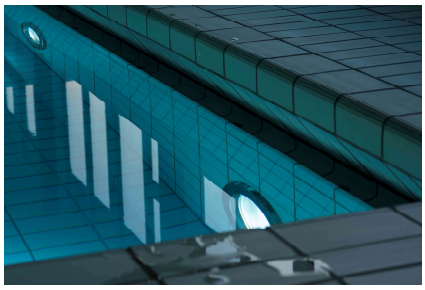
Energy consumption per week	Before	After
Filtration pumps (kWh)	1008	390
Backwash blower (kWh)	1.4	not needed
Room ventilation (kWh)	168	not needed
Water consumption (m^3)	50	16
Per bather (l)	100	32
Backwash water heating energy (kWh)	814	261
Energy saving (kWh)		**1'376**



- **70% reduction in electricity consumption**
- **68% reduction in water consumption**

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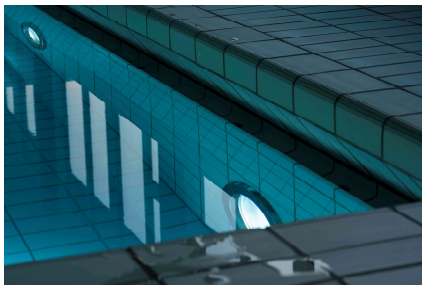
Water parameter	Before	After	Limits
pH	7,1	7,3	6,8 - 7,6
Free Chlorine (ppm)	0,3	0,4	0,2 - 0,8
Redox	730	750	
Combined Chlorine (ppm)	0,25	0,15	0,2
THMs		0.015	0.02
Chlorate		0,34	10
Turbidity (NTU)		< 0,1	0,2
Aerobic germs		0	1000



- **THMs levels extremely low, No chlorine smell**
- **Chlorates < 1 mg/l**
- **Stable water quality values, crystal clear water <0.1 NTU**

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DRYDEN AQUA DISTRIBUTION SUSTAINABLE WATER QUALITY

DRYDEN POOL ACADEMY KNOWLEDGE IS POWER!

10 HIGH-LEVEL TRAINING SESSIONS

Live Zoom

Dryden Pool Academy
SESSION 8

PUBLIC POOLS

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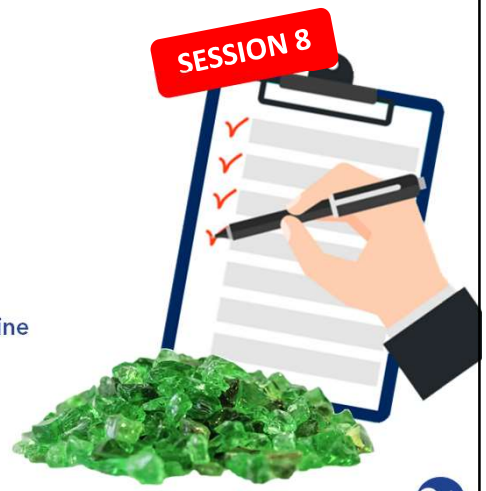
AGENDA SESSION 8

zoom

DRYDEN POOL ACADEMY KNOWLEDGE IS POWER!

- 5 ways to treat water in public swimming pools
- Differences: activated carbon / anthracite H / anthracite N
- Combined chlorine, THMs and chlorates
- Advantages and disadvantages of UV medium pressure lamps
- Treatment with ozone
- DAISY® + Advanox: Best solution for reducing combined chlorine and pharmaceuticals
- Q&A : Questions / Réponses



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Question / Answers

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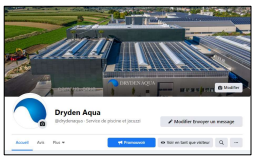
DRYDEN POOL ACADEMY
KNOWLEDGE IS POWER!



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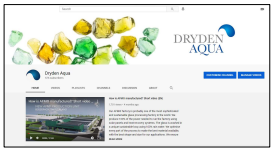

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