Industrial Test Systems, Inc.

eXact MICRO 7+

ITS

New Methodology for Poolside Compliance Testing

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Water

- It's the most important natural resource in our environment
- Not pure - contains microorganisms and dissolved minerals which need to be controlled so water can be used safely

Chlorine in Water

- Effective against a broad range of microorganisms
- Chlorine first used in 1908 for public health
- More than 79,000 tons of chlorine are used per year in the United States and Canada to treat water
- Monitoring chlorine is very important

Pool disinfection

- To protect people, water clarity and equipment
- Several pathogens can be transmitted in water
- Inactivation of pathogens depends on contact time
- Public health requires pool water testing for Hypochlorous acid or free chlorine residual concentration

Germ inactivation time in 1 ppm chlorinated water

GERM	INACTIVATION TIME
E. Coli O157:H7 Bacterium	Less than 1 minute
Hepatitis A Virus	About 16 minutes
Giardia Parasite	About 45 minutes
Cryptosporidium Parasite	About 9600 minutes (6.7 days)

Some sources of Chlorine

Chemical Name	Chemical Formula	Form	% Chlorine
Chlorine Gas	Cl_2	Gas	100%
Calcium Hypochlorite	$Ca(OCl)_2$	Solid	65-70%
Sodium Hypochlorite	NaOCl	Liquid	~12%

About the sources of Chlorine

- Despite their chemical and physical differences they all form hypochlorous acid
- This change occurs when water is added
- Hypochlorous acid (HOCl) is the actual disinfecting agent

Hypochlorite ion

- The sum of Hypochlorous acid and Hypochlorite ion is called free chlorine, and the chemical equation or relationship is:

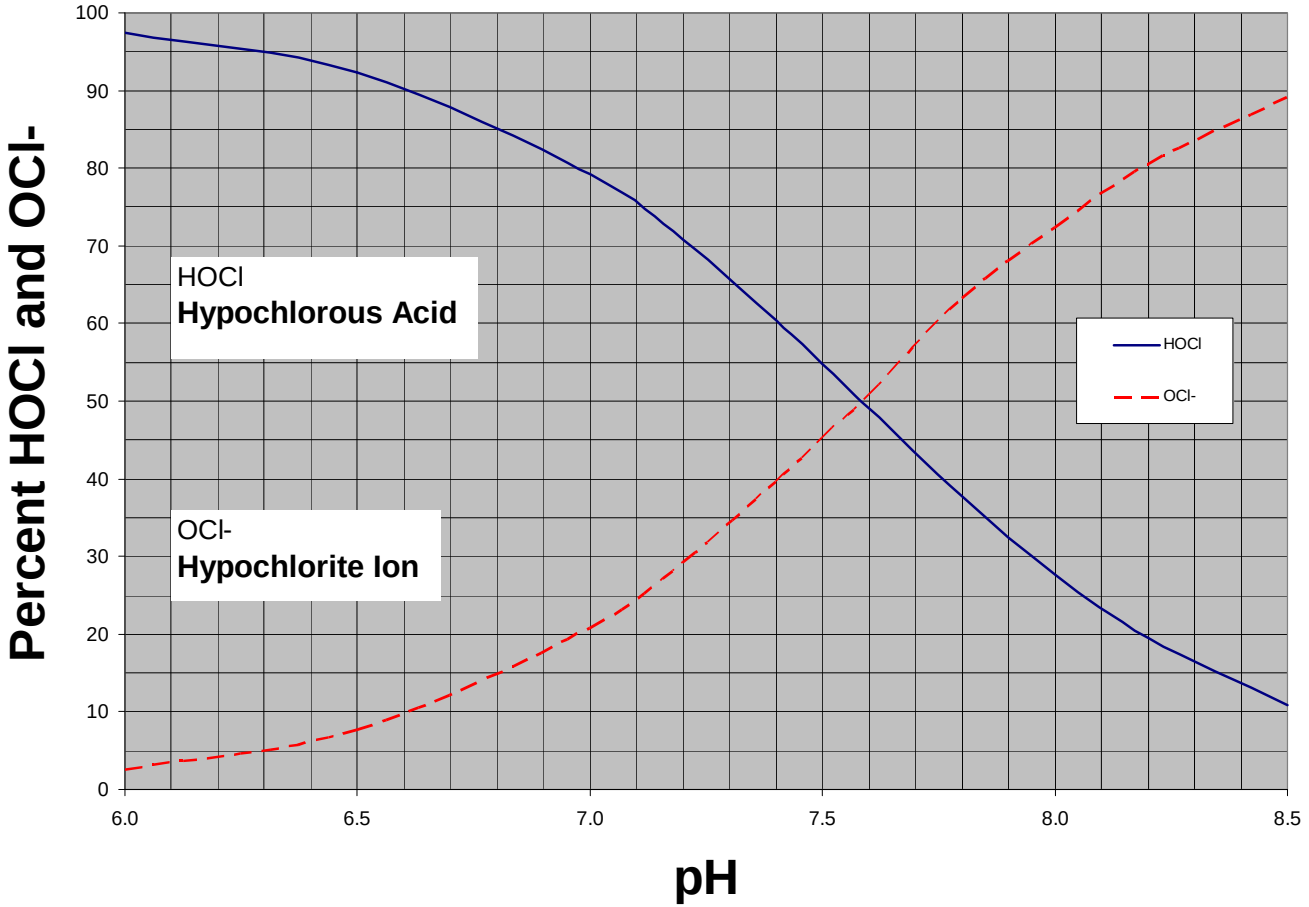
$$HOCl + OH^- \rightleftharpoons OCl^- + H_2O$$

Hypochlorous acid reactions

- **Two chemical reactions** impact the performance of Hypochlorous acid as a disinfectant:
- **First reaction** involves a hydroxide ion (OH^-)
- OH^- is available in aqueous solution especially when pH level is above 7 which causes Hypochlorous acid to form Hypochlorite ion
- Hypochlorite ion is less than one third as effective a disinfectant as Hypochlorous acid
- **Graph 1** shows the relationship between pH versus chlorine species (Hypochlorous acid and Hypochlorite ion)

pH versus chlorine species

Graph 1
Percent HOCl and OCl^- vs. pH



Chlorine reaction

- **Second chlorine reaction** is with ammonia (NH_3) and organic nitrogen compounds such as proteins and amino acids in the pool
- A series of reactions occur that form chloramines
- Chloramines are less effective as a disinfectant
- Active chlorine can be transferred from inorganic chloramine to amine (organic) containing compounds

Combined Chlorine Equations

- The sum of the chloramine species is called combined chlorine, and chemically created in the pool as follows:

$$HOCl + NH_3 \rightarrow NH_2Cl + H_2O$$

$$HOCl + NH_2Cl \rightarrow NHCl_2 + H_2O$$

$$HOCl + NHCl_2 \rightarrow NCl_3 + H_2O$$

$$HOCl + \text{organic nitrogen} \rightarrow \text{R-NHCl} + H_2O$$

$$HOCl + \text{R-NHCl} \rightarrow \text{R-NCl2} + H_2O$$

Breakpoint Chlorination

- The process which eliminates both the combined chlorine and the ammonia problem responsible for creating the chloramine is called Breakpoint Chlorination

- In the pool industry its called “Shock”

Total Chlorine

- Total chlorine is the sum of free chlorine and combined chlorine
- Free chlorine and total chlorine are monitored by automated equipment and confirmed by poolside testing for swimmer protection

Total Chlorine =
Free Chlorine + Combined Chlorine

To achieve good test results

1. Test is acceptable or compliant
2. Test is appropriate for the staff technical ability
3. Test is robust, reagents and equipment are reliable & stable
4. Test is not affected by interferences
5. Test is accurate when staff performs the test correctly

US EPA accepted test methods

- Amperometric Method
- DPD-FAS Titrimetric Method
- **DPD Colorimetric Method**
- Syringaldazine (FACTS) Colorimetric Method
- TMB (3,3',5,5'Tetramethylbenzidine) SenSafe™ Aperture Colorimetric Test Strip Method
  (Approved by the US EPA in 2007)

DPD Chlorine testing

- DPD methods have become preferred for chlorine measurement
- The DPD methods determine concentration from the color formed when chlorine reacts with the DPD
- DPD-FAS Titration method determines the chlorine by measuring the amount of FAS Titrant needed to bleach out the DPD-chlorine color formed
- Most state health departments recommend or accept DPD tests because they are quick, enjoy wide acceptance and have US EPA approval

DPD Chlorine Test Manufacturers

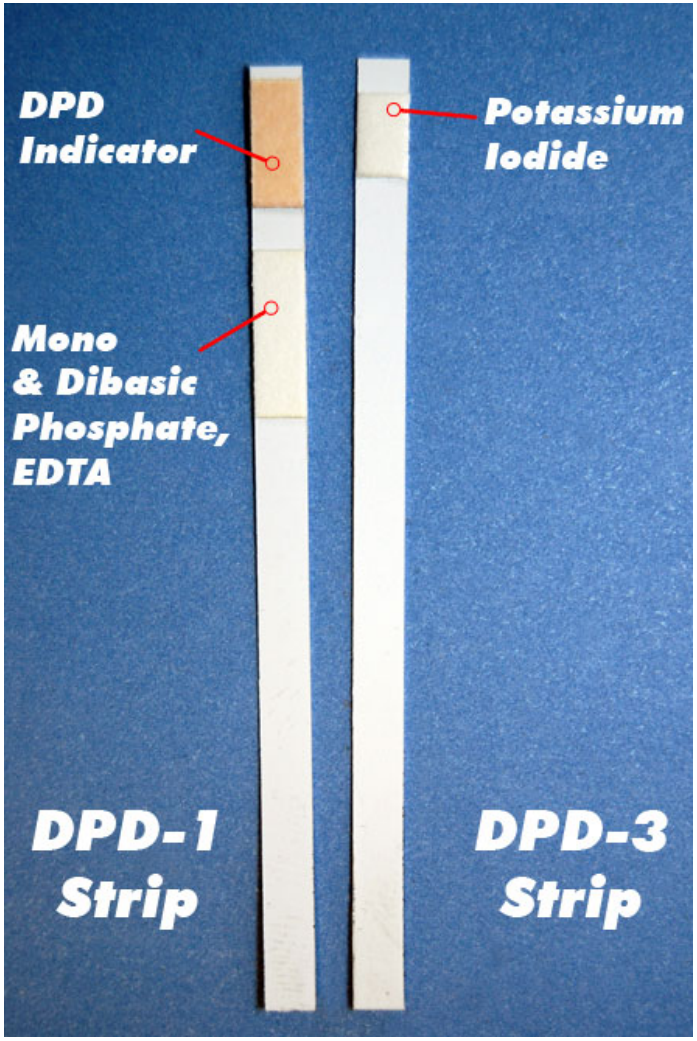
- Hach Company
- LaMotte Company
- Taylor Technologies, Inc.
- HF Scientific, Inc.
- Palintest LTD
- Industrial Test Systems, Inc.
- Others

DPD delivery methods

- DPD liquid reagents (2)
- DPD tablet
- DPD powder pillow
- eXact® Strip Micro DPD-1 and DPD-3

(All meet 4500-CL G reportable method)

- DPD is used for colorimetric or the DPD-FAS Titration methods to determine the chlorine concentration



New DPD methodology for poolside compliance testing

System consists of two items:

1. Meter with sealed sample cell
2. eXact® Strip Micro DPD-1, DPD-3 (reagent delivery device)

New DPD methodology for poolside compliance testing

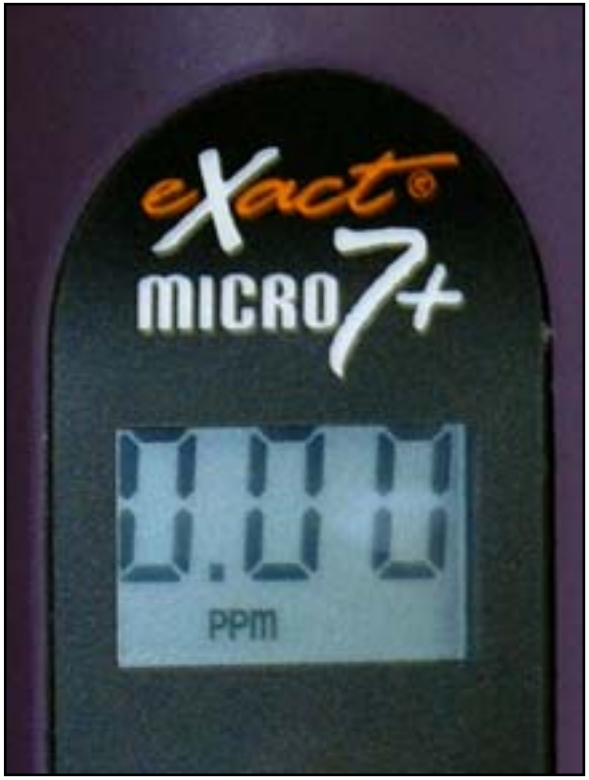
Step 1

- Rinse the sample cell, press the **“ZERO/ON”** button, dip meter upside down to elbow length turn meter upright to sample pool water and remove meter from the pool.

New DPD methodology for poolside compliance testing

Step 2

1. Press “**ZERO/ON**” button and meter will zero and display 0.00.



New DPD methodology for poolside compliance testing

Step 3

1. Press “**READ**” button and immediately dip eXact® Strip Micro DPD-1 into water sample for the 20 second count down. During the 20 seconds constantly move the strip back and forth, which releases the DPD and buffer reagents from the test strip while mixing the sample.

New DPD methodology for poolside compliance testing

Step 4

- At the end of the 20 seconds the meter will display “1” at which time you remove and discard the strip and the meter automatically reads and displays the **free chlorine** concentration, and stores the result in memory.

Free Chlorine = 1.58 ppm

New DPD methodology for poolside compliance testing

Step 5

- Continue the test to determine the Total Chlorine concentration: Press **"READ"** button and simultaneously dip eXact® Strip Micro DPD-3 into the water sample for 20 second count down.

- During the 20 seconds constantly move the strip back and forth, which releases the Potassium Iodide reagent from the strip and mixes the sample.

New DPD methodology for poolside compliance testing

Step 6

- At the end of the 20 seconds the meter will display “1” at which time you remove and discard the strip and the meter automatically reads and displays the **total chlorine** concentration, and stores the result in memory.

- Discard sample and rinse with water before storage. This DPD test method is compliant for health department and US EPA requirements.

Total Chlorine = 1.89 ppm

Total chlorine (TC) = free chlorine (FC) + combined chlorine

- Combined chlorine = TC - FC
- Free chlorine = 1.58 ppm (FC)
- Total chlorine = 1.89 ppm (TC)
- Combined chlorine = 1.89 – 1.58 = 0.31 ppm

- Combined chlorine is above the recommend level of 0.20 ppm and suggests pool needs to be shocked: in this example (10 X 0.31 = 3.1) this pool can be shocked by increasing the pool chlorine level by 3.1 ppm

Benefits of this DPD methodology

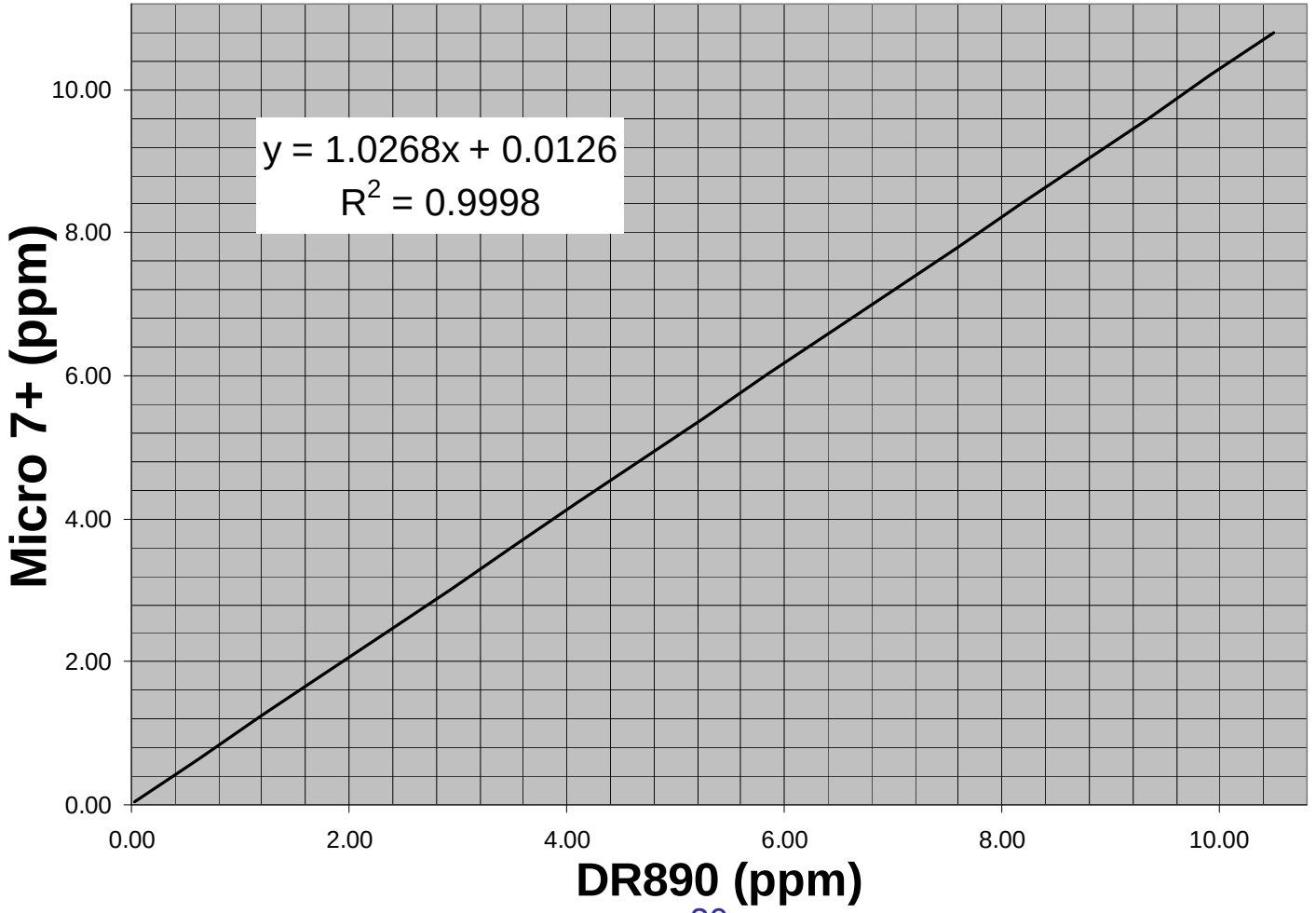
- No cell or test tube to handle
- Safe and easy to use DPD delivery device
- The eXact® DPD Strip is stable
- Non technical procedure
- Quick
- Accurate

Chlorine Test Specifications

METER	MENU	RANGE (PPM)	RESOLUTION
Micro 7+	CL1	0.00 – 2.39	0.01
		2.4 – 10.8	0.1
DR890	Program 9	0.00 – 2.20	0.01
	Program 12	0.0 – 11.0	0.1

Graph 2

Regression equation with correlation coefficient (R^2)
Free Chlorine, Hach DR890 vs. Micro 7+



Micro 7+ Specifications

Menu	Tests for	Range	Resolution	Accuracy	Ideal Levels
CL1	Free Chlorine (DPD-1) Total Chlorine (DPD-3)	0.00-2.39 ppm	0.01	0.02	1.0 to 3.0 ppm (combined less than 0.2 ppm)
		2.4-10.8 ppm	0.1	0.1, or 4%	
PH2	pH	6.1-8.4 pH	0.1	0.3	7.4 – 7.6
BR3	Bromine (DPD-1)	0.00-2.99 ppm	0.01	0.03	For spas 3.0 – 6.0 ppm
		3.0-14.0 ppm	0.1	0.1, or 4%	
AL4	Total Alkalinity	20-240 ppm	5	25	80 – 140 ppm
CA5	Calcium as $CaCO_3$	20-990 ppm	10	20 or 7%	200 – 400 ppm
CU6	Copper (Cu^{+2})	0.00-1.99 ppm	0.01	0.02	0.0
		2.0-8.0 ppm	0.1	0.1 or 4%	
TR7	Transmission	99.9-10.0 %T	0.1	0.1	For Cyanuric Acid, Nitrate and other tests
		9.99-0.01 %T	0.01	0.01	

Any Questions?