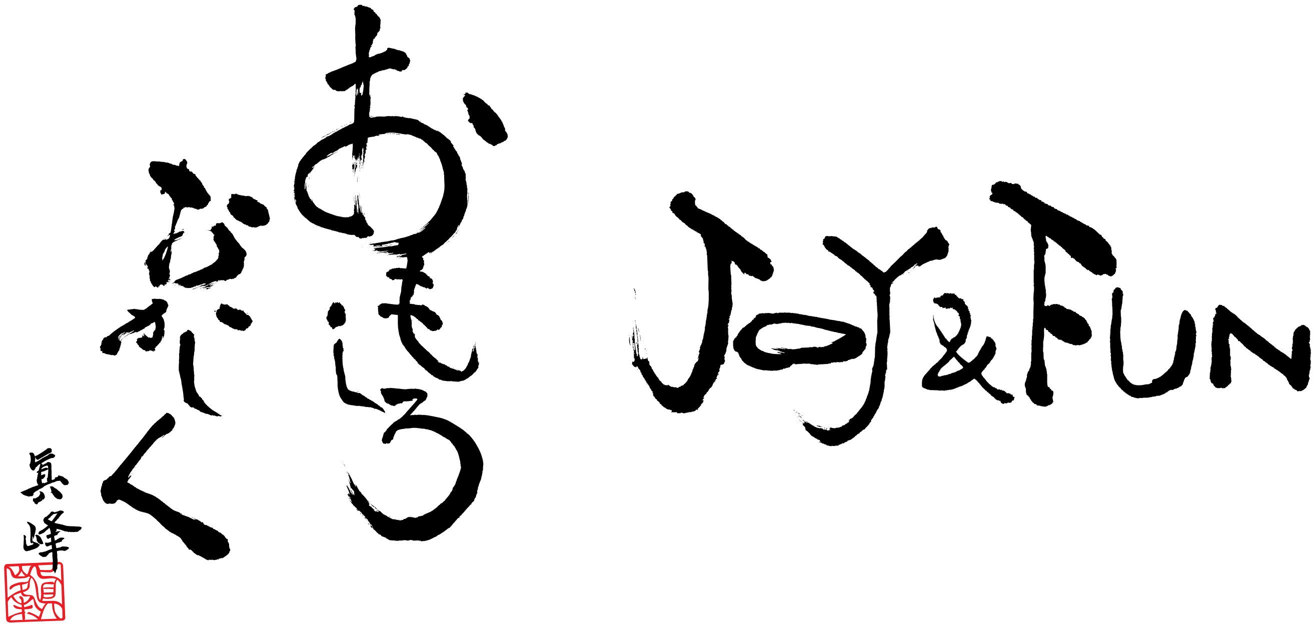
HORIBA
Scientific

LAQUA

Water Quality Instruments Catalogue

www.horiba-laqua.com



Omoshiro Okashiku - Joy and Fun

The company motto displayed above sums up the directive to everyone at HORIBA Group, which is to bring enthusiasm and excitement into our work to make our trade fulfilling and enjoy our lives.

"Omoshiro Okashiku"
The HORIBA Motto: "Joy and Fun"

"Joy and Fun" represents our desire to see all employees performing work that is rewarding and allows them to lead happy and fulfilling lives. We want our people to put "Joy" into their work through their own efforts by making the most of the time they spend in the workplace. To that end, the company provides places where employees can work with a sense of "Joy and Fun." Furthermore, if employees do work with a sense of "Joy and Fun," their ability to generate ideas increases, their imagination expands, their efficiency also rises, and corporate value increases. This results in a "win-win" relationship for customers, shareholders, suppliers, and the society.

"Omoi": five pillars to phrase the HORIBA way

"Omoi" means an emotional feeling, passion, thoughts, enthusiasm, desire, aspiration, ambition, commitment, mission, and objective. We encourage our employees to have the following "Omoi," which is the essence of acting on "Joy and Fun" through their work.

"Omoi"

- To be a part of a collaborative community, at the forefront of new ideas and creations
- To achieve goals and making my life memorable by fostering the highest intellectual potential
- Reach across the globe to expand learning that captures key business developments, wherever they occur
- To be proud of sharing what I do and what HORIBA delivers
- I want to participate all around and where I can be of help

LAQUA

History of the HORIBA pH Meter

The humble beginning of HORIBA...

In 1950, Dr. Masao Horiba pioneered and launched Asia's first pH meter in Kyoto, Japan. Since then, HORIBA has been introducing several of the world's firsts such as the first 0.001 resolution pH meter, the first flat sensor featured in the Cardy, the first wireless pH meter, the first colour LCD display, etc.

1950

HORIBA introduces Japan's first glass electrode pH meter.

1964

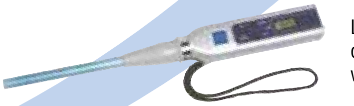
M-5 (benchtop) conversion from vacuum tube to semiconductor allows miniaturization and development of fast response meter

1977

Model F-7AD (benchtop) Incorporating an industry-first LCD display, the combination of a glass electrode, a reference electrode and a temperature-compensating electrode, makes testing easier.

1980

Model F-80 (benchtop) The world's first instrument capable of measuring pH at 0.001 resolution includes an integral computer with automatic calibration and a self-diagnostic function.



L-7 (integrated) Introduction of a small, handheld pH meter with integrated electrode.

1987

C-1 (card) Development of the world's first flat sensor.

1990

B-111 (Pen type) The pen type sensor allows small samples to be tested.

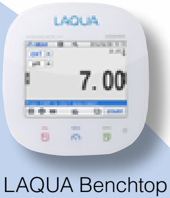
1993

F-20 (benchtop) The world's first wireless pH meter. Large graphical display gives user instructions on screen.

2003

F-50 (desktop) The world's first pH meter with colour LCD display. Navigation panel guides operators on how to use the meter as well as resolve errors.

D-50 (portable) Waterproof, IP67-rated housing and multi-parameter.



2011

LAQUA Benchtop Water Quality Instruments

2012

LAQUAtwin Pocket Water Quality Meters

2013

LAQUA Handheld Water Quality Instruments

2018

LAQUA 200 Series Handheld Water Quality Instruments

2019

LAQUA WQ-300 Series Handheld Water Quality Instruments

2021

LAQUA 2000 Series Benchtop Water Quality Instruments

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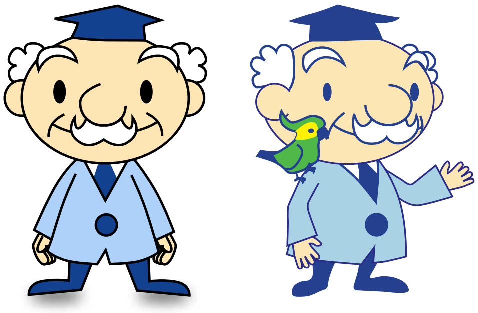

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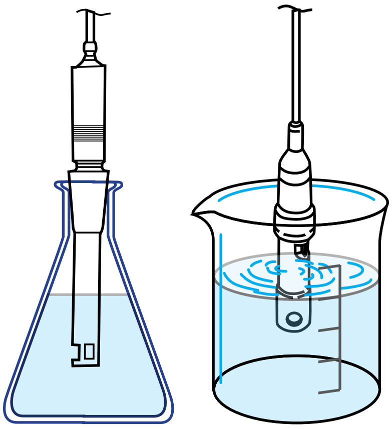
Agriculture

Aquaculture

Arts

Food & Beverage



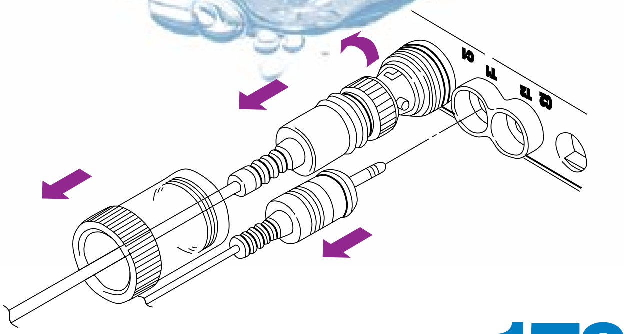
Health

Manufacturing

General

Livestock

Water & Wastewater



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Electrodes

Pocket Meters

Bench Meters

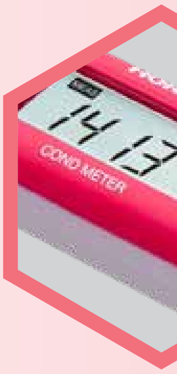
pH Meters

Models	Parameters	pH Range	Resolution	Accuracy	Max. Cal. Points	pH Buffer Groups	Channel
LAQUAtwin Pocket Meters							
pH-11	pH/mV	0.0 to 14.0	0.1	± 0.1	2	USA / NIST	1
pH-22	pH/mV	0.00 to 14.00	0.01	± 0.01	3	USA / NIST	1
pH-33	pH/mV/°C	0.00 to 14.00	0.01	± 0.01	5	USA / NIST	1
LAQUA 200 Series Handheld Meters							
PH210	pH/mV/ORP/°C/°F	-2.00 to 16.00	0.01	± 0.01	6	USA / NIST / DIN	1
PH220	pH/mV/ORP/°C/°F	-2.00 to 16.00	0.01	± 0.01	6	USA / NIST / DIN	1
PC210	pH/mV/ORP/Conductivity/TDS/Salinity/Resistivity/°C/°F	-2.00 to 16.00	0.01	± 0.01	6	USA / NIST / DIN	2
PC220	pH/mV/ORP/Conductivity/TDS/Salinity/Resistivity/°C/°F	-2.00 to 16.00	0.01	± 0.01	6	USA / NIST / DIN	2
PD210	pH/mV/ORP/DO/°C/°F	-2.00 to 16.00	0.01	± 0.01	6	USA / NIST / DIN	2
PD220	pH/mV/ORP/DO/°C/°F	-2.00 to 16.00	0.01	± 0.01	6	USA / NIST / DIN	2
LAQUA WQ-300 Series Handheld Meters							
WQ-310	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	-2.000 to 20.000	0.01 / 0.001	± 0.01 / ± 0.005	6	USA / NIST /DIN / NIST10 / Custom	1
WQ-320	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	-2.000 to 20.000	0.01 / 0.001	± 0.01 / ± 0.005	6	USA / NIST /DIN / NIST10 / Custom	2
WQ-330	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	-2.000 to 20.000	0.01 / 0.001	± 0.01 / ± 0.005	6	USA / NIST /DIN / NIST10 / Custom	3
LAQUA 2000 Series Bench Meters							
PH2000	pH/ORP/Temp/°C/°F	-2.000 to 20.000	0.1 / 0.01 / 0.001	± 0.003	6	USA / NIST / NIST2 / DIN / Custom	1
ION2000	pH/ORP/Ion/Temp/°C/°F	-2.000 to 20.000 pH	0.1 / 0.01 / 0.001 pH	± 0.003 pH	6	USA / NIST / NIST2 / DIN / Custom	1
PC2000	pH/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/Temp/°C/°F	-2.000 to 20.000	0.1 / 0.01 / 0.001	± 0.003	6	USA / NIST / NIST2 / DIN / Custom	2
LAQUA Colour Touchscreen Bench Meters							
F-72	pH/mV/ORP/Ion/°C	-2.000 to 20.000	0.01 / 0.001	± 0.001	5	USA / NIST / NIST2 / China / Custom	1
F-73	pH/mV/ORP/Ion/°C	-2.000 to 20.000	0.01 / 0.001	± 0.001	5	USA / NIST / NIST2 / China / Custom	2
F-74	pH/mV/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/°C	-2.000 to 20.000	0.01 / 0.001	± 0.001	5	USA / NIST / NIST2 / China / Custom	2

Memory	Auto Data Log	Real Time Clock	Date/Time Stamp	Cal Alarm	Backlight	Temperature Display	PC Communication	Printer Communication	Page
—	—	—	—	—	Yes	—	—	—	26
—	—	—	—	—	Yes	—	—	—	26
—	—	—	—	—	Yes	Yes	—	—	26
500	Yes	—	—	Yes	Yes	Yes	—	—	35
1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	35
500	Yes	—	—	Yes	Yes	Yes	—	—	38
1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	38
500	Yes	—	—	Yes	Yes	Yes	—	—	39
1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	39
10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	44
10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	50
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	50
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	51
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	58
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	58
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	59

Conductivity Meters

Models	Parameters	Conductivity Range	Accuracy	Max. Cal. Points
LAQUAtwin Pocket Meters				
EC-11	Conductivity	... μS/cm to 19.99 mS/cm	± 2% full scale (for each range)	2
EC-22	Conductivity/°C	... μS/cm to 199.9 mS/cm	± 2% full scale (for each range) ± 5% full scale (20.0 to 199.9 mS/cm)	3
EC-33	Conductivity/TDS/°C	… μS/cm to 199.9 mS/cm	± 2% full scale (for each range) ± 5% full scale (20.0 to 199.9 mS/cm)	3
LAQUA 200 Series Handheld Meters				
EC210	Conductivity/Resistivity/TDS/Salinity/°C/°F	... μS/cm to 200.0 mS/cm	± 0.6% full scale (18.0 to 200.0 mS/cm: ± 1.5% full scale)	5
EC220	Conductivity/Resistivity/TDS/Salinity/°C/°F	... μS/cm to 200.0 mS/cm	± 0.6% full scale (18.0 to 200.0 mS/cm: ± 1.5% full scale)	5
PC210	pH/mV/ORP/Conductivity/Resistivity/TDS/Salinity/°C/°F	... μS/cm to 200.0 mS/cm	± 0.6% full scale (18.0 to 200.0 mS/cm: ± 1.5% full scale)	5
PC220	pH/mV/ORP/Conductivity/Resistivity/TDS/Salinity/°C/°F	... μS/cm to 200.0 mS/cm	± 0.6% full scale (18.0 to 200.0 mS/cm: ± 1.5% full scale)	5
LAQUA WQ-300 Series Handheld Meters				
WQ-310	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	... μS/cm to 2000 mS/cm	± 0.5% full scale (> 200 mS/cm: ± 1.5% full scale)	5
WQ-320	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	... μS/cm to 2000 mS/cm	± 0.5% full scale (> 200 mS/cm: ± 1.5% full scale)	5
WQ-330	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	... μS/cm to 2000 mS/cm	± 0.5% full scale (> 200 mS/cm: ± 1.5% full scale)	5
LAQUA 2000 Series Bench Meters				
EC2000	Conductivity/Resistivity/TDS/Salinity/Temp/°C/°F	... μS/cm to 2.000 S/cm	± 0.6% full scale; ± 1.5% full scale > 18.0 mS/cm	5
PC2000	pH/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/Temp/°C/°F	... μS/cm to 2.000 S/cm	± 0.6% full scale; ± 1.5% full scale > 18.0 mS/cm	5
LAQUA Colour Touchscreen Bench Meters				
DS-72	Conductivity/Resistivity/TDS/Salinity/°C	... μS/cm to 200.0 mS/cm	± 0.6% full scale (18.0 to 200.0 mS/cm: ± 1.5% full scale)	4
F-74	pH/mV/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/°C	... μS/cm to 200.0 mS/cm	± 0.6% full scale (18.0 to 200.0 mS/cm: ± 1.5% full scale)	4



Auto Cal Standards	Channel	Memory	Auto Data Log	Real Time Clock	Date/ Time Stamp	Backlight	Temperature Display	PC Communication	Printer Communication	Page
1413 µS/cm, 12.88 mS/cm	1	—	—	—	—	Yes	—	—	—	27
1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	1	—	—	—	—	Yes	Yes	—	—	27
1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	1	—	—	—	—	Yes	Yes	—	—	27
84 µS/cm, 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	1	500	Yes	—	—	Yes	Yes	—	—	36
84 µS/cm, 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	1	1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	36
84 µS/cm, 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	2	500	Yes	—	—	Yes	Yes	—	—	38
84 µS/cm, 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	2	1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	38
84 µS/cm, 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	1	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	44
84 µS/cm, 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	2	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
84 µS/cm, 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	3	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
84 µS/cm, 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	1	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	51
84 µS/cm, 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	2	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	51
84 µS/cm, 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	1	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	59
84 µS/cm, 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm	2	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	59

Salinity Meters

Models	Parameters	Salinity Range	Accuracy	Max. Cal. Points	Channel
LAQUAtwin Pocket Meter					
Salt-11	Salinity/°C	0.00 to 10.00 % 0.0 to 100.0 ppt	± 0.2% full scale	2	1
LAQUA 200 Series Handheld Meters					
EC210	Conductivity/Resistivity/TDS/Salinity/°C/°F	0.00 to 10.00 % 0.0 to 100.0 ppt	± 0.2% full scale	1	1
EC220	Conductivity/Resistivity/TDS/Salinity/°C/°F	0.00 to 10.00 % 0.0 to 100.0 ppt	± 0.2% full scale	1	1
PC210	pH/mV/ORP/Conductivity/Resistivity/TDS/Salinity/°C/°F	0.00 to 10.00 % 0.0 to 100.0 ppt	± 0.2% full scale	1	2
PC220	pH/mV/ORP/Conductivity/Resistivity/TDS/Salinity/°C/°F	0.00 to 10.00 % 0.0 to 100.0 ppt	± 0.2% full scale	1	2
LAQUA WQ-300 Series Handheld Meters					
WQ-310	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	0.000 to 8.000 % 0.00 to 80.00 ppt	± 0.5% of reading or ± 0.01 ppt, whichever is greater	1	1
WQ-320	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	0.000 to 8.000 % 0.00 to 80.00 ppt	± 0.5% of reading or ± 0.01 ppt, whichever is greater	1	2
WQ-330	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	0.000 to 8.000 % 0.00 to 80.00 ppt	± 0.5% of reading or ± 0.01 ppt, whichever is greater	1	3
LAQUA 2000 Series Bench Meters					
EC2000	Conductivity/Resistivity/TDS/Salinity/Temp/°C/°F	0.00 to 10.00 % 0.0 to 100.0 ppt	± 0.2% full scale	1	1
PC2000	pH/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/Temp/°C/°F	0.00 to 10.00 % 0.0 to 100.0 ppt	± 0.2% full scale	1	2
LAQUA Colour Touchscreen Bench Meters					
DS-72	Conductivity/Resistivity/TDS/Salinity/°C	0.000 to 8.000 % 0.00 to 80.00 ppt	± 0.2% full scale	1	1
F-74	pH/mV/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/°C	0.000 to 8.000 % 0.00 to 80.00 ppt	± 0.2% full scale	1	2

All salinity meters have NaCl and seawater curves. Salinity value is derived from measured conductivity value.

Total Dissolved Solids (TDS) Meters

Models	Parameters	TDS Range	Resolution	Accuracy
LAQUAtwin Pocket Meters				
EC-33	Conductivity/TDS/°C	0.0 to 9990 ppm	0.1 / 1 / 10 ppm	± 2% full scale
LAQUA 200 Series Handheld Meters				
EC210	Conductivity/Resistivity/TDS/Salinity/°C/°F	0.00 mg/L to 100 g/L	0.01 mg/L	± 0.1% full scale
EC220	Conductivity/Resistivity/TDS/Salinity/°C/°F	0.00 mg/L to 100 g/L	0.01 mg/L	± 0.1% full scale
PC210	pH/mV/ORP/Conductivity/Resistivity/TDS/Salinity/°C/°F	0.00 mg/L to 100 g/L	0.01 mg/L	± 0.1% full scale
PC220	pH/mV/ORP/Conductivity/Resistivity/TDS/Salinity/°C/°F	0.00 mg/L to 100 g/L	0.01 mg/L	± 0.1% full scale
LAQUA WQ-300 Series Handheld Meters				
WQ-310	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	0.01 mg/L to 200,000 mg/L	0.01 mg/L	±0.5% of reading or ± 0.1mg/L, whichever is greater
WQ-320	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	0.01 mg/L to 200,000 mg/L	0.01 mg/L	±0.5% of reading or ± 0.1mg/L, whichever is greater
WQ-330	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	0.01 mg/L to 200,000 mg/L	0.01 mg/L	±0.5% of reading or ± 0.1mg/L, whichever is greater
LAQUA 2000 Series Bench Meters				
EC2000	Conductivity/Resistivity/TDS/Salinity/Temp/°C/°F	0.01 mg/L to 100 g/L	0.01 mg/L	± 0.1% full scale
PC2000	pH/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/Temp/°C/°F	0.01 mg/L to 100 g/L	0.01 mg/L	± 0.1% full scale
LAQUA Colour Touchscreen Bench Meters				
DS-72	Conductivity/Resistivity/TDS/Salinity/°C	0.01 mg/L to 1000 g/L	0.01 mg/L	± 0.1% full scale
F-74	pH/mV/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/°C	0.01 mg/L to 1000 g/L	0.01 mg/L	± 0.1% full scale

All TDS meters have Linear (TDS Factor 0.4 to 1.0), EN27888, 442, and NaCl curves. TDS value is derived from measured conductivity value.

Memory	Auto Data Log	Real Time Clock	Date/Time Stamp	Backlight	Temperature Display	PC Communication	Printer Communication	Page
—	—	—	—	Yes	Yes	—	—	27
500	Yes	—	—	Yes	Yes	—	—	36
1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	36
500	Yes	—	—	Yes	Yes	—	—	38
1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	38
10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	44
10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	51
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	51
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	59
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	59

Channel	Memory	Auto Data Log	Real Time Clock	Date/Time Stamp	Backlight	Temperature Display	PC Communication	Printer Communication	Page
1	—	—	—	—	Yes	Yes	—	—	27
1	500	Yes	—	—	Yes	Yes	—	—	36
1	1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	36
2	500	Yes	—	—	Yes	Yes	—	—	38
2	1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	38
1	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	44
2	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
3	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
1	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	51
2	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	51
1	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	59
2	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	59

Ion Meters

Models	Parameters	Ion Range	Resolution	Accuracy	Max. Cal. Points
LAQUAtwin Pocket Meters					
Na-11	Sodium Ion/°C	2 to 9900 ppm (mg/L) 0.1 to 430 mmol/L	1 / 10 / 100ppm	±10% of actual value	2
K-11	Potassium Ion/°C	4 to 9900 ppm (mg/L) 0.1 to 250 mmol/L	1 / 10 / 100ppm	±10% of actual value	2
NO3-11	Nitrate Ion/Nitrate-Nitrogen/°C	NO_3^-: 6 to 9900 ppm (mg/L) 0.1 to 160 mmol/L NO_3-N: 1.4 to 2200 ppm (mg/L)	1 / 10 / 100ppm	±10% of actual value	2
Ca-11	Calcium Ion/°C	4 to 9900 ppm (mg/L) 0.1 to 250 mmol/L	1 / 10 / 100ppm	±20% of actual value	2
LAQUA WQ-300 Series Handheld Meters					
WQ-310	pH/mV/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/DO/°C / °F	0.000 to 99900 (mg/L, mmol/L)	0.001 minimum, 3 significant digits	±0.1 mV	5
WQ-320	pH/mV/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/DO/°C / °F	0.000 to 99900 (mg/L, mmol/L)	0.001 minimum, 3 significant digits	±0.1 mV	5
WQ-330	pH/mV/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/DO/°C / °F	0.000 to 99900 (mg/L, mmol/L)	0.001 minimum, 3 significant digits	±0.1 mV	5
LAQUA 2000 Series Bench Meters					
ION2000	pH/ORP/Ion/Temp/°C/°F	0.000 µg/L to 9999 g/L (µg/L ⇔ mg/L ⇔ g/L, ppm ⇔ ppt, mmol/L ⇔ mol/L)	4 significant digits	± 0.3% full scale or ± 0.2 mV, whichever is higher	5
PC2000	pH/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/Temp/°C/°F	0.000 µg/L to 9999 g/L (µg/L ⇔ mg/L ⇔ g/L, ppm ⇔ ppt, mmol/L ⇔ mol/L)	4 significant digits	± 0.3% full scale or ± 0.2 mV, whichever is higher	5
LAQUA Colour Touchscreen Bench Meters					
F-72	pH/mV/ORP/Ion/°C	0.000 µg/L to 9999 g/L (µg/L, mg/L, g/L, mmol/L, mol/L)	4 significant digits	± 0.3% of full scale	5
F-73	pH/mV/ORP/Ion/°C	0.000 µg/L to 9999 g/L (µg/L, mg/L, g/L, mmol/L, mol/L)	4 significant digits	± 0.3% of full scale	5
F-74	pH/mV/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/°C	0.000 µg/L to 9999 g/L (µg/L, mg/L, g/L, mmol/L, mol/L)	4 significant digits	± 0.3% of full scale	5

Dissolved Oxygen (DO) Meters

Models	Parameters	DO Probe Type	DO Range	Accuracy	Max. Cal. Points
LAQUA 200 Series Handheld Meters					
DO210	DO/°C/°F	Galvanic	0.00 to 20.00 mg/L 0.0 to 200.0 %	± 0.1 mg/L	2
DO220	DO/°C/°F	Galvanic	0.00 to 20.00 mg/L 0.0 to 200.0 %	± 0.1 mg/L	2
PD210	pH/mV/ORP/DO/°C/°F	Galvanic	0.00 to 20.00 mg/L 0.0 to 200.0 %	± 0.1 mg/L	2
PD220	pH/mV/ORP/DO/°C/°F	Galvanic	0.00 to 20.00 mg/L 0.0 to 200.0 %	± 0.1 mg/L	2
LAQUA WQ-300 Series Handheld Meters					
WQ-310	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	Optical	0.00 to 20.00 mg/L 0.0 to 200.0 %	±0.2 mg/L, ±2 %	2
WQ-320	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	Optical	0.00 to 20.00 mg/L 0.0 to 200.0 %	±0.2 mg/L, ±2 %	2
WQ-330	pH/mV/ORP/Ion/Conductivity/TDS/Salinity/Resistivity/DO/°C/°F	Optical	0.00 to 20.00 mg/L 0.0 to 200.0 %	±0.2 mg/L, ±2 %	2

All DO meters compensate for temperature, salinity, and atmospheric pressure.

DO readings can be expressed in mg/L and % saturation.

Channel	Memory	Auto Data Log	Real Time Clock	Date / Time Stamp	Backlight	Temperature Display	PC Communication	Printer Communication	Page
1	—	—	—	—	Yes	Yes	—	—	28
1	—	—	—	—	Yes	Yes	—	—	28
1	—	—	—	—	Yes	Yes	—	—	28
1	—	—	—	—	Yes	Yes	—	—	28
1	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	44
2	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
3	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
1	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	50
2	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	51
1	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	58
2	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	58
2	2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	59

Channel	Memory	Auto Data Log	Real Time Clock	Date/Time Stamp	Backlight	Temperature Display	PC Communication	Printer Communication	Page
1	500	Yes	—	—	Yes	Yes	—	—	37
1	1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	37
2	500	Yes	—	—	Yes	Yes	—	—	39
2	1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	39
1	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	44
2	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
3	10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45

Multi-Parameter Meters

Models	Parameters	Range	Resolution	Accuracy	Max. Cal. Points	Channel
LAQUA 200 Series Handheld Meters						
PC210	pH	-2.00 to 16.00	0.01	± 0.01 pH	6	2
	mV / ORP	± 2000 mV	0.1 mV (< ±1000 mV), 1 mV (≥ ±1000mV)	±0.3 mV (< ±1000 mV), 0.3% of reading (≥ ±1000mV)	1	
	Conductivity	... µS/cm to 200.0 mS/cm	0.05% full scale	± 0.6% of full scale (18.0 to 200.0 mS/cm: ± 1.5% of full scale)	5	
	Resistivity	0.000 Ω·cm to 20.00 MΩ·cm	0.05% full scale	±0.6% of full scale (1.80 to 20.00 MΩ·cm: ±1.5% of full scale)	—	
	TDS	0.00 mg/L to 100 g/L	0.01 ppm (mg/L) / 0.1 ppt (g/L)	±0.1% of full scale	—	
	Salinity	0.00 to 10.00 % 0.0 to 100.0 ppt	0.01 % / 0.1 ppt	± 0.2% of full scale	1	
	°C / °F	-30.0 to 130.0 °C / -22.0 to 266.0 °F	0.1 °C / °F	± 0.5 °C / ± 0.9 °F	1	
PC220	pH	-2.00 to 16.00	0.01	± 0.01 pH	6	2
	mV / ORP	± 2000 mV	0.1 mV (< ±1000 mV), 1 mV (≥ ±1000mV)	±0.3 mV (< ±1000 mV), 0.3% of reading (≥ ±1000mV)	1	
	Conductivity	... µS/cm to 200.0 mS/cm	0.05% full scale	± 0.6% of full scale (18.0 to 200.0 mS/cm: ± 1.5% of full scale)	5	
	Resistivity	0.000 Ω·cm to 20.00 MΩ·cm	0.05% full scale	±0.6% of full scale (1.80 to 20.00 MΩ·cm: ±1.5% of full scale)	—	
	TDS	0.00 mg/L to 100 g/L	0.01 ppm (mg/L) / 0.1 ppt (g/L)	±0.1 % of full scale	—	
	Salinity	0.00 to 10.00 % 0.0 to 100.0 ppt	0.01 % / 0.1 ppt	±0.2 % of full scale	1	
	°C / °F	-30.0 to 130.0 °C / -22.0 to 266.0 °F	0.1 °C / °F	± 0.5 °C / ± 0.9 °F	1	
PD210	pH	-2.00 to 16.00	0.01	± 0.01 pH	6	2
	mV / ORP	± 2000 mV	0.1 mV (< ±1000 mV), 1 mV (≥ ±1000mV)	±0.3 mV (< ±1000 mV), 0.3% of reading (≥ ±1000mV)	1	
	DO	0.00 to 20.00 mg/L 0.0 to 200.0 %	0.01 mg/L	± 0.1 mg/L	2	
	°C / °F	-30.0 to 130.0 °C / -22.0 to 266.0 °F	0.1°C / °F	± 0.5 °C / ± 0.9 °F	1	
PD220	pH	-2.00 to 16.00	0.01	± 0.01 pH	6	2
	mV / ORP	± 2000 mV	0.1 mV (< ±1000 mV), 1 mV (≥ ±1000mV)	±0.3 mV (< ±1000 mV), 0.3% of reading (≥ ±1000mV)	1	
	DO	0.00 to 20.00 mg/L 0.0 to 200.0 %	0.01 mg/L	± 0.1 mg/L	2	
	°C / °F	-30.0 to 130.0 °C / -22.0 to 266.0 °F	0.1°C / °F	± 0.5 °C / ± 0.9 °F	1	

Memory	Auto Data Log	Real Time Clock	Date / Time Stamp	Backlight	Temperature Display	PC Communication	Printer Communication	Page
500	Yes	—	—	Yes	Yes	—	—	38
1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	38
500	Yes	—	—	Yes	Yes	—	—	39
1,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	39

Multi-Parameter Meters

Models	Parameters	Range	Resolution	Accuracy	Max. Cal. Points	Channel
LAQUA WQ-300 Series Handheld Meters						
WQ-310	pH	-2.000 to 20.000	0.01 / 0.001	± 0.01 / ± 0.005	6	1
	mV / ORP	± 2000 mV	< ±1000.0 mV: 0.1mV, ≥ 1000.0 mV: 1 mV	< ±1000.0 mV: ±0.1 mV, ≥ 1000.0 mV: ±1 mV	1	
	Ion	0.000 to 99900 (mg/L, mmol/L)	0.001 minimum, 3 significant digits	±0.1 mV	5	
	Conductivity	... μS/cm to 2000 mS/cm	Auto ranging, up to 4 significant digits	± 0.5% full scale of each range > 200 mS/cm (20.0 S/m): ± 1.5% full scale	5	
	Resistivity	0.1 Ω·cm to 200.0 MΩ·cm	Auto ranging, up to 4 significant digits	± 0.5% full scale of each range > 200 mS/cm (20.0 S/m): ± 1.5% full scale	—	
	TDS	0.01 mg/L to 200,000 mg/L	0.01 minimum, 4 significant digits	± 0.5% of reading or ± 0.1 mg/L, whichever is greater	—	
	Salinity	0.00 to 80.00 ppt 0.000 to 8.000 %	0.01 ppt, 0.001 %	± 0.5% of reading or ± 0.01 ppt, whichever is greater	1	
	DO	0.00 to 20.00 mg/L 0.0 to 200.0 %	0.01 mg/L, 0.1%	±0.2 mg/L, ±2 %	2	
	°C / °F	-30.0 to 130.0 °C / -22.0 to 266.0 °F	0.1 °C / °F	±0.5 °C / ±0.9 °F	1	
WQ-320	pH	-2.000 to 20.000	0.01 / 0.001	± 0.01 / ± 0.005	6	2
	mV / ORP	± 2000 mV	< ±1000.0 mV: 0.1mV, ≥ 1000.0 mV: 1 mV	< ±1000.0 mV: ±0.1 mV, ≥ 1000.0 mV: ±1 mV	1	
	Ion	0.000 to 99900 (mg/L, mmol/L)	0.001 minimum, 3 significant digits	±0.1 mV	5	
	Conductivity	... μS/cm to 2000 mS/cm	Auto ranging, up to 4 significant digits	± 0.5% full scale of each range > 200 mS/cm (20.0 S/m): ± 1.5% full scale	5	
	Resistivity	0.1 Ω·cm to 200.0 MΩ·cm	Auto ranging, up to 4 significant digits	± 0.5% full scale of each range > 200 mS/cm (20.0 S/m): ± 1.5% full scale	—	
	TDS	0.01 mg/L to 200,000 mg/L	0.01 minimum, 4 significant digits	± 0.5% of reading or ± 0.1 mg/L, whichever is greater	—	
	Salinity	0.00 to 80.00 ppt 0.000 to 8.000 %	0.01 ppt, 0.001 %	± 0.5% of reading or ± 0.01 ppt, whichever is greater	1	
	DO	0.00 to 20.00 mg/L 0.0 to 200.0 %	0.01 mg/L, 0.1%	±0.2 mg/L, ±2 %	2	
	°C / °F	-30.0 to 130.0 °C / -22.0 to 266.0 °F	0.1 °C / °F	±0.5 °C / ±0.9 °F	1	
WQ-330	pH	-2.000 to 20.000	0.01 / 0.001	± 0.01 / ± 0.005	6	3
	mV / ORP	± 2000 mV	< ±1000.0 mV: 0.1mV, ≥ 1000.0 mV: 1 mV	< ±1000.0 mV: ±0.1 mV, ≥ 1000.0 mV: ±1 mV	1	
	Ion	0.000 to 99900 (mg/L, mmol/L)	0.001 minimum, 3 significant digits	±0.1 mV	5	
	Conductivity	... μS/cm to 2000 mS/cm	Auto ranging, up to 4 significant digits	± 0.5% full scale of each range > 200 mS/cm (20.0 S/m): ± 1.5% full scale	5	
	Resistivity	0.1 Ω·cm to 200.0 MΩ·cm	Auto ranging, up to 4 significant digits	± 0.5% full scale of each range > 200 mS/cm (20.0 S/m): ± 1.5% full scale	—	
	TDS	0.01 mg/L to 200,000 mg/L	0.01 minimum, 4 significant digits	± 0.5% of reading or ± 0.1 mg/L, whichever is greater	—	
	Salinity	0.00 to 80.00 ppt 0.000 to 8.000 %	0.01 ppt, 0.001 %	± 0.5% of reading or ± 0.01 ppt, whichever is greater	1	
	DO	0.00 to 20.00 mg/L 0.0 to 200.0 %	0.01 mg/L, 0.1%	±0.2 mg/L, ±2 %	2	
	°C / °F	-30.0 to 130.0 °C / -22.0 to 266.0 °F	0.1 °C / °F	±0.5 °C / ±0.9 °F	1	

Memory	Auto Data Log	Real Time Clock	Date / Time Stamp	Backlight	Temperature Display	PC Communication	Printer Communication	Page
10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	44
10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45
10,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	45

Multi-Parameter Meters

Models	Parameters	Range	Resolution	Accuracy	Max. Cal. Points	Channel
LAQUA 2000 Series Bench Meters						
ION2000	pH	-2.000 to 20.000 pH	0.1 / 0.01 / 0.001	± 0.003 pH	6	1
	mV / ORP	± 2000.0 mV	0.1 mV	±0.2 mV	**1**	
	Ion	0.000 µg/L to 9999 g/L (µg/L ⇔ mg/L ⇔ g/L, ppm ⇔ ppt, mmol/L ⇔ mol/L)	4 significant digits	± 0.3% of full scale	5	
	°C / °F	-30.0 to 130.0 °C / -22.0 to 266.0 °F	0.1 °C / °F	± 0.5 °C / ± 0.9 °F	1	
PC2000	pH	-2.000 to 20.000 pH	0.1 / 0.01 / 0.001	± 0.003 pH	6	2
	mV / ORP	± 2000.0 mV	0.1 mV	±0.2 mV	**1**	
	Ion	0.000 µg/L to 9999 g/L (µg/L ⇔ mg/L ⇔ g/L, ppm ⇔ ppt, mmol/L ⇔ mol/L)	4 significant digits	± 0.3% full scale or ± 0.2 mV, whichever is higher	5	
	Conductivity	... µS/cm to 2.000 S/cm	0.05% full scale	± 0.6% full scale; ± 1.5% full scale > 18.0 mS/cm	5	
	Resistivity	0.000 Ω•cm to 20.0 MΩ•cm	0.05% full scale	± 0.6% full scale; ± 1.5% full scale > 1.80 MΩ•cm	—	
	TDS	0.01 mg/L to 100 g/L	0.01 mg/L	±0.1% full scale	—	
	Salinity	0.00 to 10.00 % 0.0 to 100.0 ppt	0.01 % / 0.1 ppt	± 0.2% full scale	**1**	
	°C / °F	-30.0 to 130.0 °C / -22.0 to 266.0 °F	0.1 °C / °F	± 0.5 °C / ± 0.9 °F	1	
LAQUA Colour Touchscreen Bench Meters						
F-72	pH	-2.000 to 20.000	0.01 / 0.001 pH	± 0.001 pH	5	1
	mV / ORP	± 1999.9 mV	0.1 mV	±0.2 mV	1	
	Ion	0.000 µg/L to 9999 g/L (µg/L, mg/L, g/L, mmol/L, mol/L)	4 significant digits	± 0.3% of full scale	5	
	°C	-30.0 to 130.0 °C	0.1 °C	± 0.4°C	1	
F-73	pH	-2.000 to 20.000	0.01 / 0.001 pH	± 0.001 pH	5	2
	mV / ORP	± 1999.9 mV	0.1 mV	±0.2 mV	1	
	Ion	0.000 µg/L to 9999 g/L (µg/L, mg/L, g/L, mmol/L, mol/L)	4 significant digits	± 0.3% of full scale	5	
	°C	-30.0 to 130.0 °C	0.1 °C	± 0.4°C	1	
F-74	pH	-2.000 to 20.000	0.01 / 0.001 pH	± 0.001 pH	5	2
	mV / ORP	± 1999.9 mV	0.1 mV	±0.2 mV	1	
	Ion	0.000 µg/L to 9999 g/L (µg/L, mg/L, g/L, mmol/L, mol/L)	4 significant digits	± 0.3% of full scale	5	
	Conductivity	... µS/cm to 199.9 mS/cm	0.05% full scale	± 0.6% of full scale (18.0 to 199.9 mS/cm: ± 1.5% of full scale)	4	
	Resistivity	0.000 Ω·cm to 19.99 MΩ·cm	0.05% full scale	±0.6% of full scale (1.80 to 19.99 MΩ·cm: ±1.5% of full scale)	—	
	TDS	0.01 mg/L to 1000 g/L	0.01 mg/L	±0.1% of full scale	—	
	Salinity	0.000 to 8.000 % 0.00 to 80.00 ppt	0.001 % / 0.01 ppt	± 0.2% of full scale	1	
	°C	-30.0 to 130.0 °C	0.1 °C	± 0.4°C	1	

Memory	Auto Data Log	Real Time Clock	Date / Time Stamp	Backlight	Temperature Display	PC Communication	Printer Communication	Page
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	50
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	51
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	58
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	58
2,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	59

Water Quality Instruments


LAQUA
7.000
pH
25.0
HORIBA
7.34
0.001
8.05
pH
7.00
COND
14.13
20.00
5.00
Salt EC
LAQUAtwin

LAQUAtwin

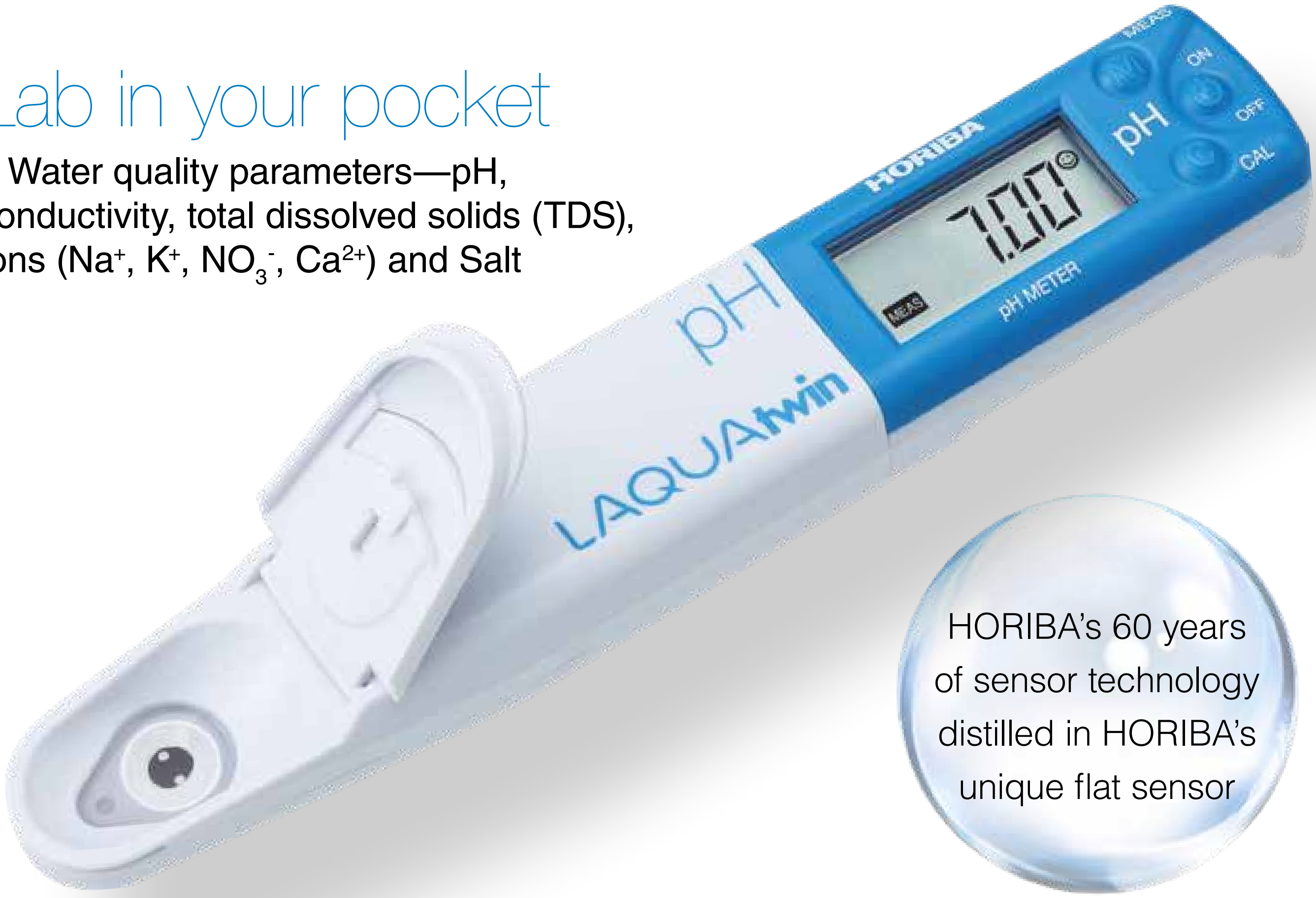
Pocket Water Quality Meters

Originating from the Cardy series, the LAQUAtwin series offers easy, quick, and accurate measurements of 8 parameters using microvolume samples. The waterproof body, backlit LCD, and replaceable sensor of each meter allow you to perform your measurements anywhere and anytime. This series brings new dimension to your water quality testing.

LAQUAtwin Pocket Water Quality Meters

Lab in your pocket

8 Water quality parameters—pH, conductivity, total dissolved solids (TDS), Ions (Na^+, K^+, NO_3^-, Ca^{2+}) and Salt



HORIBA's 60 years of sensor technology distilled in HORIBA's unique flat sensor

Multiple Measurement Techniques

7 different ways of testing samples


Immersion


Scoop

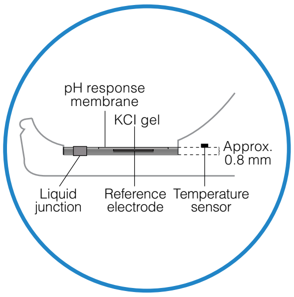

Wipe


Paper, textiles and films


Powders


Solid samples


Drops



Employ same principle as conventional laboratory electrodes

Auto calibrates at a touch of a button

IP67 Dust resistant and waterproof

Long battery life (approx. 400 hrs. continuous use) and auto power off capability

Accurate reading from single drop of sample in just seconds

Smiley ☺ reading stability indicator

Sensor cap protects sample against light and sensor membrane against damage

Warranties of 2 years for meter and 6 months for sensor

Monochrome digital display with switchable backlight

Auto stable and auto hold measurement modes

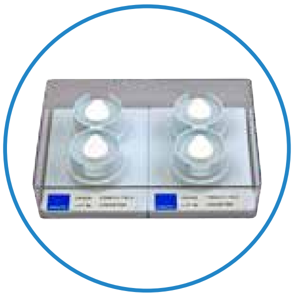
Lightweight (approx. 55g including batteries)

Packaged in a storage case with calibration solutions and accessories

Replaceable unique sensors

Temperature calibration function (applicable to models with temperature display)

Easy to carry



Sampling sheet for minute (as low as 50µL) and suspension samples

LAQUAtwin Pocket Water Quality Meters

Scan QR code with your mobile device to know more about LAQUAtwin Meters

pH

General Features

- 0.00 to 14.00 pH range
- ±650 mV range
- 0.1ml (0.05ml with sampling sheet) minimum sample
- Flat pH sensor with sliding cap
- Auto buffer recognition - USA (pH 1.68, 4.01, 7.00, 10.01, & 12.46) & NIST (pH 1.68, 4.01, 6.86, 9.18, 12.46)
- Auto temperature compensation
- Packaged with pH 4.01 & 7.00 buffers (14ml each), 2pcs CR2032 batteries, dropper, and manuals

pH-11

- pH/mV meter
- 0.1 pH resolution
- Up to 2 calibration points

pH-22

- pH/mV meter
- 0.01 pH resolution
- Up to 3 calibration points

pH-33

- pH/mV/temperature meter
- 0.01 pH resolution
- Up to 5 calibration points
- 0.0 to 50.0°C temperature range
- Temperature calibration

Conductivity / TDS / Salinity

General Features

- Wide conductivity, TDS, and salt ranges
- 0.12ml minimum sample
- Titanium/platinum black sensor with protection cap
- Auto range
- Auto standard recognition
- Auto temperature compensation (fixed 2%/°C)
- Packaged with 1413 µS/cm, 12.88 mS/cm standards (14ml each) and conditioning solution (4ml) for EC models, 0.5% & 5.0% NaCl standards (14ml) for Salt-11 meter, 2pcs CR2032 batteries, dropper, and manuals

EC-11

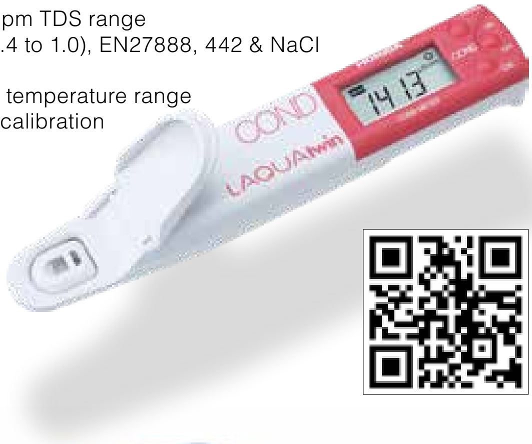
- Conductivity meter
- 0 µS/cm to 19.99 mS/cm conductivity range
- Up to 2 calibration points
- Auto standard recognition - 1413 µS/cm & 12.88 mS/cm

EC-22

- Conductivity/temperature meter
- 0 µS/cm to 199.9 mS/cm conductivity range
- Up to 3 calibration points
- Auto standard recognition - 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm
- 0.0 to 50.0°C temperature range
- Temperature calibration

EC-33

- Conductivity/TDS/temperature meter
- 0 µS/cm to 199.9 mS/cm conductivity range
- Up to 3 calibration points
- Auto standard recognition - 1413 µS/cm, 12.88 mS/cm, 111.8 mS/cm
- 0.0 to 9990 ppm TDS range
- TDS factor (0.4 to 1.0), EN27888, 442 & NaCl curves
- 0.0 to 50.0°C temperature range
- Temperature calibration



Salt-11

- Salt/temperature meter
- 0.0 to 100.0 g/L & 0.00 to 10.00% salt range
- Up to 2 calibration points
- Auto standard recognition - 0.5% & 5.0% NaCl
- NaCl and seawater curves
- 0.0 to 50.0°C temperature range
- Temperature calibration

General Features

- Wide ion measurement ranges
- Up to 2 calibration points
- 0.0 to 50.0°C temperature range with temperature calibration function
- 0.3ml (0.05ml with sampling sheet) minimum sample
- Flat ion selective sensor with sliding cap
- Changeable calibration values
- Auto standard recognition
- Multiplication compensation
- Packaged with 150ppm & 2000ppm standards (14ml each), 2pcs CR2032 batteries, 5pcs sampling sheets, dropper, and manuals

Na-11

Sodium (Na^+) measurement ranges:

- 2 to 9900 ppm (mg/L)
- 0.1 to 430 mmol/L

NO3-11

Nitrate (NO_3^-) & Nitrate-Nitrogen (NO_3^-N) measurement ranges:

- NO_3^- : 6 to 9900 ppm (mg/L)
- NO_3^- : 0.1 to 160 mmol/L
- NO_3^- N: 1.4 to 2200 ppm (mg/L)

K-11

Potassium (K^+) measurement ranges:

- 4 to 9900 ppm (mg/L)
- 0.1 to 250 mmol/L
- 2 to 5000 kg/10a (soil/water ratio 1:5)

Ca-11

Calcium (Ca^{2+}) measurement ranges:

- 4 to 9900 ppm (mg/L)
- 0.1 to 250 mmol/L

Ca-11C

Blood ionized calcium (Ca^{2+})
- 0.1 to 5.0 mmol/L measurement range
- Packaged with 1.25 & 2.50 mmol/L standards (25ml x 2 each), 251 cleaning solution (250ml x 3), CR2032 batteries, wash bottle, and manuals

Notes

LAQUA

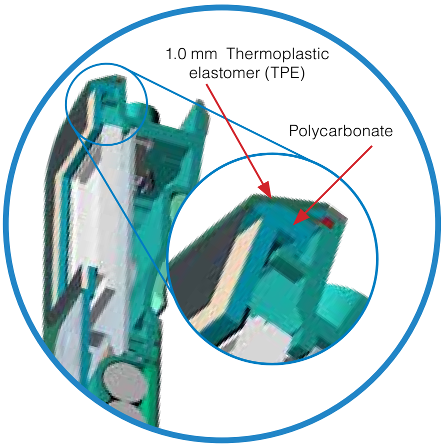
LAQUA 200 Series Handheld Water Quality Instruments

Basic yet efficiently designed, the 200 series meters are ideal for measurement on the go. These IP67-rated handheld meters feature monochrome backlit LCD with single-channel display, dual-layer housing that fits comfortably in the hand, easy operation, bare minimum keypad, and PC connectivity via USB cable and software.

LAQUA **200 Series** Handheld Water Quality Meters

Precision in the palm of your hand

Eco-friendly, Shock & Scratch Resistant, & Non-Slip



Ergonomic black housing design

Integrated Foldable Meter Stand

IP67 Waterproof and Dustproof

Backlit, Monochrome LCD display

9-Button Keypad Minimal Matrix

Built-in Electrode Holder and Optional Electrode Adapter

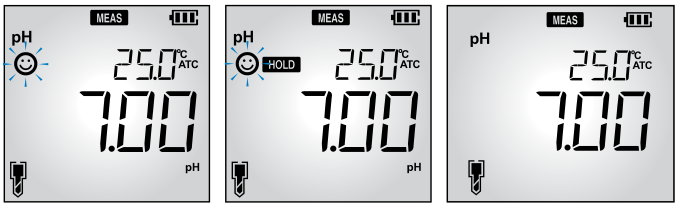
High Battery Capacity

Hands-free Testing

PC & Printer Compatible (Applicable to 220 Series Models)

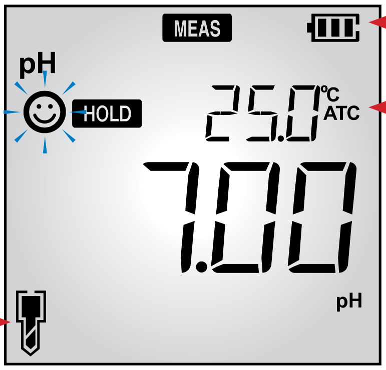
LAQUA **200 Series** Handheld Water Quality Meters

Auto Stable, Auto Hold, and Real Time Measurement Modes Indicator

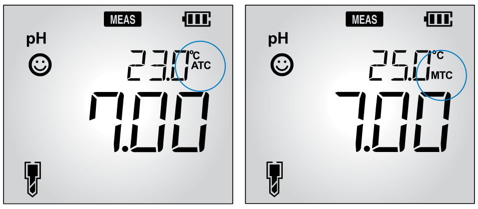


Auto Stable
Auto Hold
Real Time

Battery Indicator

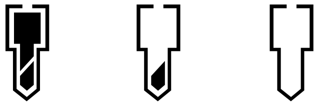


Temperature Sensor Indicator



Temperature sensor connected
Temperature sensor disconnected

Electrode Status Indicator



Excellent
Very Good
Good

Rugged Carrying Case

Scan QR code with
your mobile device
to know more about
LAQUA 200 Series
Handheld Meters

General Features

- -2.00 to 16.00 pH range
- USA, NIST, and DIN pH buffer groups with up to 6 pH calibration points
- -2000 to +2000 mV range with ORP calibration option
- -30.0 to 130.0 °C and -22.0 to 266.0 °F temperature ranges with calibration option
- Offset and average slope result with electrode status indicator after calibration
- Adjustable calibration alarm (1 to 90 days)
- Adjustable auto shut-off time (1 to 30 mins)
- Auto data log
- Meter kit packaged in carrying case includes meter, 9652-10D gel pH electrode, 3 x 60ml pH buffers (either USA or NIST), 2 x AA batteries, and manuals

PH 210

- pH/ORP/Temperature (°C/°F) meter
- 500 data sets memory

PH 220

- pH/ORP/Temperature (°C/°F) meter
- 1000 data sets memory
- Real-time clock and date time stamp for GLP compliance
- PC and printer compatible

LAQUA **200 Series** Handheld Water Quality Meters

Scan QR code with
your mobile device
to know more about
LAQUA 200 Series
Handheld Meters

Conductivity / TDS / Resistivity / Salinity

General Features

- …µS/cm to 200.0 mS/cm conductivity range
- Adjustable reference temperature: 15 to 30 °C
- Adjustable temperature coefficient: 0.00 to 10.00%
- Adjustable cell constant: 0.07 to 13.00
- Up to 4 (auto) and 5 (manual) conductivity calibration points
- S/cm and S/m auto ranging units
- …ppm to 100ppt TDS range (default TDS factor = 0.5)
- 4 TDS curves: Linear (0.40 to 1.00 TDS factor), EN27888, 442, and NaCl
- 0.000 Ω•cm to 20.0 MΩ•cm resistivity range
- 0.0 to 100.0 ppt and 0.00 to 10.00 % salinity ranges with calibration option
- 2 Salinity curves: NaCl and seawater
- -30.0 to 130.0 °C and -22.0 to 266.0 °F temperature ranges with calibration option
- Average calibration factor with electrode status indicator after calibration
- Adjustable auto shut-off time (1 to 30 mins)
- Auto data log
- Meter kit packaged in carrying case includes meter, 9383-10D conductivity electrode,
- 4 x 60ml conductivity standards, 2 x AA batteries, and manuals

EC 210

- Conductivity/TDS/Resistivity/ Temperature (°C/°F) meter
- 500 data sets memory

EC 220

- Conductivity/TDS/Resistivity/ Temperature (°C/°F) meter
- 1000 data sets memory
- Real-time clock and date time stamp for GLP compliance
- PC and printer compatible

Dissolved Oxygen

General Features

- 0.00 to 20.00 mg/L and 0.0 to 200.0% dissolved oxygen ranges
- Adjustable salinity compensation value: 0.0 to 40.0 ppt
- Adjustable barometric compensation value: default 101.3kPa
- Automatic temperature compensation
- Galvanic DO probe with built-in temperature sensor compatible
- Up to 2 DO calibration points
- -30.0 to 130.0 °C and -22.0 to 266.0 °F temperature ranges with calibration option
- Span coefficient result with electrode status indicator after calibration
- Adjustable auto shut-off time (1 to 30 mins)
- Auto data log
- Meter kit packaged in carrying case includes meter, 9552-20D galvanic DO probe,
- 2 x AA batteries, and manuals

DO 210

- Dissolved Oxygen/Temperature (°C/°F) meter
- 500 data sets memory

DO 220

- Dissolved Oxygen/Temperature (°C/°F) meter
- 1000 data sets memory
- Real-time clock and date time stamp for GLP compliance
- PC and printer compatible

LAQUA **200 Series** Handheld Water Quality Meters

Scan QR code with
your mobile device
to know more about
LAQUA 200 Series
Handheld Meters

Multi-Parameter

General Features

- -2.00 to 16.00 pH range
- USA, NIST, and DIN pH buffer groups with up to 6 pH calibration points
- -2000 to +2000 mV range with ORP calibration option
- Offset and average slope result with electrode status indicator after pH calibration
- …µS/cm to 200.0 mS/cm conductivity range
- Adjustable reference temperature: 15 to 30 °C
- Adjustable temperature coefficient: 0.00 to 10.00%
- Adjustable cell constant: 0.07 to 13.00
- Up to 4 (auto) and 5 (manual) conductivity calibration points
- S/cm and S/m auto ranging units
- …ppm to 100ppt TDS range (default TDS factor = 0.5)
- 4 TDS curves: Linear (0.40 to 1.00 TDS factor), EN27888, 442, and NaCl
- 0.000 Ω•cm to 20.0 MΩ•cm resistivity range
- 0.0 to 100.0 ppt and 0.00 to 10.00 % salinity ranges with calibration option
- 2 Salinity curves: NaCl and seawater
- -30.0 to 130.0 °C and -22.0 to 266.0 °F temperature ranges with calibration option
- Average calibration factor with electrode status indicator after conductivity calibration
- Adjustable pH calibration alarm (1 to 90 days)
- Adjustable auto shut-off time (1 to 30 mins)
- Auto data log
- Meter kit packaged in carrying case includes meter, 9652-10D gel pH electrode, 9383-10D conductivity electrode,
- 2 x 60ml pH buffers (either USA or NIST), 1413µS/cm and 12.88mS/cm (60ml each) conductivity standards, 2 x AA batteries, electrode adapter, and manuals

PC 210

- pH/ORP/Conductivity/TDS/ Resistivity/Temperature (°C/°F) meter
- 500 data sets memory

PC 220

- pH/ORP/Conductivity/TDS/ Resistivity/Temperature (°C/°F) meter
- 1000 data sets memory
- Real-time clock and date time stamp for GLP compliance
- PC and printer compatible

Multi-Parameter

General Features

- -2.00 to 16.00 pH range
- USA, NIST, and DIN pH buffer groups with up to 6 pH calibration points
- -2000 to +2000 mV range with ORP calibration option
- Offset and average slope result with electrode status indicator after pH calibration
- 0.00 to 20.00 mg/L and 0.0 to 200.0% dissolved oxygen ranges
- Adjustable salinity compensation value: 0.0 to 40.0 ppt
- Adjustable barometric compensation value: default 101.3kPa
- Automatic temperature compensation
- Galvanic DO probe with built-in temperature sensor compatible
- Up to 2 DO calibration points
- DO Span coefficient result with electrode status indicator after calibration
- -30.0 to 130.0 °C and -22.0 to 266.0 °F temperature ranges with calibration option
- Adjustable pH calibration alarm (1 to 90 days)
- Adjustable auto shut-off time (1 to 30 mins)
- Auto data log
- Meter kit packaged in carrying case includes meter, 9652-20D gel pH electrode, 9552-20D galvanic DO probe,
- 3 x 60ml pH buffers (either USA or NIST), 2 x AA batteries, electrode adapter, and manuals

PD 210

- pH/ORP/Dissolved Oxygen/Temperature (°C/°F) meter
- 500 data sets memory

PD 220

- pH/ORP/Dissolved Oxygen/Temperature (°C/°F) meter
- 1000 data sets memory
- Real-time clock and date time stamp for GLP compliance
- PC and printer compatible


LAQUA
HORIBA
LAQUA
7.34
0.001
8.05
HORIBA
HORIBA

LAQUA

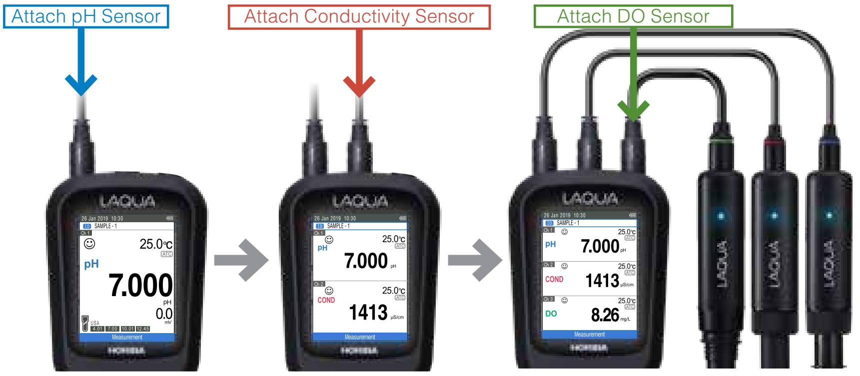
LAQUA WQ-300 Series

Smart Handheld Water Quality Meters

With their modern technology, versatile design, and advanced features, the WQ-300 series smart meters are first of its kind offering flexibility and dependability in every application. These portable meters feature color LCD display that adapts to sensors connected, replaceable sensor heads and cartridges allowing users to configure own meter/sensor system based on application, and built-in Wi-Fi for transferring data to PC and mobile devices wirelessly.

Digital versatility in the palm of your hand

Versatile Channels & Adaptive Display

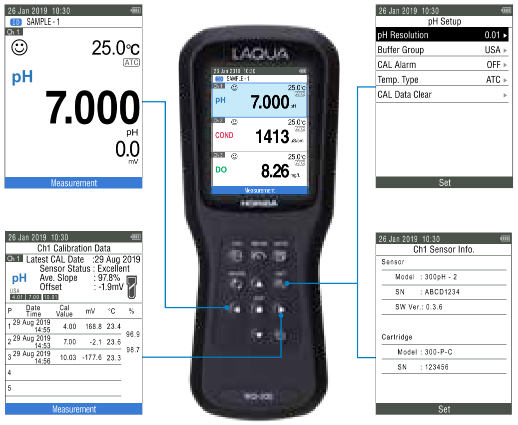


1 channel is displayed

2 channels are displayed

3 channels are displayed

Automatic Sensor Recognition



26 Jan 2019 10:30
ID SAMPLE - 1
Ch 1
25.0°C ATC
pH
7.000 pH
0.0 mV
Measurement

26 Jan 2019 10:30
Ch1 Calibration Data
Ch 1 Latest CAL Date :29 Aug 2019
pH Sensor Status : Excellent
Ave. Slope : 97.8%
Offset : -1.9mV
USA 4.01 7.00 10.01

P	Date Time	Cal Value	mV	°C	%
1	29 Aug 2019 14:55	4.00	168.8	23.4	96.9
2	29 Aug 2019 14:53	7.00	-2.1	23.6	98.7
3	29 Aug 2019 14:56	10.03	-177.6	23.3	
4					
5					

Measurement

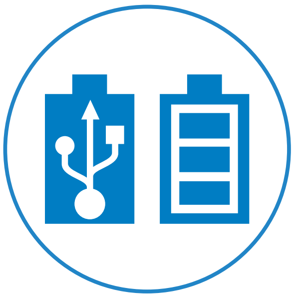
26 Jan 2019 10:30
pH Setup

pH Resolution	0.01 ▸
Buffer Group	USA ▸
CAL Alarm	OFF ▸
Temp. Type	ATC ▸
CAL Data Clear	▸

Set

26 Jan 2019 10:30
Ch1 Sensor Info.
Sensor
Model : 300pH - 2
SN : ABCD1234
SW Ver.: 0.3.6
Cartridge
Model : 300-P-C
SN : 123456
Set

Large Colour
Graphic LCD Screen
with Backlight



Battery and
USB Powered

Compatible with Conventional
Electrodes having BNC and Phono
Connectors and Long Cables

Printer
Communication via
RS232 cable

Built-in Foldable
Meter Stand

Hands-free
Testing

Efficient Sensor
Locking Mechanism

Multi-Language Options

IP67 Waterproof
and Dustproof

Ergonomic Design

No Sensor
Adapter Needed

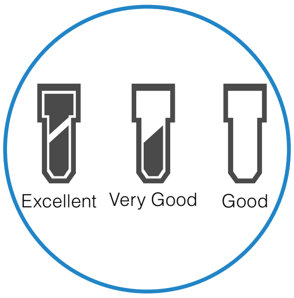
Simultaneous
Calibrations and
Measurements

Eco-friendly, Shock-
proof, Scratch Resistant,
and Non-slip

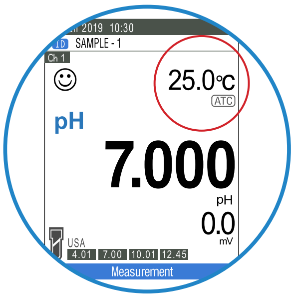
Built-in Sensor
Holders

Data Transfer via
USB or Wireless
Communication

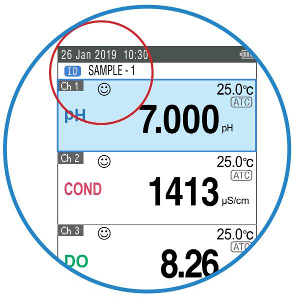
Sensor's LED
Light as Reading
Stability Indicator



Sensor Status
Indicator



Temperature Sensor
Indicator



Sample ID

Customizable Meter Kit

LAQUA **WQ-300 Series** Smart Water Quality Meters

Scan QR code with your mobile device to know more about LAQUA WQ-300 Series Smart Meters

Multi-Parameter

General Features

- Memory of 10,000 data sets with date and time stamp
- Real-time clock
- Auto data log
- Auto stable, auto hold, and real time measurement modes
- Adjustable calibration alarm: 0 to 400 days
- Adjustable auto power off time: 0 to 60 mins.
- Sensor status indicator
- English, Japanese, French, German, Spanish, Portuguese, and Chinese languages
- PC and printer compatible
- Each meter comes with 4 x AA batteries, wireless SD card, and manuals packaged in a carrying case

Rugged Carrying Case

WQ-310-K

Single Channel

WQ-320-K

Dual Channel

WQ-330-K

Triple Channel

LAQUA

Benchtop Water Quality Instruments

LAQUA 2000 Series

The LAQUA 2000 Series Monochrome Bench Meters have simple yet efficient user interface, which is perfectly adequate for most applications. This series offers economical solutions for universities, laboratories, and research institutes requiring affordable basic meters.

LAQUA Benchtop Water Quality Instruments
LAQUA 2000 Series

Sophisticated Simplicity

Rugged Reliability

Adjustable, Integrated Electrode Stand

Holds up to 2 electrodes and can be positioned on either side of the meter

5” Digital Backlit Display

Shows all important readings and indicators for every measurement

Ready to go out of the box

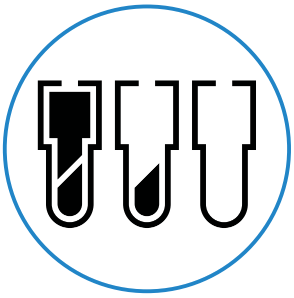
Meter kits come with electrodes and calibration solutions

Universal Power Adaptor

Multi-voltage 100~240V with 6 plugs (US, UK, EU, ANZ, Korea, China)

Audible Feedback

Emits single beep when keys are pressed



Electrode Status

Reveals electrode condition based on calibration data

Auto Cal Standards

Icon lights up after calibration making standard solutions used viewable at a glance

Real Time Clock

Keeps precise time and date and facilitates functions that are time-dependent

Large Internal Memory

Accepts up to 2000 data sets

Auto Data Log

Captures and stores data into memory based on specified time interval

Data Printing Capability

Data with date and time stamp can be printed for GLP/GMP compliance

Password Protected

A 4-digit password secures the meter setup mode from unauthorized access

Software Upgrade

Latest software version can be loaded into the meter when available

Adjustable Shut-Off Time

Switches the meter off at idle (up to 30 minutes)

Temperature Calibration

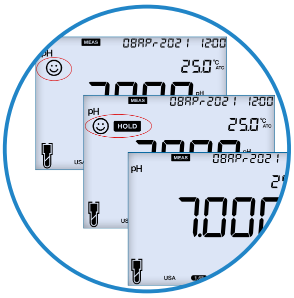
CAL Temp Mode allows temperature calibration

Temperature Compensation

Temperature in °C or °F is either automatically detected when temperature sensor is connected (ATC mode) or manually entered by the user (MTC mode)

Data Acquisition Software Connectivity

Data can be transferred to computer and exported to CSV/Excel/PDF via USB cable and complimentary DAS20 software



Auto Stable, Auto Hold, & Real Time Measurement Modes

Auto Stable mode signals stable reading, Auto Hold mode locks stable reading, and Real Time mode continuously displays live readings

LAQUA Benchtop Water Quality Instruments
LAQUA 2000 Series

Scan QR code with
your mobile device
to know more about
LAQUA 2000 Series
Bench Meters

General Features:

- -2.000 to 20.000 pH range
- 0.1 / 0.01 / 0.001 pH resolutions
- USA, NIST, NIST2, DIN, Custom pH buffer groups with up to 6 calibration points
- -2000.0 to +2000.0 mV range with ORP calibration option
- -30.0 to 130.0°C / -22.0 to 266.0°F temperature range with calibration option
- Offset, segment and average slopes after pH calibration
- Adjustable calibration alarm up to 90 days
- Single channel

pH / ORP

PH2000

- pH/ORP/Temperature (°C/°F) meter
- Meter kit includes meter & accessories, 9615S-10D pH electrode, and either 501-S or 502-S pH buffers kit

Ion

ION2000

- pH/ORP/Ion/Temperature(°C/°F) meter
- 0.000 µg/L to 9999 g/L ion range with 3 selectable units
- Accepts up to 5 ion calibration points
- Meter kit includes meter & accessories and ion selective electrode

Conductivity / TDS / Resistivity / Salinity

EC2000

- Conductivity/Resistivity/TDS/Salinity/Temperature(°C) meter
- …µS/cm to 2.000 S/cm conductivity range
- Adjustable reference temperature: 15 to 30°C
- Adjustable temperature coefficient: 0.00 to 10.00%
- Accepts 0.0700 to 13.000 cell constant
- Accepts up to 4 (auto) / 5 (manual) calibration points
- Auto ranging S/cm and S/m conductivity units
- 0.01 mg/L to 100 g/L TDS range
- 4 TDS curves: Linear (0.40 to 1.00 TDS factor), EN27888, 442, & NaCl
- 0.000 Ω•cm to 20.0 MΩ•cm resistivity range
- 0.0 to 100.0 ppt and 0.00 to 10.00 % salinity ranges
- 2 Salinity curves: NaCl and seawater
- -30.0 to 130.0°C / -22.0 to 266.0°F temperature range with calibration option
- Single channel
- Meter kit includes meter & accessories, 9382-10D conductivity electrode, and 503-S conductivity standards kit

Multi-Parameter

PC2000

- Dual channel pH/ORP/Ion/Conductivity/Resistivity/TDS/Salinity/Temperature(°C/°F) meter
- 0.1 / 0.01 / 0.001 pH resolutions
- USA, NIST, NIST2, DIN, Custom pH buffer groups with up to 6 calibration points
- -2000.0 to +2000.0 mV range with ORP calibration option
- 0.000 µg/L to 9999 g/L ion range with 3 selectable units
- Accepts up to 5 ion calibration points
- …µS/cm to 2.000 S/cm conductivity range
- Adjustable reference temperature: 15 to 30°C
- Adjustable temperature coefficient: 0.00 to 10.00%
- Accepts 0.0700 to 13.000 cell constant
- Accepts up to 4 (auto) / 5 (manual) calibration points
- Auto ranging S/cm and S/m conductivity units
- 0.01 mg/L to 100 g/L TDS range
- 4 TDS curves: Linear (0.40 to 1.00 TDS factor), EN27888, 442, & NaCl
- 0.000 Ω•cm to 20.0 MΩ•cm resistivity range
- 0.0 to 100.0 ppt and 0.00 to 10.00 % salinity ranges
- 2 Salinity curves: NaCl and seawater
- -30.0 to 130.0°C / -22.0 to 266.0°F temperature range with calibration option
- Offset, segment and average slopes after pH calibration
- Adjustable calibration alarm up to 90 days
- Meter kit includes meter & accessories, data acquisition software, 9615S-10D pH electrode, 9382-10D conductivity electrode, pH buffers kit either 501-S or 502-S, and 503-S conductivity standards kit

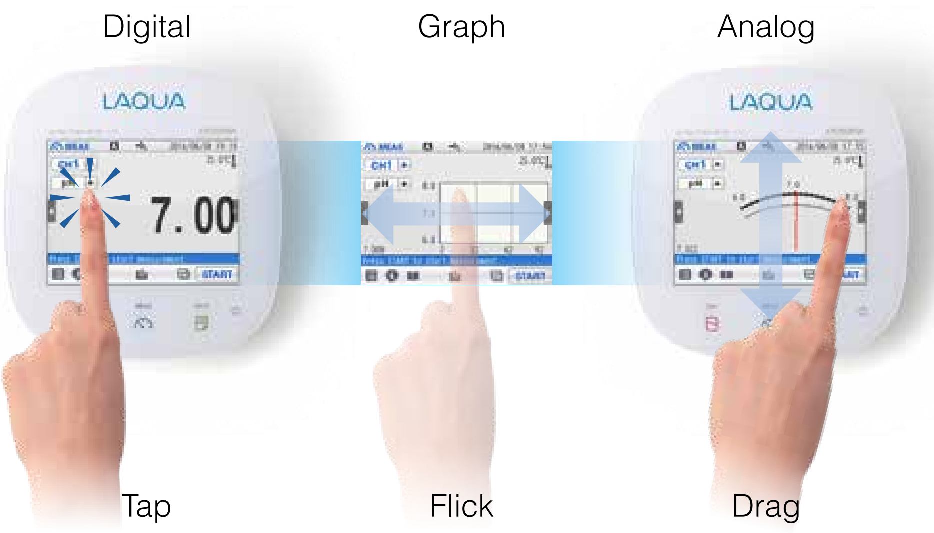

HORIBA

LAQUA

Benchtop Water Quality Instruments
Colour Touchscreen Meters

The feature-rich LAQUA F-7X / DS-72 Colour Touchscreen Bench Meters are equipped with smart navigation functions and easy control-touch operations that simplify the way we do measurements in laboratories, universities, or research institutes. Novice and expert users can enjoy the convenience of having intelligent assistant and myriad features packed in these sophisticated meters.

LAQUA Benchtop Water Quality Instruments
Colour Touchsreen Meters



Advanced Bench Meters with Customizable Display and Touch Control Operation

Designed with chemical-resistant glass panel and durable body, the colour touchscreen bench meters offer not only large color LCD, switchable reading output type on display, and stylish screen themes but also effortless single touch techniques, simultaneous measurements for dual-channel models, and various application functions for basic to complex applications

360° Maneuverability with Freestanding Electrode Stand

Flexible arm holds up to 3 electrodes and rotates around the shaft attached to a stand-alone base

PC and Printer Communications

Connect meter to computer via USB or RS232C port or to printer via RS232C port using appropriate cables

Data Management

Store data with date and time stamp to meter memory (2000 data sets) and USB stick simultaneously or copy data from meter to USB stick

21 CFR Part 11 Software

Meet U.S. Food and Drug Administration's system requirements for electronic records and signatures with this software

Data Acquisition Software

Load real time or memory data from meter to computer with this software (cable is sold separately)

Multi-Voltage Power Adaptor

Bring the meter anywhere and use the plug (US, UK, EU, ANZ, Korea and China) compatible with the power outlet

Bench Meter Kit

Each kit includes meter & accessories (electrode stand, power adaptor, protection cover, manual), data acquisition software, CFR software (optional), electrode(s), and calibration solutions

Smart Navigation

Operate the meter with built-in electronic manual and intelligent assistant

Intelligent Assistant

Calibration Support Function

2016/06/08 16:24
CH 1 USA 25.00℃
pH7 STD
pH 4.01
Stability: 2.992
Press START to start calibration

2016/06/08 16:23
CH 1 USA 25.00℃
pH7 STD
pH 7.00
Stability: 0.002
Press START to start calibration

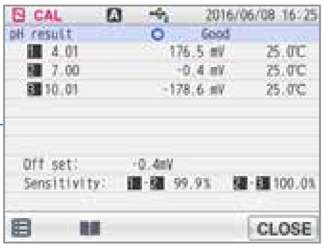
2016/06/08 16:24
CH 1 USA 25.00℃
pH7 pH4 STD
pH 10.01
Stability: 6.004
Press START to start calibration

Reading Stability Check

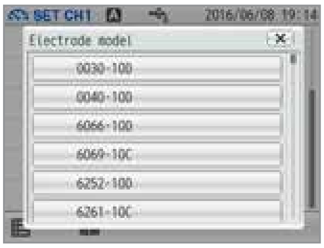
2016/06/08 16:23
CH 1 USA 25.00℃
pH7 STD
pH 7.00
Stability: 0.002
Press START to start calibration

2016/06/08 18:21
CH 1 pH 7.02 USA 24.96℃
Press START to start calibration

Electrode Status



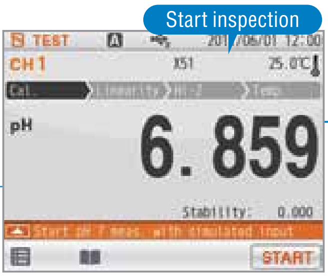
2016/06/08 16:25
pH result ○ Good
1 4.01 176.5 mV 25.0℃
2 7.00 -0.4 mV 25.0℃
3 10.01 -178.6 mV 25.0℃
Off set: -0.4mV
Sensitivity: 1-2 99.9% 2-3 100.0%



2016/06/08 19:14
Electrode model
0030-10D
0040-10D
6066-10D
6069-10C
6252-10D
6261-10C

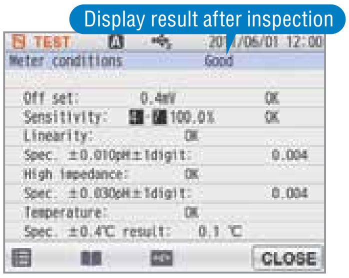
Inspection Function

Start inspection



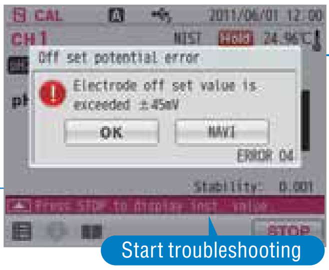
2011/06/01 12:00
CH 1 X51 25.0℃
pH 6.859
Stability: 0.000
Start pH 7 meas. with simulated input

Display result after inspection



2011/06/01 12:00
Meter conditions Good
Off set: 0.4mV OK
Sensitivity: 1-2 100.0% OK
Linearity: OK
Spec. ±0.010pH±1digit: 0.004
High impedance: OK
Spec. ±0.030pH±1digit: 0.004
Temperature: OK
Spec. ±0.4℃ result: 0.1 ℃

Troubleshooting Function



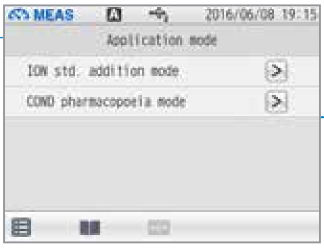
2011/06/01 12:00
CH 1 NIST Hold 24.96℃
Off set potential error
Electrode off set value is exceeded ±45mV
ERROR 04
Stability: 0.001
Press STOP to display inst. value

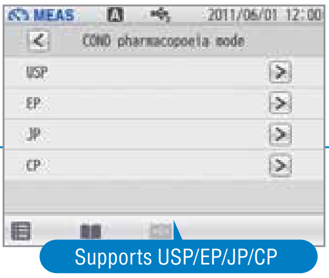
Start troubleshooting

2011/06/01 12:00
Liquid junction is a ceramic of about 1mm in the diameter. When this part is dirty, it becomes as shown in the photograph.

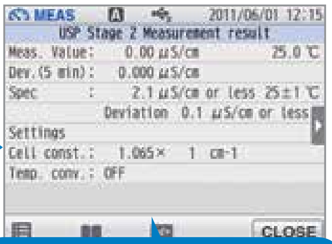
Display tip

Application Function





Supports USP/EP/JP/CP

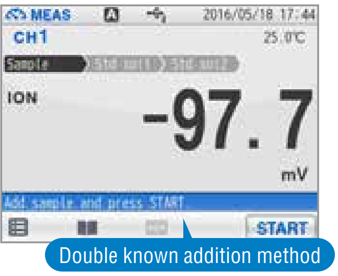


Meas. Value: 0.00 µS/cm 25.0 ℃
Dev.(5 min): 0.000 µS/cm
Spec : 2.1 µS/cm or less 25±1 ℃
Deviation 0.1 µS/cm or less
Settings
Cell const.: 1.065× 1 cm-1
Temp. conv.: OFF

Automated measurement using the standard method. Just wait for the result.

TEMP setting ATC

Supports ion standard addition methods



Add sample and press START.

Double known addition method

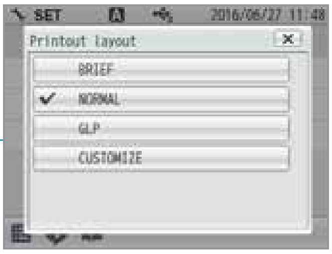
Multi-Language Interface

Meter Security

Require to resister administrator to activate user management function

Data Search

Custom Printout

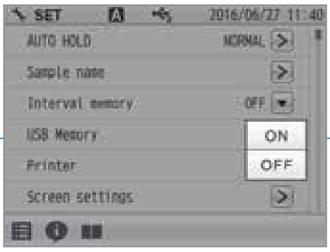


Auto Stable & Auto Hold Measurement Modes

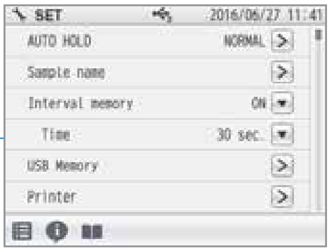
Press START to start measurement.

Press START to start measurement.

Auto Log Data



AUTO HOLD NORMAL
Interval memory OFF



AUTO HOLD NORMAL
Interval memory ON
Time 30 sec.

Sample ID

pH / ORP / Ion

General Features:

- -2.000 to 20.000 pH range
- 0.01 & 0.001 pH resolutions with auto setting option
- Up to 5 pH calibration points
- USA, NIST, NIST2, China, & Custom pH buffer groups
- Auto buffer recognition
- Auto calibration
- -1999.9 to +1999.9 mV with ORP calibration option
- 0.000 µg/L to 9999 g/L (mol/L) ion range
- Up to 5 ion calibration points
- -30.0 to 130.0°C temperature range with calibration option
- Offset & segment slope display after pH calibration
- Adjustable pH calibration interval: 1 to 999 days
- Built-in application function: ion standard addition methods
- Meter kit includes meter & accessories, data acquisition software, 9615S-10D pH electrode, and either 501-S or 502-S pH buffers kit

F-72

Single Channel

pH/ORP/Ion/Temperature(°C) Meter

F-73

Dual Channel

pH/ORP/Ion/Temperature(°C) Meter

Conductivity / TDS / Resistivity / Salinity

DS-72

Single Channel

Conductivity/Resistivity/TDS/Salinity/ Temperature(°C) Meter

- …µS/cm to 200.0 mS/cm conductivity range
- Adjustable reference temperature: 15 to 30°C
- Adjustable temperature coefficient: 0.00 to 10.00%
- Selectable cell constants: 0.1, 1.0, 10.0
- Auto/Manual conductivity calibration up to 4 points
- Auto ranging S/cm, S/m and fixed mS/cm conductivity units
- 0.01 mg/L to 1000 g/L TDS range
- 4 TDS curves: Linear (0.40 to 1.00 TDS factor), EN27888, 442, & NaCl
- 0.000 kΩ•cm to 19.99 MΩ•cm resistivity range
- 0.00 to 80.00 ppt and 0.000 to 8.000 % salinity ranges with calibration option
- 2 Salinity curves: NaCl and seawater
- -30.0 to 130.0°C temperature range with calibration option
- Built-in application function: USP, EP, JP and CP conductivity standard methods
- Meter kit includes meter & accessories, data acquisition software, 3552-10D conductivity electrode, and 503-S conductivity standards kit

Multi-Parameter

F-74

Dual Channel

pH/ORP/Ion/Conductivity/Resistivity/TDS/ Salinity /Temperature(°C) Meter

- -2.000 to 20.000 pH range
- 0.01 & 0.001 pH resolutions with auto setting option
- Up to 5 pH calibration points
- USA, NIST, NIST2, China, & Custom pH buffer groups
- Auto buffer recognition
- Auto calibration
- -1999.9 to +1999.9 mV with ORP calibration option
- 0.000 µg/L to 9999 g/L (mol/L) ion range
- Up to 5 ion calibration points
- Offset & segment slope display after pH calibration
- Adjustable pH calibration interval: 1 to 999 days
- …µS/cm to 200.0 mS/cm conductivity range
- Adjustable reference temperature: 15 to 30°C
- Adjustable temperature coefficient: 0.00 to 10.00%
- Selectable cell constants: 0.1, 1.0, 10.0
- Auto/Manual conductivity calibration up to 4 points
- Auto ranging S/cm, S/m and fixed mS/cm conductivity units
- 0.01 mg/L to 1000 g/L TDS range
- 4 TDS curves: Linear (0.40 to 1.00 TDS factor), EN27888, 442, & NaCl
- 0.000 kΩ•cm to 19.99 MΩ•cm resistivity range
- 0.00 to 80.00 ppt and 0.000 to 8.000 % salinity ranges with calibration option
- 2 Salinity curves: NaCl and seawater
- -30.0 to 130.0°C temperature range with calibration option
- Built-in application function: ion standard addition methods and USP, EP, JP and CP conductivity standard methods
- Meter kit includes meter & accessories, data acquisition software, 9615S-10D pH electrode, 3552-10D conductivity electrode, either 501-S or 502-S pH buffers kit, and 503-S conductivity standards kit

Channel 1: pH

Channel 2: Conductivity

Dual Channel

LAQUA

Electrodes & Sensors

HORIBA's superior electrode technology has produced unparalleled tough pH glass bulbs and unique flat membranes. Electrodes come in different designs and constructions to cater a wide range of applications - from pure water to complex samples. Select the suitable electrode that is specially designed for your application.

Expertise in Manufacturing

Sophisticated processing technology

HORIBA's in-house expertise in the manufacture of electrodes is the accumulation of more than 60 years of experience. Our sophisticated electrode processing technology provides flexibility in designing various shapes of the electrode bulb and different structural designs of the electrodes.

Miniaturization

Invention Award (Japan)

Unique flat electrode design as well as 3mm diameter micro-electrode with integrated temperature sensor (US Patent No. 7314541/ China Patent No. ZL0315796)

Convenient slider

Refillable electrodes are equipped with a slider to open or close the refilling port easily.

Thick membrane technology

HORIBA's glass moulding technology allows the manufacture of tougher pH glass bulbs.

Double-junction electrodes

All HORIBA pH combination electrodes are double-junction electrodes. Flexible to use in a wide-range of applications.

Fast response & highly accurate

ToupH glass bulb does not compromise responsiveness and sensitivity (US Patent No. 8262877). Specially designed electrodes are available for hydrofluoric acid & strong alkaline application.

Built-in clip for hooking onto electrode stand arm

Top housing of electrodes is designed with a built-in clip to hook onto HORIBA's electrode stands.

Stable measurement for a wide range of samples. Standard ToupH glass electrode (9615S-10D)

STANDARD ToupH water proof Pb Free

High stability and drift reduction. No more worries about the timing of your measurement value readings.

- Uses responsive glass that is 10 times stronger than JIS standard. The domed shape provides strength in all directions, greatly reducing damage concerns.
- Constructed with smooth surfaces for easy wiping and cleaning.

Recommendation

Perfect for preparing buffers. Can be used on a wide range of aqueous test solutions.

Stable measurement for routine testing. Standard plastic electrode (9625-10D)

STANDARD water proof Pb Free

The electrode has a plastic body which is ideal for general purpose measurement.

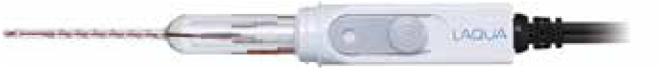
- Can be submerged up to 1m depth and 30mins. (with refilling port closed)
- Waterproof, Pb-free

Recommendation

Ideal for general purpose use. For measurement of tap water and drinking water.

For extremely small samples Micro ToupH glass electrode (9618S-10D)

MICRO ToupH water proof



This pH electrode with temperature compensation sensor can take measurements from samples as small as 50μL, the smallest in the world.

- Our original manufacturing technology (Japanese Patent No. 4054245) is used to produce 2-ply piping 3mm in diameter.
- Compatible with extremely small containers such as micro tubes etc.
- The temperature sensor is located at the tip for high-speed temperature response. Refrigerated samples can be measured without needing to wait for them to return to room temperature.

Recommendation

Can be used for a wide range of aqueous solutions, including those that cannot be obtained in large quantities. We recommend using our specialized cleaning solution after measuring samples that contain proteins.

For using a large container Long ToupH glass electrode (9680S-10D)

LONG ToupH water proof Pb Free

283 mm length & 8 mm diameter. The long, thin design makes this electrode perfect for measuring in large containers and test tubes.

- Uses responsive glass that is 10 times stronger than JIS standard. The domed shape provides strength in all directions, greatly reducing damage concerns.

Recommendation

For measuring samples such as microbe culture fluids in test tubes.
We recommend that it be used with the long type electrode stand (FA-70L).

For highly viscous samples Sleeve ToupH glass electrode (9681S-10D)

SLEEVE ToupH water proof Pb Free

Stable measurement can also be achieved for high viscous samples.

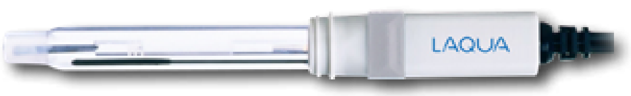
- The liquid junction section is constructed with a movable sleeve that can be rinsed clean, preventing highly viscous samples from clogging the liquid junction, and maintaining stable measurement performance

Recommendation

For highly viscous samples and solutions, and samples that contain non-aqueous solvents (such as cosmetics or paints). We recommend that you take measurements while using the graph display function to confirm stable responses.
(We recommend washing with a neutral detergent after use with samples that contain oil.)

For the surface of solid samples Flat pH electrode (6261-10C)

FLAT water proof



The sensor is located on the flat surface of the tip.

- Measurements can be made from a minute amount of moisture on the solid sample surface.
- Pure water can be applied for samples with no moisture

Recommendation

Perfect for measuring samples in shallow containers (e.g. petri dishes) and gelatinous materials (e.g. nutrient agar). For surface measurement of meat, paper, skin, and cloth.

LAQUA Electrode Technology

Born from the fusion of our technical expertise and state-of-the-art manufacturing

As a leading pH electrode manufacturer, HORIBA uses the latest technology for all your measurement needs.

Since the development of Japan's first glass electrode for pH meter, HORIBA has focused on continually improving our electrode technology, especially in materials and manufacturing. HORIBA is committed to continually explore and employ groundbreaking solutions in manufacturing next-generation electrodes so that we always provide you with the newest and best electrodes.

pH Electrode Selection Guide

		3-in-1 ELECTRODES								
		PLASTIC					STANDARD ToupH	LONG ToupH	MICRO ToupH	SLEEVE ToupH
		9651-10D / 9652-10D	9625-10D	9630-10D	9631-10D	9632-10D	9615S-10D	9680S-10D	9618S-10D	9681S-10D
Specification	Applicable temperature range (°C)	0-60 / 0-80	0-100	0-100	0-60	0-100	0-100	0-100	0-60	0-60
	Diameter (mm)	16	16	16	16	16	12	8	3	12
	Length (mm)	150	150	150	155	150	198	283	185	203

pH - Sample Conditions

			9651-10D / 9652-10D	9625-10D	9630-10D	9631-10D	9632-10D	9615S-10D	9680S-10D	9618S-10D	9681S-10D
Aqueous Solution	Conductivity	Normal (over 100 mS/m)	◉	◉	◉	◉	◉	◉	◉	◉	◉
		Low (approx.10 ~100 mS/m			◉						○
		Very low (approx. 5 ~100 mS/m			○						○
		High (approx. 5 S/m)	○	○	○	○	○	○	○		◉
	Strong alkaline (pH 10-12)						◉	○	○		○
	Strong acidity (pH 0-2) * Except HF sample					◉		◉			
	Quick heat change (within 50°C)		◉	◉	◉	◉	◉				
	High viscosity (approx. 5 Pa·S)										◉
	Containing non-aqueous solvent							○	○	○	○
	Suspension							○	○	○	◉
Solid/ Semisolid	Inside										
	Surface										
Sample Containers	Microtube/plate (> 50 μL)									◉	
	Ampule	> ø4 mm								◉	
	Micro container (> 2 mL)								○	◉	
	Tube	ID:13 mm, L:100 ~ 150 mm							◉		
	Beaker	10 mL ~ 1 L	◉	◉	◉	◉	◉	◉	○	○	○
	Large container (> 1 L)		○	○	○	○	○	○	◉		
	Petri dish										
	Droplet										
Water	Pure/ion-exchange water (approx. 0.1 mS/m)/ Distilled water (approx. 0.5 mS/m)							○			
	Tap/drinking water (approx. 10 mS/m)		○	○	◉			○			○
	Surface water				◉			○			○
	Pharmaceutical water/ Enviromental water/acid rain		○	○	○			○			○
Chemical reagent/ solvent	Caustic/strong acid (Except HF sample)					◉		◉			○
	Hydrofluoric acid					◉					
	Surfactant							○			◉
	Water-based paint							○			◉
	Dye/coloring agent										◉
Pharmaceutical/ biological sample	Protein-containing sample							○		○	◉
	Medicinal preparation									○	○
	Enzyme solution								○	◉	
	Tris buffer							◉		○	○
	Suspension							○			◉
	Agar medium										
Food	Jam							○			◉
	Meat/fish/Fruit/vegetable/ Dough										
	Honey										
	Cheese/butter										
	Yogurt		○	○	○			○			○
Beverage/ seasoning	Beer		○	○	○			○			◉
	Milk/Carbonated drink/juice/ sauce/soy sauce							○			◉
	Mayonnaise/ketchup							○			◉
Cosmetic/ lotion	Beauty cream/mascara							○			◉
	Gel/soap/shampoo/Hairdye lotion							○			◉
	Emulsified liquid							○			○

				COMBINATION ELECTRODES							ISFET ELECTRODES
	SLEEVE	NON-AQUEOUS	NEEDLE	PLASTIC	STANDARD ToupH	MICRO ToupH	SLEEVE ToupH	LONG	LONG ToupH	FLAT	GENERAL
	6367-10D	6377-10D	6252-10D	9425-10C	9415-10C	9418-10C	9481-10C	6069-10C	9480-10C	6261-10C	0040-10D
	0-60	0-60	0-60	0-100	0-100	0-60	0-60	0-60	0-100	0-50	0-60
	12	12	12	16	12	3	12	3	8	12	16
	150	150	150	150	198	185	203	291	283	150	190
	●	●	●	●	●	●	●	●	●	●	●
		●					○				
		●					○				
				○	○		●		○		
	○				○		○		○		
					●						
				●							
	○	●					●				
	○	●			○	○	○		○		○
		●			○	○	●		○		○
			○								
										●	●
						●					
						●		○			
						●		○	○		
								●	●		
	○	○	○	●	●	○	○	○	○	○	○
				○	○				●		
										●	●
										●	●
		●			○						
		●		○	○		○				
		●			○		○				
		○		○	○		○				
					●		○				
		○			○		●				
		○			○		●				
		○					●				
	○				○	○	●				
		○				○	○				
			○			●			○		
					●	○	○				
		●			○		●				
										●	●
		○	○		○		●			○	● (surface)
			●							○	● (surface)
		●									○ (surface)
			○							○	○ (surface)
	○		○	○	○		○			○	● (surface)
	○	●		○	○		●				
	○	○			○		●				
		○			○		●				
		○	○		○		●				
		○			○		●				
		●			○		○				

● Recommended ○ Can be measured

pH Combination Electrodes

HORIBA pH Combination electrodes manufactured with 1 meter cable terminating in BNC connector allow these electrodes to be used with any pH meter[1]. Enjoy the full spectrum of features and benefits of these electrodes on your existing pH meter[1]. (For applications where temperature measurement and compensation is required, please refer to the 3-in-1 pH electrodes).

[1] pH meters must have BNC connector

Scan QR code with
your mobile device
to know more about
LAQUA pH Electrodes

ToupH Standard Electrode

9415-10C

General laboratory application

pH Range: 0-14
Operating Temperature Range (°C): 0-100
Liquid Junction: Ceramic
Applications: The electrode offers quick stability and drift reduction.

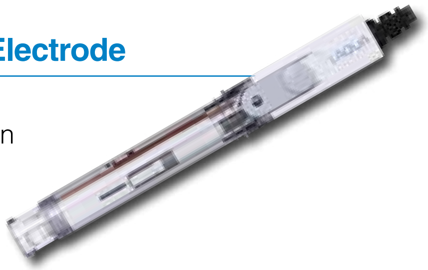
- Constructed with responsive glass that is 10X stronger than JIS standards
- The one-touch refilling port slider allows one-hand operation
- Waterproof, Pb-free glass

Perfect for preparing pH buffers and other aqueous test solutions.

Standard Plastic Electrode

9425-10C

General field application



pH Range: 0-14
Operating Temperature Range (°C): 0-100
Liquid Junction: Ceramic
Applications: The electrode has plastic body, which is ideal for field measurement.

- Can be submerged up to 1m depth and 30mins (with refilling port closed)
- Waterproof, Pb-free glass

Recommended for field use. For measurement of tap water and drinking water.

ToupH Sleeve Electrode

9481-10C

High viscosity application

pH Range: 0-14
Operating Temperature Range (°C): 0-60
Liquid Junction: Movable Sleeve
Applications: The electrode gives stable readings in highly viscous samples.

- The liquid junction is designed with a movable sleeve that can be cleaned easily and prevents clogging
- Waterproof, Pb-free glass

For measurement of highly viscous samples and samples containing non-aqueous solvents (e.g., cosmetics, paints).

ToupH Micro Electrode

9418-10C

Precious trace
amount sample

pH Range: 0-14
Operating Temperature Range (°C): 0-60
Liquid Junction: Ceramic
Applications: The electrode can measure samples as small as 50µL.

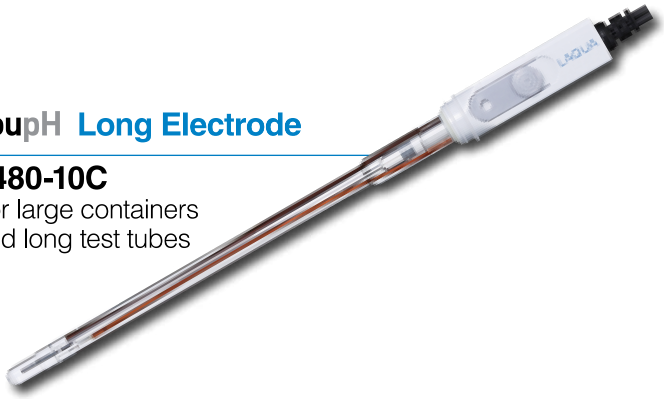
- Compatible with extremely small containers (e.g., micro tubes)
- Temperature sensor is placed next to the bulb for quick response
- Waterproof

Suitable for low-volume samples and wide range of aqueous solutions.

ToupH Long Electrode

9480-10C

For large containers
and long test tubes



pH Range: 0-14
Operating Temperature Range (°C): 0-100
Liquid Junction: Ceramic
Applications: The long, thin body of the electrode is perfect for large containers and test tubes.

- 283mm length, 8mm diameter
- Constructed with responsive glass that is 10X stronger than JIS standards
- Waterproof, Pb-free glass

For measuring samples (e.g., microbial culture fluids) in test tubes and tall beakers.

Long Electrode

6069-10C

For very slender test tubes

pH Range: 0-14
Operating Temperature Range (°C): 0-60
Liquid Junction: Ceramic
Applications: The long, thin body of the electrode is perfect for very slender test tubes.

- 291mm length, 3mm diameter
- Waterproof

For measuring samples in slender tubes (e.g., NMR test tube).

Flat Electrode

6261-10C

pH Range: 0-12
Operating Temperature Range (°C): 0-50
Liquid Junction: Sleeve
Applications: The sensor is located on the flat surface of the tip.

- Measurement can be made from minute amount of moisture on solid sample surface
- Pure water can be applied for samples with no moisture
- Waterproof

Perfect for measuring samples in shallow containers (e.g., petri dishes) and gelatinous materials (e.g., nutrient agar). For surface measurement of meat, paper, skin, and cloth.

3-in-1 pH Glass Body Electrodes[2]

HORIBA pH Combination electrodes with an integrated thermistor offer higher accuracy as these electrodes measure temperature concurrently with pH. The pH meter is able to continuously monitor and compensate for temperature effects automatically.

ToupH Standard Electrode

9615S-10D

General laboratory application

pH Range: 0-14
Operating Temperature Range (°C): 0-100
Liquid Junction: Ceramic
Applications: The electrode offers quick stability and drift reduction.

- Constructed with responsive glass that is 10x stronger than JIS standards
- The one-touch refilling port slider allows one-hand operation
- Waterproof, Pb-free glass

Perfect for preparing pH buffers and other aqueous test solutions.

ToupH Sleeve Electrode

9681S-10D

High viscosity application

pH Range: 0-14
Operating Temperature Range (°C): 0-60
Liquid Junction: Movable sleeve
Applications: The electrode gives stable readings in highly viscous samples.

- The liquid junction is designed with a movable sleeve that can be cleaned easily and prevents clogging
- Waterproof, Pb-free glass

For measurement of highly viscous samples and samples containing non-aqueous solvents (e.g. cosmetics, paints).

ToupH Micro Electrode

9618S-10D

Precious trace amount sample

pH Range: 0-14
Operating Temperature Range (°C): 0-60
Liquid Junction: Ceramic
Applications: The electrode can measure samples as small as 50μL.

- Compatible with extremely small containers (e.g. micro tubes)
- Temperature sensor is placed next to the bulb for quick response
- Waterproof

Suitable for low-volume samples and a wide range of aqueous solutions.

ToupH Long Electrode

9680S-10D

For large containers and long test tubes

pH Range: 0-14
Operating Temperature Range (°C): 0-100
Liquid Junction: Ceramic
Applications: The long, thin body of the electrode is perfect for large containers and test tubes.

- 283mm length, 8mm diameter
- Constructed with responsive glass that is 10x stronger than JIS standards
- Waterproof, Pb-free glass

For measuring samples (e.g. microbial culture fluids) in test tubes and tall beakers.

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[2] Only compatible with HORIBA pH meters

continued on the next page

continued from previous page

Needle Electrode

6252-10D
For food application

pH Range: 0-12
Operating Temperature Range (°C): 0-60
Liquid Junction: Ceramic
Applications: Needle electrode allows measurement of food samples and aqueous solutions.

Low-Conductivity Electrode

6377-10D
For pure water &
non-aqueous solvents

pH Range: 0-14
Operating Temperature Range (°C): 0-60
Liquid Junction: Movable sleeve
Applications: Uses a glass membrane that is highly sensitive to low-conductivity water and non-aqueous solvents.

Standard Sleeve Electrode

6367-10D

pH Range: 0-14
Operating Temperature Range (°C): 0-60
Liquid Junction: Sleeve
Applications: Uses a sleeve at the liquid junction for improved stability and repeatability. For measuring pH at high accuracy.

3-in-1 pH Plastic Body Electrodes[2]

Gel-filled pH Electrode

9651-10D

pH Range: 0-14
Operating Temperature Range (°C): 0-80
Liquid Junction: Porous sintered polyethylene
Applications: The plastic body of the electrode is filled with gel electrolyte. Less maintenance is needed as refilling is not required.

- Can be submerged up to 1m depth of water for 30mins.
- Waterproof, Pb-free glass

Recommended for field use.

Gel-filled pH Electrode

9652-10D; 9652-20D For Field

pH Range: 0-14
Operating Temperature Range (°C): 0-80
Liquid Junction: Porous sintered polyethylene
Applications: The plastic body of the electrode is filled with gel electrolyte. Less maintenance is needed as refilling is not required.

- Can be submerged up to 1m depth of water for 30mins.
- Waterproof, Pb-free glass

Recommended for field use.

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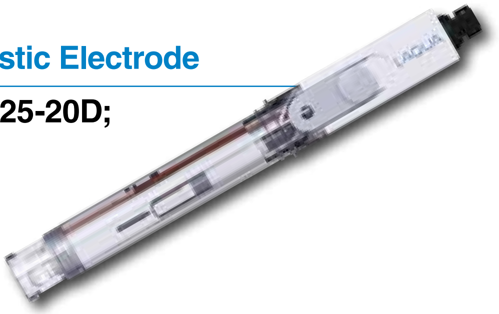
[2] Only compatible with HORIBA pH meters

Standard Plastic Electrode

9625-10D; 9625-20D; 9625-30D

For Field



pH Range: 0-14
Operating Temperature Range (°C): 0-100
Liquid Junction: Ceramic
Applications: The electrode has a plastic body which is ideal for field measurement.

- Can be submerged up to 1m depth of water for 30mins. (with refilling port closed)
- Waterproof, Pb-free glass

Recommended for field use. For measurement of tap water and drinking water.

Hydrofluoric Acid Resistant Electrode

9631-10D

pH Range: 2-12
Operating Temperature Range (°C): 0-60
Liquid Junction: Ceramic
Applications: The electrode can measure 1% hydrofluoric acid solution (at 25°C, immersed at 1min.) for about 1000 times.

- Rolled glass design for long-term reliable measurement and easy maintenance
- Compliant with Japan's Measurement Act Certification
- Waterproof, Pb-free glass

Suitable for drain water measurement after etching process.

Strong Alkali Resistant Electrode

9632-10D

pH Range: 0-14
Operating Temperature Range (°C): 0-100
Liquid Junction: Ceramic
Applications: The alkali-resistant glass membrane has higher resistance and longer stability (about 5X in 0.1mol/L sodium at 60°C, pH 13) than conventional electrodes.

- Waterproof, Pb-free glass

Suitable for strong alkali samples such as plating solutions.

Standard Plastic Electrode

9630-10D

For tap water

pH Range: 0-14
Operating Temperature Range (°C): 0-100
Liquid Junction: Ceramic
Applications: The electrode can measure samples with low conductivity or buffering capacity.

- Made of high purity multicomponent lithium series glass
- Waterproof, Pb-free glass

Suitable for tap water measurement and quality control in water purification plant. Recommended to use with cleaning solution 230.

3-in-1 ORP Electrodes

Standard ORP Electrode

9300-10D

For Laboratory

Electrode Material: Pt / glass
Operating Temperature Range (°C): 0-60
Applications: Waterproof & refillable; Platinum on the flat tip allows measurement of small volume samples

Gel-filled ORP Electrode

9301-10D

For Field

Electrode Material: Pt / glass / polycarbonate
Operating Temperature Range (°C): 0-80
Applications: Waterproof & maintenance-free; Suitable for field measurements

Conductivity Electrode Cells

HORIBA Conductivity cells are available as Submersible type and Flow type, as well as in a variety of cell constants ranging from 0.1 to 10.0.

Scan QR code with your mobile device to know more about LAQUA Conductivity Electrodes

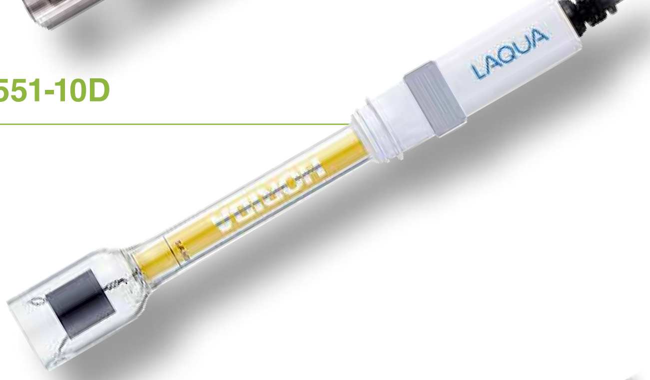
The HORIBA Conductivity cells are integrated with temperature sensor (except for 3573 & 3574) and the wetted material is **Platinum / Titanium, coated with Platinum black**, except 9371-10D which is made of stainless steel. Rugged Titanium allows cell to be used in a wide range of applications, including highly corrosive samples such as concentrated acids and sea water. Maintenance is simple – soak in deionized/demineralized water or with the conditioning solution.

Conductivity Cells (Submersible Type)

9371-10D

Cell Constant: 0.1 cm^{-1}; 10 m^{-1}
Measurement Range: 0.01 µS/cm - 500 µS/cm; 1 µS/m - 50 mS/m
Temp. Range (°C): 0 - 100
Cell Material: Stainless Steel
Thermistor: Built-in
Minimum Sample Volume (ml): 50
Application: Low conductivity water and ultra-pure water

3551-10D

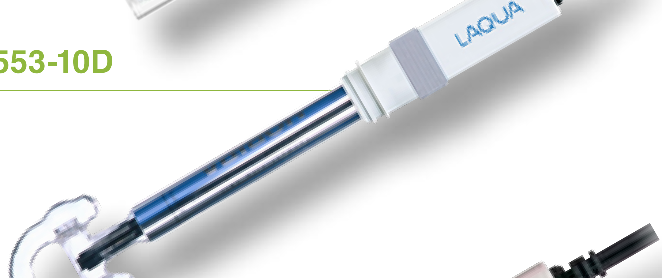


Cell Constant: 0.1 cm^{-1}; 10 m^{-1}
Measurement Range: 0.1 µS/cm - 10 mS/cm; 10 µS/m - 1 S/m
Temp. Range (°C): 0 - 60
Cell Material: Pt-Pt black / Glass
Thermistor: Built-in
Minimum Sample Volume (ml): 50
Application: Low conductivity water (e.g., deionized, distilled)

3552-10D

Cell Constant: 1 cm^{-1}; 100 m^{-1}
Measurement Range: 1 µS/cm - 100 mS/cm; 0.1 mS/m - 10 S/m
Temp. Range (°C): 0 - 100
Cell Material: Pt-Pt black / Glass
Thermistor: Built-in
Minimum Sample Volume (ml): 15
Application: General purpose use

3553-10D



Cell Constant: 10 cm^{-1}; 1000 m^{-1}
Measurement Range: 10 µS/cm - 1 S/cm; 1 mS/m - 100 S/m
Temp. Range (°C): 0 - 60
Cell Material: Pt-Pt black / Glass
Thermistor: Built-in
Minimum Sample Volume (ml): 50
Application: High conductivity water

9382-10D

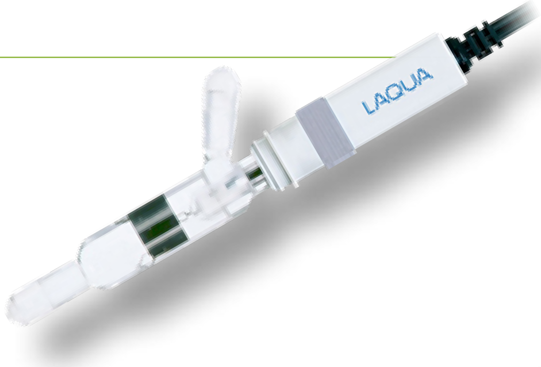
Cell Constant: 1 cm^{-1}; 100 m^{-1}
Measurement Range: 1 µS/cm - 100 mS/cm; 0.1 mS/m - 10 S/m
Temp. Range (°C): 0 - 80
Cell Material: Ti-Pt black / Plastic
Thermistor: Built-in
Minimum Sample Volume (ml): 20-30
Application: General purpose use; Waterproof

9383-10D

Cell Constant: 1 cm-1 ; 100 m-1
Measurement Range: 1 µS/cm - 100 mS/cm; 0.1 mS/m - 10 S/m
Temp. Range (°C): 0 - 80
Cell Material: Ti-Pt black / Glass
Thermistor: Built-in
Minimum Sample Volume (ml): 20-30
Application: General purpose use; Waterproof

Conductivity Cells (Flow Type)

3561-10D



Cell Constant: 0.1 cm^{-1}; 10 m^{-1}
Measurement Range: 0.1 µS/cm - 10 mS/cm; 10 µS/m - 1 S/m
Temp. Range (°C): 0 - 60
Cell Material: Pt-Pt black / Glass
Thermistor: Built-in
Minimum Sample Volume (ml): 10
Application: Low conductivity water (e.g., deionized, distilled)

3562-10D

Cell Constant: 1 cm^{-1}; 100 m^{-1}
Measurement Range: 1 µS/cm - 100 mS/cm; 0.1 mS/m - 10 S/m
Temp. Range (°C): 0 - 60
Cell Material: Pt-Pt black / Glass
Thermistor: Built-in
Minimum Sample Volume (ml): 16
Application: General purpose use

3573-10C

Cell Constant: 10 cm^{-1}; 1000 m^{-1}
Measurement Range: 10 µS/cm - 1 S/cm; 1 mS/m - 100 S/m
Temp. Range (°C): 0 - 60
Cell Material: Pt-Pt black / Glass
Thermistor: —
Minimum Sample Volume (ml): 4
Application: High conductivity water

3574-10C

Cell Constant: 10 cm^{-1}; 1000 m^{-1}
Measurement Range: 10 µS/cm - 100 mS/cm; 1 mS/m - 10 S/m
Temp. Range (°C): 0 - 60
Cell Material: Pt-Pt black / Glass
Thermistor: —
Minimum Sample Volume (ml): 0.25
Application: Small volume sample (e.g., column chromatography)

Combination ISE

Ion-selective electrodes are responsive to concentration of particular ions in the test liquid and are variable-potential electrodes. They are used in conjunction with reference electrodes to measure the concentration of particular ions. HORIBA's years of experience and know-how in this field are behind the wide range of ion electrodes we offer.

When measurements are made using an ion meter, calibrating it with various standard solutions will give direct readings of the ion concentration. Note that since volume-detection level changes with temperature, measurements must be taken at a fixed temperature.

Ammonia (NH_3) electrode

pH Range: pH 12 or more
Measurement Range: 0.01 - 18,000 mg/L NH_4^+ (5×10^{-7} to 1 mol/L NH_4^+)
Temp. Range (°C): 0 - 50

Application: Agriculture, Soil, Power Station Water, Fish Tanks, Sea Water, Waste Water, Plating Baths, Air / Stack Gases and Biological Cultures or Samples

Calcium ion (Ca^{2+}) electrode

pH Range: 4.0 mg/L (10^{-4} mol/L) Ca^{2+}, pH 5 to 11
Measurement Range: 0.4 - 40,080 mg/L Ca^{2+} (10^{-5} to 1 mol/L Ca^{2+})
Temp. Range (°C): 0 - 50

Application: Agriculture / Plant Tissue, Soil, Water Softening Systems, Boiler Feed Water, Drinking / Mineral Water, Biological Cultures, Dental / Clinical Analysis and Dairy / Food / Beverages Applications

Chloride ion (Cl^-) electrode

pH Range: 350 mg/L (10^{-2} mol/L) Cl^-, pH 3 to 11
Measurement Range: 0.35 - 35,000 mg/L Cl^- (10^{-5} to 1 mol/L Cl^-)
Temp. Range (°C): 0 - 50

Application: Agriculture, River / Tap Water, Plant Tissue, Soils, Boiler Feed Water, Clinical Analysis, Sweat, Urine, Cement, Plating Baths and Dairy / Food / Beverages Samples

Scan QR code with your
mobile device to know
more about LAQUA Ion
Selective Electrodes

Fluoride ion (F^-) electrode

pH Range: 0.1 to 1,000 mg/L F^-, pH 5 to 8
Measurement Range: 0.02 - 19,000 mg/L F^- (10^{-6} to 1 mol/L F^-)
Temp. Range (°C): 0 - 50

Application: Dental / Toothpaste / Mouth Wash, Drinking / Seawater, Wastewater, Air / Stack Gases, Acids, Soils, Food, Biological Fluids, Plant Tissue, Coal, Carbonated Beverages and Bone

Nitrate ion (NO_3^-) electrode

pH Range: 62 mg/L (10^{-3} mol/L) NO_3^-, pH 3 to 7
Measurement Range: 0.62 - 62,000 mg/L NO_3^- (10^{-5} to 1 mol/L NO_3^-)
Temp. Range (°C): 0 - 50

Application: Agriculture / Plant Tissue / Fertilizers, Surface / Seawater / Drinking Water, Sewage Effluent, Soils, Meats, Vegetables, Foods / Beverages

Potassium ion (K^+) electrode

pH Range: 3.9 mg/L (10^{-4} mol/L) K^+, pH 5 to 11
Measurement Range: 0.39 - 39,000 mg/L K^+ (10^{-5} to 1 mol/L K^+)
Temp. Range (°C): 0 - 50

Application: Agriculture / Plant Tissue, Soils, Wastewater, River / Tap Water, Clinical Analysis, Saliva, Serum, Fertilizers, Soils and Wines, Dairy / Foods / Beverages

Dissolved Oxygen Electrodes & Tips

HORIBA Dissolved Oxygen (DO) electrodes are galvanic probes with integrated temperature sensors. With galvanic DO probes, calibration can be performed immediately and in air. The HORIBA DO probes use unique and innovative tips which are replaceable. No need to replace membranes or refill electrolytes.

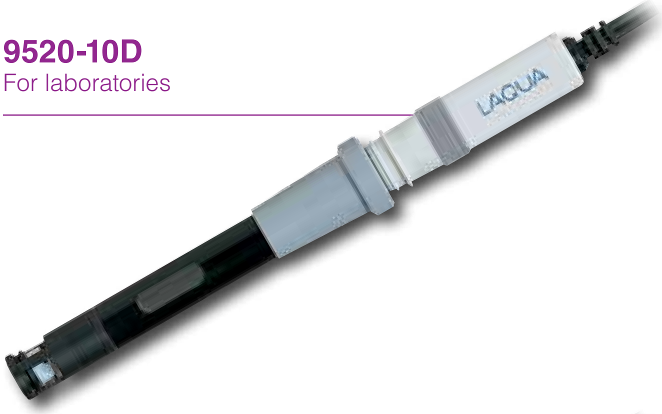
Scan QR code with your mobile device to know more about LAQUA Dissolved Oxygen Electrodes

Two models are available: a Laboratory model (9520) that can be used for BOD measurements, and a Field immersible model (9551 & 9552) housed in a rugged casing available in 2m, 5m, and 10m cable configurations. The Laboratory 9520 DO probe is fitted with a rotor as well as an adaptor to facilitate BOD measurements.

Dissolved Oxygen Electrodes

9520-10D

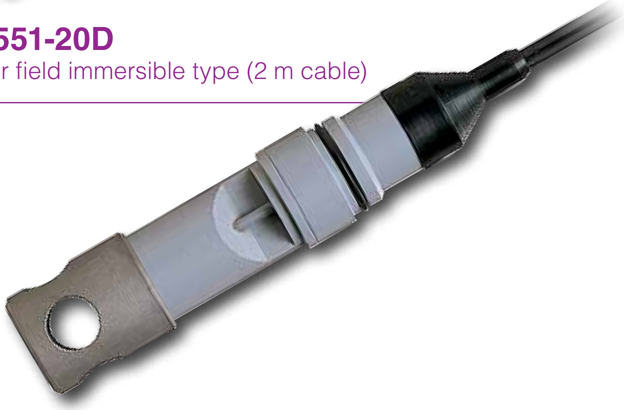
For laboratories



Measurement Range: 0-19.99mg/L DO
Response Time: 20 seconds (90% response time at constant temperature)
Temp. Range (°C): 0-45
Features: Waterproof; It operates with the built-in temperature sensor and replaceable DO tip 7541.

9551-20D

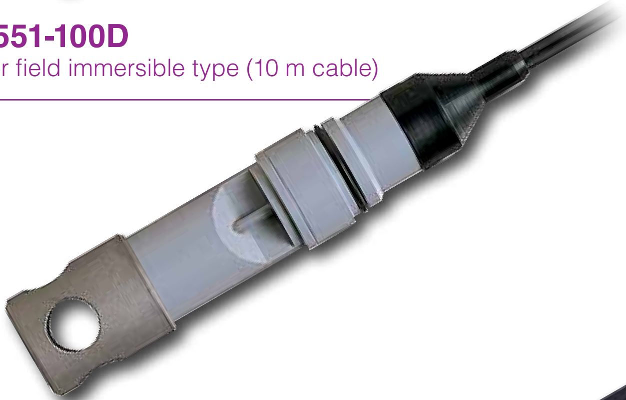
For field immersible type (2 m cable)



Measurement Range: 0-19.99mg/L DO
Response Time: 30 seconds (90% response time at constant temperature)
Temp. Range (°C): 0-40
Features: Waterproof; It operates with the built-in temperature sensor and replaceable DO tip 5401.

9551-100D

For field immersible type (10 m cable)



Measurement Range: 0-19.99mg/L DO
Response Time: 30 seconds (90% response time at constant temperature)
Temp. Range (°C): 0-40
Features: Waterproof; It operates with the built-in temperature sensor and replaceable DO tip 5401.

9552-20D

For field immersible type (2m cable)

Measurement Range: 0-20.00 mg/L DO
Response Time: 30 seconds (90% response time at constant temperature)
Temp. Range (°C): 0-50
Features: Waterproof; It operates with the built-in temperature sensor and replaceable DO tip 5402.

9552-50D

For field immersible type (5m cable)

Measurement Range: 0-20.00 mg/L DO
Response Time: 30 seconds (90% response time at constant temperature)
Temp. Range (°C): 0-50
Features: Waterproof; It operates with the built-in temperature sensor and replaceable DO tip 5402.

Dissolved Oxygen Electrode Tips

7541

Replacement DO tip for 9520-10D

5401

Replacement DO tip for 9551-20D and 9551-100D

5402

Replacement DO tip for 9552-20D and 9552-50D

LAQUA WQ-300 Series Smart Digital Sensors

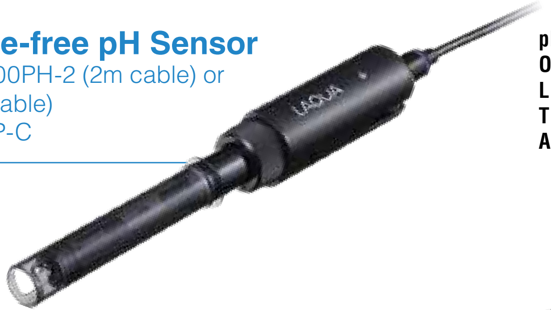
Scan QR code with your mobile device to know more about LAQUA Smart Digital Sensors

All smart digital sensors are automatically recognized when connected to any WQ-300 series meters. With their efficient sensor locking mechanism, the sensors do not easily come off when pulled from the meter or dropped to water. Each sensor consists of two parts – head and cartridge (DO cap for the optical DO sensor head). The sensor head has switchable LED light that signals when reading is stable, own circuit board that stores cartridge information, calibration data, and measurement details, and durable cable that is available in both 2m and 5m lengths in some models. The cartridge is replaceable and comes with a nut to protect the sensor head from water intrusion.

Aside from their respective cartridges, the sensor heads also accept conventional electrodes with BNC connectors. The 300-BNC adapter must be used to connect the electrodes to sensor heads. Sensor kits comprising of sensor head, cartridge, and solutions are available.

Maintenance-free pH Sensor

Sensor Head: 300PH-2 (2m cable) or
300-PH-5 (5m cable)
Cartridge: 300-P-C



pH Range: -2.00 to 20.00 pH / -2.000 to 20.000 pH
Operating Temperature Range (°C): 0 to 80 °C / 32.0 to 176.0 °F
Liquid Junction: Porous sintered polyethylene
Thermistor: Built-in
Application: No electrolyte refilling required. Recommended for field use.

4-Cell Conductivity Sensor

Sensor Head: 300-C-2 (2m cable) or
300-C-5 (5m cable)
Cartridge: 300-4C-C

Cell Constant: 0.172 cm^{-1}
Conductivity Range: 10 µS/cm to 2000 mS/cm
Operating Temperature Range (°C): 0 to 100 °C / 32.0 to 212.0 °F
Cell Material: Carbon, Epoxy
Thermistor: Built-in
Application: Suitable for measurements of samples with wide range conductivities.

2-Cell Conductivity Sensor

Sensor Head: 300-C-2 (2m cable) or
300-C-5 (5m cable)
Cartridge: 300-2C-C


Detachable glass flow cell

Cell Constant: 0.1 cm^{-1}
Conductivity Range: 0.01 to 500 µS/cm
Operating Temperature Range (°C): 0 to 100 °C / 32.0 to 212.0 °F
Cell Material: Stainless steel
Thermistor: Built-in
Application: Suitable for measurements of low conductivity samples including ultra-pure water.

Optical Dissolved Oxygen Sensor

Sensor Head: 300-D-2 (2m cable) or 300-D-5 (5m cable)
Sensor Cap: 300-D-M

DO Range: 0.00 to 20.00 mg/L, 0.0 to 200.0 %
Operating Temperature Range (°C): 0 to 50.0 °C / 32.0 to 122.0 °F
Thermistor: Built-in
Application: Longer usable life and easy to handle. Suitable for most samples including those with strong acids and hydrogen sulfide gas.

Ion Sensor Head

Sensor Head: 300-I-2 (2m cable) or
300-I-5 (5m cable)
Cartridge: 300-BNC + Any ISE with
BNC connector

Ion Range: 0.000 to 99900 (mg/L, mmol/L)
Operating Temperature Range (°C): -30.0 to 130.0 °C / -22.0 to 266.0 °F
Application: Compatible with any ISE having BNC connector. Require the adapter 300-BNC to connect ISE to sensor head.

ORP Sensor

Sensor Head: 300-O-2 (2m cable) or
300-O-5 (5m cable)
Cartridge: 300-O-C

ORP Range: -2000 to +2000 mV
Operating Temperature Range (°C): 0 to 80 °C / 32.0 to 176.0 °F
Thermistor: Built-in
ORP Sensing Element: Platinum / Glass
Application: Suitable for measuring activity of oxidizing and reducing agents in aqueous solution.

LAQUA

Solutions & Accessories

Our pH buffers, standard solutions, electrode filling solutions, and cleaning solutions are manufactured under stringent quality standards to meet the required physical properties, long stability, and product specifications.

LAQUA Solutions

pH Buffer Solution Kits (4 x 250ml bottles per pack)

Model	Description
501-S	NIST pH Buffer Solution Kit (pH 4.01, 6.86, 9.18 buffers & 3.33M KCl)
502-S	USA pH Buffer Solution Kit (pH 4.01, 7.00, 10.01 buffers & 3.33M KCl)

pH Buffer Solutions (500ml each)

Model	Description
500-2	pH 1.68 Buffer Solution at 25°C
500-4	pH 4.01 Buffer Solution at 25°C
500-686	pH 6.86 Buffer Solution at 25°C
500-7	pH 7.00 Buffer Solution at 25°C
500-9	pH 9.18 Buffer Solution at 25°C
500-10	pH 10.01 Buffer Solution at 25°C
500-12	pH 12.46 Buffer Solution at 25°C

Conductivity Standard Solution Kit (250ml each)

Model	Description
503-S	Conductivity Standard Solution Kit (84µS/cm, 1413µS/cm, 12.88mS/cm & 111.8mS/cm)

Conductivity Standard Solutions (500ml each)

Model	Description
500-21	84 µS/cm Conductivity Standard Solution
500-22	1413 µS/cm Conductivity Standard Solution
500-23	12.88 mS/cm Conductivity Standard Solution
500-24	111.8 mS/cm Conductivity Standard Solution

ORP Powders (10 sachets per pack)

Model	Description
500-225	ORP Standard Solution 225 mV at 25°C, 500ml
160-51	89 mV at 25°C (for 250ml solution) ◈ ⚠
160-22	258 mV at 25°C (for 250ml solution) ◈ ⚠

pH/ORP Electrode Filling Solutions (250ml each)

Code	Description
525-3	3.33M KCl
300	3.33M KCl

pH Electrode Cleaning Solutions

Model	Description
220	For removing inorganic residues from glass membrane and liquid junction (2 x 50ml) ◈ ⚠
230	For removing inorganic and organic residues from glass membrane (30ml Solution A & 100ml Solution B)
250	For removing protein residues from glass membrane and liquid junction (400ml)

501-S NIST pH Buffer Solution Kit

502-S USA pH Buffer Solution Kit

503-S Conductivity Standard Solution Kit

ORP Standard Solution

ORP Powders

220

250

230
Cleaning Solutions

Ion Standard Solutions (500ml each)

Model	Description
500-NH4-SH	1000 mg/L Ammonium Ion Standard Solution
500-NH4-SL	100 mg/L Ammonium Ion Standard Solution
500-CA-SH	1000 mg/L Calcium Ion Standard Solution
500-CA-SL	100 mg/L Calcium Ion Standard Solution
500-CL-SH	1000 mg/L Chloride Ion Standard Solution
500-CL-SL	100 mg/L Chloride Ion Standard Solution
500-F-SH	1000 mg/L Fluoride Ion Standard Solution
500-F-SL	100 mg/L Fluoride Ion Standard Solution
500-NO3-SH	1000 mg/L Nitrate Ion Standard Solution
500-NO3-SL	100 mg/L Nitrate Ion Standard Solution
500-K-SH	1000 mg/L Potassium Ion Standard Solution
500-K-SL	100 mg/L Potassium Ion Standard Solution

Ionic Strength Adjustors (500ml each)

Model	Description
500-NH3-ISA	Ammonia Ionic Strength Adjustor
500-CA-ISA	Calcium Ionic Strength Adjustor
500-CL-ISA	Chloride Ionic Strength Adjustor
500-F-TISAB	Fluoride Ionic Strength Adjustor
500-NO3-ISA	Nitrate Ionic Strength Adjustor
500-K-ISA	Potassium Ionic Strength Adjustor

Ion Selective Electrode Filling Solutions (500ml each)

Model	Description
500-NH3-IFS	Ammonia Electrode Filling Solution
500-CA-IFS	Calcium Electrode Filling solution
500-CL-IFS	Chloride Electrode Filling Solution
500-F-IFS	Fluoride Electrode Filling Solution
500-NO3-IFS	Nitrate Electrode Filling Solution
500-K-IFS	Potassium Electrode Filling Solution

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LAQUA Solutions


Calcium Ion Electrode Solutions


Chloride Ion Electrode Solutions


Fluoride Ion Electrode Solutions


Potassium Ion Electrode Solutions


Ammonia Ion Electrode Solutions


Nitrate Ion Electrode Solutions

LAQUAtwin Pocket Water Quality Instruments Solutions & Accessories

LAQUAtwin Replacement Sensors

Model	Description
S010	pH Sensor (for B-711, B-712, B-713, pH-11, pH-22 & pH-33)
S021	Salt Sensor (for B-721)
S022	Sodium Ion Sensor (for B-722 & Na-11)
S030	Potassium Ion Sensor (for B-731 & K-11)
S040	Nitrate Ion Sensor (for B-741, B-742, B-743, NO3-11, NO3-11C & NO3-11S)
S050	Calcium Ion Sensor (for B-751 & Ca-11)
S070	Conductivity Sensor (for B-771, EC-11, EC-22, & EC-33)
S071	Salt EC Sensor (for Salt-11)
S051	Calcium Ion Sensor (for Ca-11C)

LAQUAtwin Standard Solutions (6 x 14ml bottles per pack)

Model	Description
514-4	pH 4.01 Buffer
514-7	pH 7.00 Buffer
514-22	1413 µS/cm Conductivity Standard Solution
514-23	12.9 Conductivity Standard Solution
514-05	0.5% NaCl Standard Solution
514-50	5.0% NaCl Standard Solution
514-20	Conditioning Solution (For Conductivity & Salt Sensors)
Y022H	2000ppm Sodium Ion Standard Solution
Y022L	150ppm Sodium Ion Standard Solution
Y031H	2000ppm Potassium Ion Standard Solution
Y031L	150ppm Potassium Ion Standard Solution
Y041	5000ppm Nitrate Ion Standard Solution
Y042	300ppm Nitrate Ion Standard Solution
Y043	2000ppm Nitrate Ion Standard Solution
Y044	30ppm Nitrate Ion Standard Solution
Y045	150ppm Nitrate Ion Standard Solution
Y051H	2000ppm Calcium Ion Standard Solution
Y051L	150ppm Calcium Ion Standard Solution
Y053	Solution kit - Y052L, Y052H, & 251 x 3
Y052L	1.25 mmol/L standard solution (25ml x 2)
Y052H	2.50 mmol/L standard solution (25ml x 2)
251	Ion sensor cleaning solution (250ml)

LAQUAtwin Accessories

Model	Description
Y046	Sampling Sheet B (100pcs) for minute samples (≥ 0.05ml)
Y048	Sampling Sheet Holder (use with sampling sheet B for samples with particulates)

Scan QR code with your mobile device to know more about LAQUAtwin Accessories & Solutions

LAQUAtwin Replacement Sensors

pH Buffers

Conductivity Standard Solutions

NaCl Standard Solutions

Sodium Ion Standard Solutions

Potassium Ion Standard Solutions

Calcium Ion Standard Solutions

Nitrate Ion Standard Solutions

Blood Ionized Calcium Standard Solutions

Ion Sensor Cleaning Solution

Sampling Sheet B

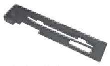
LAQUA Benchtop & Handheld Water Quality Instruments Accessories

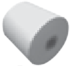
Model	Description
LAQUA-SW-21CFR11	Package includes CD with PIN code, USB cable, and manual
Printer	Printer (230V & 120V) with paper (cable sold separately)
Printer cable	1.5 m length
Printer paper	20 rolls per pack
Ink ribbon	5 pcs per pack
Universal AC adapter	Multi-Voltage (100-240V) with 6 plugs (US, UK, EU, ANZ, Korea and China) 1.8 m cable
X-51	pH, mV, Ion, DO, temperature simulator
X-52	Conductivity, temperature simulator
LCD protection sheet	2 pcs per pack
Protection cover	For F-70, DS-70, 1000 series bench meters
USB cable	To connect bench meter (F-70, DS-70, 1000 series) and PC
PC (USB) cable	To connect 200 series / 2000 series meter and PC (1.5m)
Serial cable	To connect bench / handheld meter and PC (serial, 9 pins)
25-pin D-sub printer cable	To connect 200 series / 2000 series / WQ-300 series meter and printer (1.5m)
300-BNC	Sensor head adapter for WQ-300 pH/ORP/Ion sensor heads
300-EXT-10	10-m sensor head extension cable
Flow cell	Glass; Suitable for 300-2C-C and 9371-10D
Electrode adapter	For attaching two electrodes together
Clear pH sensor tip guard	For plastic pH electrodes 9651, 9625, 9630 etc. (5pcs per pack)
Black pH sensor tip guard	For 9652 and 300-P-C (3pcs per pack)
FA-70A	Integrated electrode stand (height: 338mm) for 1000 series bench meters
FA-70S	Adjustable, free-standing electrode stand (height: 384 mm)
FA-70L	Long, free-standing electrode stand (height: 450-650mm)
DP-70S	Electrode stand for 100 series and D-70, ES-70, OM-70 series handheld meters (height: 400mm)
Arm for electrode stand	For DP-70S, FA-70A, FA-70S, & FA-70L
Electrode holders	2pcs (for mounting electrode with round cap on electrode stand arm)
Electrode protection caps (short)	3pcs (for glass pH electrodes)
Electrode protection caps (standard)	5pcs (for most glass & plastic pH electrodes 2060A-10T, 9300-10D, combination ISEs, 9832 / 9383, 3552-10D)
Electrode protection cap (long)	For 9680S-10D, 9480-10C pH electrodes


LAQUA-SW-21CFR11


Printer


Printer cable


Ink ribbon


Printer paper


Universal AC adapter


X-51


X-52


LCD protection sheet


Protection cover


USB cable

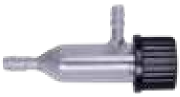

Serial cable


25-pin D-sub printer (RS232) cable


PC (USB) cable

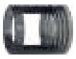

300-BNC Sensor Head Adapter


300-EXT-10 sensor head extension cable


Flow Cell


Electrode Adapter


Clear pH sensor tip guard


Black pH sensor tip guard


Integrated Electrode Stand for LAQUA 2000 Series Bench Meters

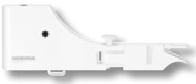

FA-70A


FA-70L


FA-70S


DP-70S


Electrode protection caps (short)


Arm for electrode stand


Electrode protection caps (standard)

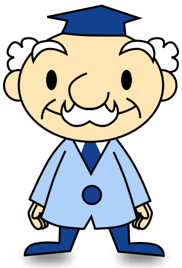

Electrode holder


Electrode protection cap (long)


LAQUA
23.3
9.94
HORIBA
CAL
MEAS
DATA
MODE
SET
ENT

Story of pH & Water Quality

You probably heard pH the first time from your science class in school and even measured pH values of some water samples. pH is a measure of how acidic or basic a water sample is in a scale of 0 to 14. The theory of pH in the next page explains the principles of pH and pH measuring instruments and the correct way of performing pH measurement.



Theory of pH

pH Definition

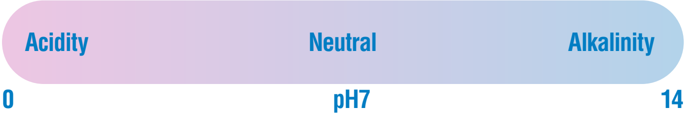
pH stands for “power of Hydrogen”. It was originally defined as logarithmic measure of hydrogen ion concentration, mathematically written as pH = $-\log_{10}[H^+]$, by Danish biochemist, Søren Peter Lauritz Sørensen in 1909. This definition was later revised to pH = $-\log_{10}a_{H^+}$ in 1920 as further research demonstrated that pH is more related to hydrogen ion activity rather than hydrogen ion concentration.

$$\mathrm{pH} = -\log_{10} a_{\mathrm{H}^+} \quad \text{Where} \quad \underbrace{a_{\mathrm{H}^+}}_{\text{Activity of hydrogen Ions}} = \underbrace{f}_{\text{activity coefficient}} \times \underbrace{[\mathrm{H}^+]}_{\text{hydrogen-Ion concentration}}$$

pH Scale

pH is used to specify the acidity or alkalinity of an aqueous solution on a scale of 0 to 14.

Each number in the scale represents a 10-fold change in acidity or alkalinity. A solution with pH value of 3 is 10X more acidic than a solution with pH value of 4.



The relative activities of free hydrogen ions (H^+) and hydroxyl ions (OH^-) in water determines the pH. When the activity of H^+ is greater than that of OH^-, the resulting pH is less than 7 and the solution is described as acidic. If the reverse is true, then the solution is basic or alkaline. When the activities of H^+ and OH^- are equal, the resulting pH is 7 and the solution is described as neutral.

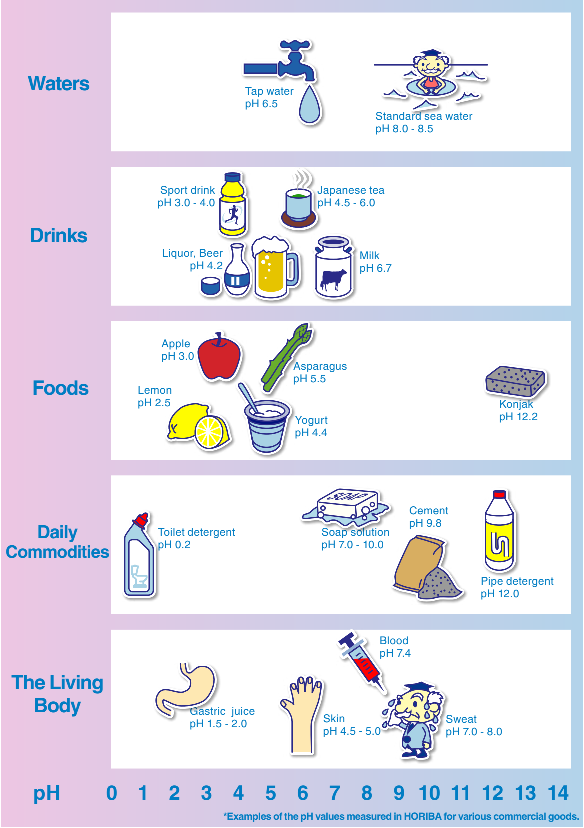


Figure 1: Common test solutions and their pH values

pH Measuring Instruments

To measure pH accurately, it is recommended to use a fast responding pH electrode integrated with a temperature sensor and a pH meter with automatic temperature compensation (ATC) capability.

The easiest way to measure pH is by using litmus papers. Litmus papers are impregnated with chemical indicators that change color when in contact with test solution. Although the resulting color is visible after few seconds and can be interpreted by comparing to a chart, it is rather subjective and provides only a rough estimation of pH. With pH electrode and pH meter, measurement of pH can be carried out and recorded with high level of accuracy.

pH Electrode

A pH electrode is a type of ion-selective electrode, which has a membrane that responds to hydrogen ions (H^+) in aqueous solution.

There are two electrode technologies which use different H^+ sensitive membranes and mechanisms for measuring pH: the glass electrode technology and the ion-sensitive field-effect transistor (ISFET) technology. The former produces conventional glass pH electrodes while the latter produces non-glass alternatives.

HORIBA has over 60 years of experience utilizing glass electrode technology and ISFET technology in manufacturing pH electrodes to cater a wide range of applications.

1. Glass pH Electrode

The glass electrode technology uses two silver-based electrodes, the glass and the reference. When immersed in test solution, the two electrodes generate potential and their potential difference determines the pH.

The glass electrode consists of a silver wire coated with silver chloride and suspended in a neutral potassium chloride (KCl) solution contained in a glass tube. The tip of the glass tube has a thin membrane that responds to pH when immersed in a solution. If there is a difference in pH between the internal solution (pH 7.00) of the glass electrode and the solution outside the glass membrane (e.g., pH buffer or sample), a potential proportional to the difference is generated. To measure the potential, the glass electrode must be paired with a reference electrode that gives a stable and constant potential.

The reference electrode consists of a silver wire coated with silver chloride and suspended in a KCl solution contained in either glass or plastic tube. The tip of the glass or plastic tube has a liquid junction that leak small amount of KCl filling solution into a test solution to complete the circuit. The reference electrode can be built in the same body as glass electrode. This is called combination pH electrode.

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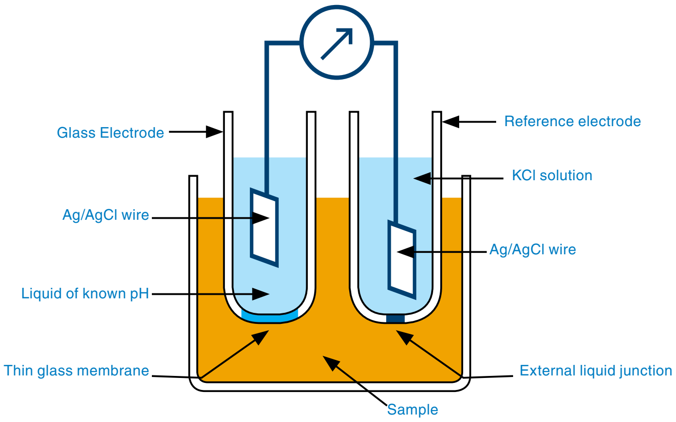

Figure 2: Schematic of Glass pH Electrode

Since the potential quickly reaches equilibrium and shows good reproducibility, the glass electrode technology can be used in various samples, even with oxidizing and reducing substances as they have very little effect on the result.

HORIBA glass pH electrodes are combination and 3-in-1. A combination pH electrode has glass electrode and reference electrode built in one body. A 3-in-1 pH electrode is a combination pH electrode integrated with temperature sensor.

2. Ion-Sensitive Field-Effect Transistor (ISFET) pH Electrode

The development of ISFET technology started around 1970. The glass electrode was replaced with a semiconductor chip. This provided a new solution for environments where glass breakage is unacceptable and for difficult applications that are challenging with the conventional glass pH electrodes.

The semiconductor chip is miniaturized and mounted on the tip of rugged electrode body (usually made of epoxy or polymer). This arrangement allows the use of small amount of sample for measurement and makes it possible to perform measurements in very small or shallow containers and on moist solid or semi-solid surfaces.

The Ion-Sensitive Field-Effect Transistor (ISFET) technology uses a silicon semiconductor substrate with two electrodes, the source and drain. Overlaying the source and drain is another electrode called gate. Instead of a glass membrane, the gate has chemical layer, which is sensitive to H^+. ISFET technology also uses a reference electrode consists of a silver wire coated with silver chloride and suspended in a KCl solution in gel form.

When the semiconductor chip is immersed in test solution, the H^+ in the test solution come in contact with the chemical layer of the gate through a small gap. The positive charge of the H+ generates an electric field that influences the current between the source and drain. To quantify this effect, the control voltage that must be applied via reference electrode to maintain the drain-source current at a constant value is measured. The pH value is then derived from this measurement.

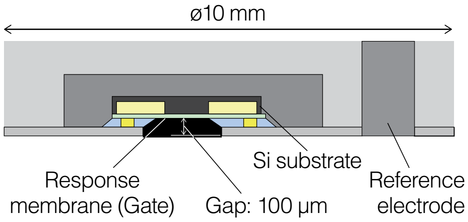

Figure 3: Schematic of ISFET pH Electrode

The features and advantages of ISFET pH electrode are summarized below:

- Made of non-glass material
- Resistant to damage
- Can be stored dry and cleaned with toothbrush
- Measures small amount of liquid samples and solid / semi-solid samples
- Replaceable pH sensor
- Integrated with temperature sensor
- Usable in samples with extreme pH
- Reduces static electricity effect
- Shuts off automatically

HORIBA 0040-10D ISFET pH electrode has a replaceable flat tip, ideal for surface measurement of solid or semi-solid samples such as meat, paper, skin, cloth, leather, cheese, leaves, bread dough, nutrient agar in petri dishes, and even drop or small volume liquid samples.

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pH Meter

The pH electrode can be thought of as a battery with high internal resistance. Thus, one cannot measure the difference in potential accurately if pH electrode is connected to an ordinary potentiometer (voltmeter). An amplifier with high input impedance is needed. The pH meter is built with amplifier and allows adjustment for temperature, asymmetry potential (offset), and sensitivity (slope). It measures the difference in potential generated by the pH electrode and converts it to pH unit.

The bench pH meters are suitable for laboratory use while the portable pH meters such as pocket meters and handheld meters are suitable for both laboratory and field use.

HORIBA pH meters have automatic temperature compensation (ATC) feature to compensate temperature effect during calibration and display slope(s) and offset after calibration. Other features are automatic calibration and automatic buffer recognition.

pH Calibration

A pH electrode / meter system must be calibrated with at least two pH buffers that bracket the expected sample pH before proceeding with sample measurement.

pH Buffers

Since activity cannot be measured directly, it cannot be used as the basis for theoretical calculation of pH value. As such, the pH of a sample is determined by comparison with the pH values of standard solutions. These standard solutions, called pH buffers, have known pH values at different temperatures. Table 1 shows the values of commonly used pH buffers at different temperatures.

Table 1: Values of pH Buffers at Different Temperatures

°C	pH Buffers at 25°C						
	1.68	**4.01**	**6.86**	**7.00**	**9.18**	**10.01**	**12.46**
0	1.67	4.01	6.98	7.12	9.46	10.32	13.47
5	1.67	4.01	6.95	7.09	9.39	10.25	13.25
10	1.67	4.00	6.92	7.06	9.32	10.18	13.03
15	1.67	4.00	6.90	7.04	9.27	10.12	12.83
20	1.68	4.00	6.88	7.02	9.22	10.06	12.64
25	1.68	4.01	6.86	7.00	9.18	10.01	12.46
30	1.69	4.01	6.85	6.98	9.14	9.97	12.29
35	1.69	4.02	6.84	6.98	9.10	9.93	12.14
40	1.70	4.03	6.84	6.97	9.07	9.89	11.99
45	1.70	4.04	6.83	6.97	9.04	9.86	11.86
50	1.71	4.06	6.83	6.97	9.01	9.83	11.73
55	1.72	4.08	6.83	6.97	8.99	9.81	11.61

As temperature affects pH, it is important to use a pH electrode integrated with temperature sensor (3-in-1) for accurate pH measurement. When a 3-in-1 pH electrode is connected to a pH meter and immersed in pH buffer during calibration, the pH electrode generates potential and the temperature sensor measures the temperature of pH buffer. Both values are communicated to the pH meter. The pH meter will then recognize the pH buffer based on the potential reading (automatic buffer recognition) and adjust the measured pH value to the theoretical pH value (automatic temperature compensation) and calculate the slope based on the temperature detected. If combination pH electrode is used, temperature should be measured with a calibrated thermometer and manually entered into the pH meter.

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To facilitate easy calibration, HORIBA pH meters are programmed with commonly used pH buffer sets such as USA (1.68, 4.01, 7.00, 10.01, & 12.46) and NIST (1.68, 4.01, 6.86, 9.18, & 12.46) for automatic buffer recognition and automatic calibration.

After calibration, the meter displays values for asymmetry potential (offset) and sensitivity (slope) that indicate the electrode status.

Asymmetry Potential (Offset)

A glass electrode has an internal solution with pH value of 7. If the glass electrode is immersed in a solution with pH value of 7, the difference in potential generated on the membrane should be 0. However, a certain difference in potential exists there. This is called the asymmetry potential or offset.

The asymmetry potential varies depending on the distortion and shape of the glass, which resulted from limits of precision in manufacturing and the composition of the glass. It may also be caused by contamination of the internal solution of the reference electrode. Moreover, when the glass membrane is dry, the difference in asymmetry potential becomes large, causing errors in measurement. The acceptable asymmetry potential is ± 30mV or ± 0.5 pH.

Sensitivity (Slope)

In Japan Industrial Standard (JIS), pH is determined based on equations 1 and 2 below.

$$\mathrm{pH} = -\log_{10} a_{\mathrm{H}^+} \pm 0.02$$

Where a_{H^+} = activity of hydrogen ions

The difference between the pH values of two solutions, let's say pH buffer X and pH buffer S, at the same temperature, is defined by the following equation:

$$\mathrm{pH(X)} - \mathrm{pH(S)} = \frac{E_x - E_s}{2.3026RT/F}$$

Where:
E_x = potential of pH electrode pPpoooa placed in pH buffer X
E_s = potential of pH electrode placed in pH buffer S
R = gas constant of 8.3144 J/mol.K
T = temperature in Kelvin
F = Faraday constant of 96485 C/mol

In equation 2, the same units must be used in the denominator and numerator. Table 2 below shows the values of 2.3026 RT/F (equivalent to theoretical slope) at different temperatures.

Table 2: Values of 2.3026RT/F (Slope) at Different Temperatures

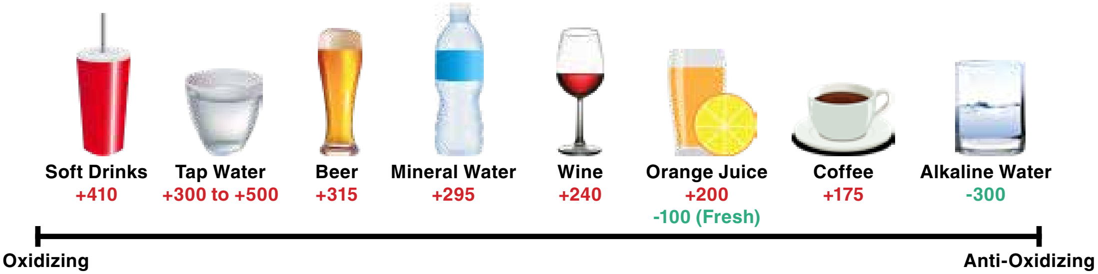
°C	2.3026RT/F (mV)	°C	2.3026RT/F (mV)
0	54.19	50	64.11
5	55.19	55	65.11
10	56.18	60	66.10
15	57.17	65	67.09
20	58.16	70	68.08
25	59.15	75	69.07
30	60.15	80	70.07
35	61.14	85	71.06
40	62.13	90	72.05
45	63.12	95	73.04

The pH values of samples are measured in reference to those of pH buffers used in calibration. The pH meter gives slope in percentage (%) for every two consecutive calibration points. The slope is calculated by dividing the actual slope by the theoretical slope at the measured temperature. The acceptable slope range is 90 – 105 %.

Applications

Agriculture, Aquaculture, Food and Beverage, Medicine, Cosmetics, Environment Testing.

Theory of ORP



(Approx. ORP)
Note: Some results may vary

ORP Definition

Oxidation-reduction potential (ORP), also called Redox potential, is an indicator of the oxidizing or reducing ability of a solution and is expressed in millivolts (mV).

Generally, sample water contains different kinds of oxidizing and reducing substances. The ORP of sample water is determined by the chemical equilibrium of the oxidizing and reducing substances in it.

An oxidizing agent or oxidizer (electron acceptor) attracts electrons and shows a positive ORP value. It causes oxidation and undergoes reduction in the process. Examples are chlorine, bromine, chlorine dioxide, hydrogen peroxide, and ozone. A reducing agent or reducer (electron donor) loses electrons and shows a negative ORP value. It causes reduction and undergoes oxidation in the process. Examples are sodium sulfite, sodium bisulfate, and hydrogen sulfide.

Redox reactions involve simultaneous transfer of electrons between chemical species. The electrons that are lost in oxidation reaction are the same electrons that are gained in reduction reaction. When the oxidizing substance is Ox^{n+}, the reducing substance is Red, and the exchanged electron is ne^-, the relationship can be expressed as follows:

$$O_x^{n+}\ ne^- \rightleftarrows \text{Red, ORP; } E=E^0-\frac{2.303RT}{nF}\log\frac{Red}{[O_x^{n+}]}$$

ORP is a common measurement in monitoring water quality. To understand ORP, let us explain ORP application in chlorination and dechlorination. Chlorination is a process of adding chlorine to water to kill microorganisms. Chlorine is a strong oxidizer and the chlorinated water is an oxidative solution, which exhibits a positive ORP value. A strongly oxidative solution is harmful to the environment. To neutralize it, a strong reducer such as sodium bisulfite can be added to lessen the chlorine.

Another application of ORP is chemical oxygen demand (COD). COD is an indicator of the presence of organic substances in wastewater. It tells us the degree of organic pollution in wastewater by the amount of oxidizing agent required to chemically oxidize organic substances in wastewater. COD is determined by titration of certain amount of wastewater with potassium permanganate solution ($KMnO_4$), a strong oxidizing agent. The endpoint of titration is detected by the slight coloration caused by $KMnO_4$ or the ORP. ORP measurement provides an effective method of detecting the endpoint of titration, especially for colored or turbid wastewater samples. ORP is a useful indicator in wastewater treatment and potentiometric titrations of solutions.

ORP Measuring System

ORP is measured using the mV mode of a pH meter and an ORP electrode.

ORP Electrode

The construction of an ORP electrode is similar to that of a pH electrode. The only difference is the sensing electrode – the pH electrode has a glass electrode while an ORP electrode has a noble metal electrode (e.g., platinum or gold). The sensing electrode act as platform for electron transfer to or from the reference electrode. The electrons are constantly transferred back and forth on the measuring surface which generates a tiny voltage. Like a pH electrode, the sensing metal electrode has to be paired with a reference electrode filled with electrolyte. The reference electrode has known potential and measured ORP of solution will depend on the reference electrode used. In addition, the ORP electrode should have a built-in temperature sensor for measuring and recording the temperature of standards and samples together with the ORP value.

HORIBA 9300-10D combination ORP electrode has flat platinum tip for measuring even small volume samples and temperature sensor for measuring temperature of the standards and samples.

ORP Meter

The ORP meter measures the potential difference between the sensing metal electrode in contact with the solution and reference electrode in contact with the solution through its liquid junction or salt bridge.

Meters can detect temperature from the built-in temperature sensor of the ORP electrode or separate temperature probe, but they have no temperature compensation feature. Although ORP is affected by temperature, the meter is not able to adjust or convert the reading to a temperature-compensated value.

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Absolute potentials in ORP measurement are not always used. Some meters are equipped with standard or zero adjustment feature.

All HORIBA 100 Series pH handheld meters, 1000 Series Custom pH bench meters, and F-7X Colour Touchscreen Series pH bench meters have mV mode, which displays absolute and relative potentials (zero adjustment). Of all the meters, the F-7X Colour Touchscreen Series pH bench meters have additional ORP mode that accepts one-point calibration.

ORP Measurement

As ORP is affected by temperature, measurement is carried out using an ORP electrode integrated with temperature sensor and samples (and ORP standards, if available) are maintained at a constant temperature. To check whether the ORP electrode / meter system is working properly (or calibrate, if necessary), a standard solution with known ORP value must be prepared and measured. The ORP reading should be within the specified range of the ORP standard solution.

HORIBA 160-22 and 160-51 ORP powders are packaged in sachets and prepared by dissolving in 250ml distilled or deionized water to provide the freshest standard solutions whenever ORP measurement is carried out. The ORP values of the resulting standard solutions at 25°C are 258mV ± 15 and 89mV ± 15, respectively.

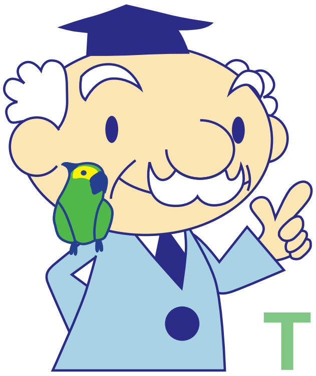
Table 1 below shows the values at different temperatures of the ORP standard solutions prepared using HORIBA ORP powders.

Table 1: Values of HORIBA ORP powders when dissolved in 250ml DI water at different temperatures

°C	160-22 (mV)	160-51 (mV)
0	+277.5	+116.5
5	+274.2	+111.9
10	+270.9	+106.9
15	+266.8	+101.0
20	+262.5	+95.0
25	+257.6	+89.0
30	+253.5	+82.7
35	+248.6	+76.2
40	+243.6	+69.0

Applications

Wastewater Treatment Plant, Swimming Pools, Spas, Aquaculture, Drinking Water, Cooling Tower Disinfection, Groundwater Remediation, Environmental Testing, Bleaching, Metal Etching, etc.



Theory of Conductivity

Conductivity

Electrical conductivity (EC), often simply referred to as conductivity, is a measure of the ability of an aqueous solution to carry an electric current. It is affected by presence of electrolytes in water. Electrolytes are substances that produce ions when dissolved in water. They can be covalent compounds (e.g., acids and bases) that chemically react to yield ions or ionic compounds (e.g., salts) that dissociate to yield their constituent positively-charged ion (called cations) and negatively-charged ion (called anions) in water. Substances that completely ionize in water are called strong electrolytes (e.g., strong acids, strong bases, and ionic salts) while those which partially ionize in water are called weak electrolytes. Substances that do not produce ions when dissolved in water (e.g., organic compounds) are called nonelectrolytes. Table 1 shows the differences between electrolytes and nonelectrolytes.

Ionization of hydrochloric acid (HCl) in water

$$\mathrm{HCl\ (l) + H_2O\ (l) \rightarrow H_3O^+\ (aq) + Cl^-\ (aq)}$$

Dissociation of sodium hydroxide (NaOH) in water

$$\mathrm{NaOH\ (s) \rightarrow Na^+\ (aq) + OH^-\ (aq)}$$

Table 1 Electrolytes vs Nonelectrolytes

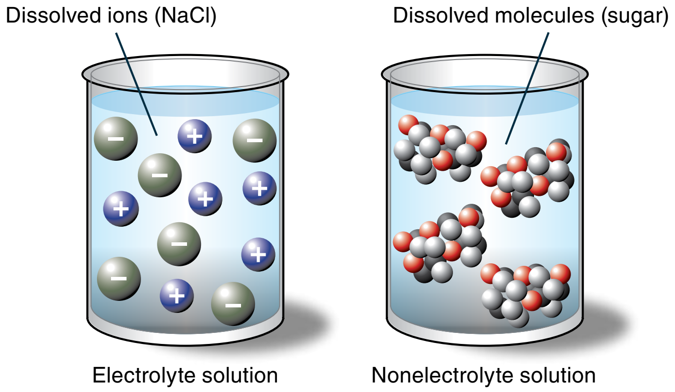
Electrolytes	Nonelectrolytes
Produce ions when dissolved in water	Do not produce ions when dissolved in water
Aqueous solutions conduct electricity	Aqueous solutions do not conduct electricity
Classified as strong or weak electrolytes	-
Examples: Acids, bases, salts	Example: organic compounds (sugar, oil, alcohol)

For electricity to travel through an aqueous solution, there must be movement of charged particles or ions. These will carry current effectively. Solutions with strong electrolytes are good conductors of electricity and those with weak electrolytes are weak conductors of electricity. Nonelectrolytes do not conduct electricity.

Inorganic compounds are strong electrolytes because they dissociate into charged ions capable of conducting electric current. An example of inorganic salt is sodium chloride (NaCl), known as table salt. It dissociates into sodium (Na+) ion and chloride (Cl-) ion in water. Conversely, organic compounds tend to be nonelectrolytes as they do not dissociate into ions when they dissolved in water and therefore do not affect the conductivity of water. An example of organic compound is sucrose (C12H22O11), also called table sugar. Although it dissolves in water, sucrose does not produce ions. Sucrose molecules are simply surrounded by clusters of water molecules and remain uncharged.

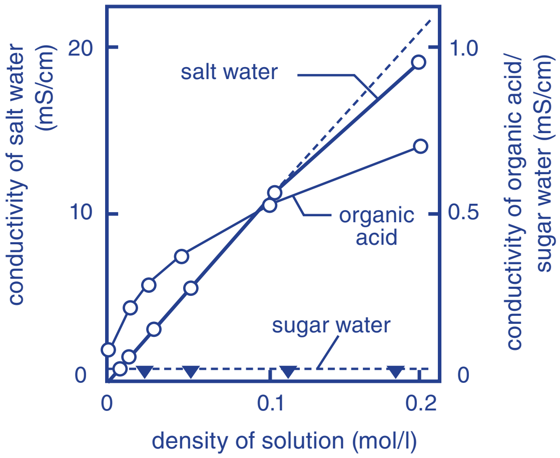
Dissociation of table salt (NaCl) in water

$$\mathrm{NaCl\ (s) \rightarrow Na^+\ (aq) + Cl^-\ (aq)}$$



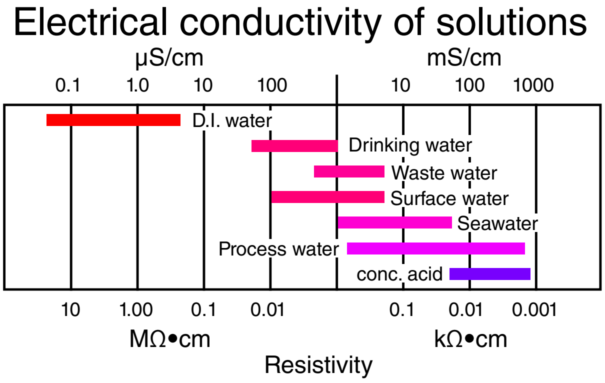
https://solutions4.weebly.com/electrolytes-vs-non-electrolytes.html

Figure 1: Salt Water vs Sugar Water



The more ions dissolved, the higher the conductivity of aqueous solution. Deionized water exhibits very low conductivity because it has no ions. Seawater, on the other hand, contains a number of different ions and thus, it exhibits high conductivity. Figure 2 shows the conductivity ranges of common aqueous solutions.

In very low-density solutions, conductivity has a linear relationship with density as seen with organic acids. Acetic acid solution is a good example. However, as density increases, the rate of ionization decreases as seen with highly concentrated strong acids. In high-density solutions, only part of the electrolyte is ionized, and the overcrowding causes most of the potential ions to remain dissolved in water as molecules.



Source: https://andyjconnelly.wordpress.com/2017/07/14/conductivity-of-a-solution/

Figure 2: Electrical Conductivity of Solutions

Factors Affecting Conductivity of Water

1. **Type of Substance Present**
   Strong electrolytes form ions easily, weak electrolytes do not form ions easily, and nonelectrolytes do not form ions in water.
2. **Concentration of Ions**
   The higher the concentration of dissolved ions, the higher the conductivity of water.
3. **Temperature**
   The warmer or the higher the temperature of water, the higher the solubility of substance present and the higher the conductivity as well.

When low conductivity water is contaminated, its conductivity value increases. Polluted water contains more ions and therefore gives high conductivity. For this reason, conductivity is used as indicator of contamination or pollution of water. It can tell us the quality of water but does not specify the quantity and identification of dissolved ions.

Conductivity Measurement

Conductivity can be measured either by 2-AC bipolar method or electromagnetic induction method. The bipolar method measures the current that passes through the solution between a pair of electrodes while the electromagnetic induction method measures the induction current generated by two coils immersed in the solution. Between the two methods, the bipolar method is commonly used in conductivity measurement.

Conductivity meters that use the bipolar method have a simple structure, allowing the creation of a compact measurement system. They are also good for measuring low-conductivity aqueous solutions such as pure water. However, they cannot be used to measure samples that stain or dissolve electrode surfaces, such as highly-concentrated acids and alkaline solutions. Conductivity meters that work by electromagnetic induction method, corrosion-resistant materials such as plastics can be used for the parts that become wet, and these meters are good for measuring highly-concentrated acids and alkaline solutions. However, they are not suitable for measuring low-conductivity aqueous solutions such as pure water.

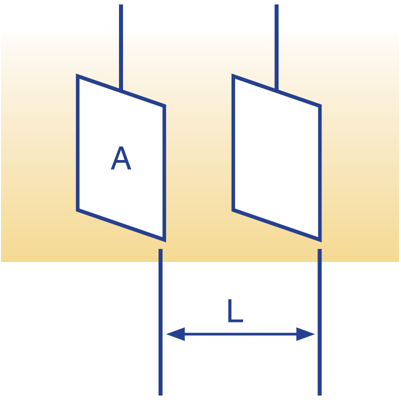


Figure 3: Diagram illustrating the 2-AC bipolar method

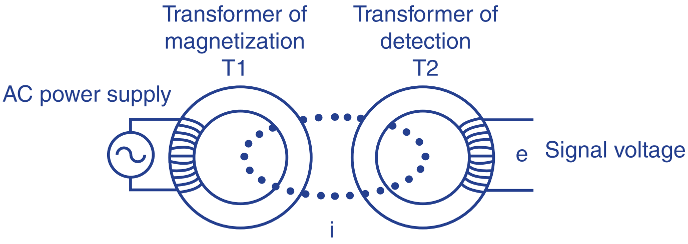


Figure 4: Diagram illustrating the electromagnetic induction method

In 2-AC bipolar method, a conductivity meter applies an AC voltage (V) to two flat metal electrodes, usually platinum, titanium, or stainless steel, immersed in a solution. The ions in the solution move towards the opposite charged electrode and the resulting current (I) is measured to calculate the electrical resistance of the solution.

Ohm's Law

Resistance (R) = Voltage (V) / Current (I)

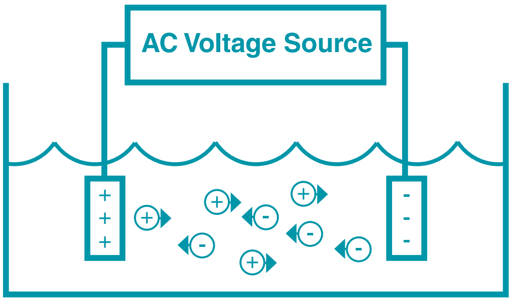


Figure 5: Movement of ions in solution

Conductance (G) is defined as the reciprocal of the electrical resistance (R) of a solution between two electrodes. It is

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calculated from electrical resistance as per the Ohm's Law. The unit of resistance is ohm (Ω) and the unit of conductance is Siemen (S or Ω-1), formerly known as mho (just ohm written backwards).

Conductance (G) = 1 / Resistance (R)

Since conductivity is measured using a conductivity probe with two electrodes placed at a fixed distance, the cell constant of the conductivity probe is taken into account when reporting conductivity. The cell constant (k) is the ratio of the distance (d) between the electrodes to the area (a) of the electrodes. Cell constants of conductivity probes are measured at the factory and indicated on their labels. Over time, the cell constants change so it should be periodically checked and calibrated, if necessary. In most applications, cell constant is measured against a solution of known conductivity value. The cell constant is the ratio of the known conductivity of calibration standard (µS/cm) to the measured conductance (µS). The common cell constants are 0.1, 1.0, and 10.0 cm-1 which are equivalent to 10, 100, and 1000 m-1, respectively. As the sample conductivity gets higher, a higher cell constant is required.

Cell constant (k) = distance between the electrodes (d) / area of the electrodes (a)

The conductivity meter derived the conductivity value by multiplying the measured conductance by the cell constant to correct for the effect of conductivity probe's geometry on the measurement.

Conductivity (C) = Conductance (G) x Cell Constant (k)
→ Current (I) / Voltage (V) x distance between the electrodes (d) / area of the electrodes (a)

The SI unit for conductivity is Siemens per meter (S/m) but Siemens per centimeter is typically used. HORIBA conductivity meters can report conductivity in S/cm and S/m units. Both units automatically switch to microSiemens per centimeter or meter (µS/cm or µS/m) or milliSiemens per centimeter or meter (mS/cm or mS/m) depending on the measured value and set conductivity unit.

Conductivity and Temperature

The conductivity of a solution varies with temperature. When performing conductivity measurement, the temperature of solutions should be controlled and measured as accurately as possible. A good practice is to use a conductivity electrode integrated with temperature sensor and allow it to equilibrate in solution before recording the stable reading. The user decides whether to normalize the conductivity reading at a specific reference temperature (e.g., 20 or 25°C) or record the conductivity reading at the actual temperature. For the former, it is recommended that the conductivity meter has an adjustable temperature coefficient setting, which the meter uses to calculate conductivity. If not available, adjust the temperature of the sample to the reference temperature.

In linear temperature compensation, it is assumed that the temperature coefficient has the same value for all measurement temperatures. Although the assumption is not true, this does not contribute significantly to the combined uncertainty for many measurements. To determine the exact temperature coefficient (α) of the sample expressed as a percentage change in conductivity per °C change in temperature, use the following formula.

> **For electricity to travel through an aqueous solution, there must be movement of charged particles or ions. These will carry current effectively. Solutions with strong electrolytes are good conductors of electricity and those with weak electrolytes are weak conductors of electricity. Nonelectrolytes do not conduct electricity.**

$$\boxed{\alpha_{T,\ Ref} = \frac{C_T\ - C_{Ref}\ \text{x}\ 100}{C_{Ref}\ (T-T_{Ref})}}$$

where:
C_T = conductivity at measured temperature (°C)
C_{Ref} = conductivity at reference temperature (°C)
α = temperature coefficient of solution at T_{Ref}
T_{Ref} = reference temperature
T = measured temperature

HORIBA offers conductivity meters and probes following the 2-AC bipolar method. HORIBA conductivity probes are available in submersible and flow type and constructed with either platinum or titanium conductive elements that are corrosion-resistant, making them ideal for measuring high salinity samples, and built-in temperature sensor for accurate measurement. Each conductivity probe has a cell constant (0.1, 1.0, and 10.0 cm-1 are available), which is to be entered into the meter to improve the accuracy of reading. HORIBA conductivity meters can recognize common conductivity standards and detect temperature directly from conductivity probes. They also have temperature coefficient adjustment setting and algorithms for normalizing conductivity value at a reference temperature.

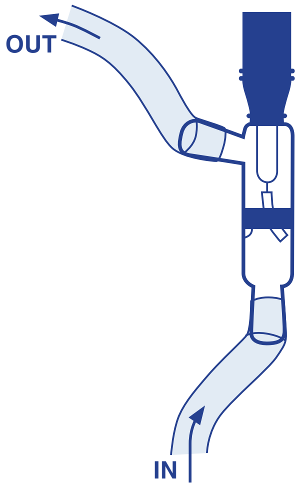


Figure 6: Flow-type Conductivity Probe

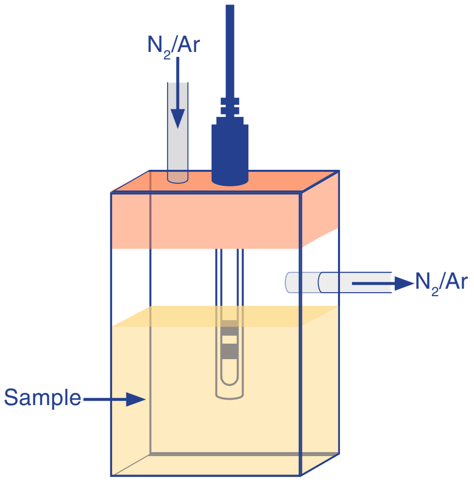


Figure 7: Submersible Conductivity Probe

Resistivity

Resistivity is a measure of the ability of an aqueous solution to oppose the flow of electric current and is expressed in Ω·cm or Ω·m (SI) unit. It is the reciprocal of conductivity. Unlike conductivity, the value of resistivity decreases as the ionic concentration in water increases. In most cases, resistivity is used in measurement of low conductivity water such as ultrapure water. Ultrapure water is usually reported in MΩ·cm resistivity unit while less pure water, like tap water, is reported in kΩ·cm.

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) is a measure of all inorganic (e.g., salts, minerals) and organic substances (e.g., sugar, ethanol) dissolved in water. It is commonly expressed in parts per million (ppm or mg/L).

To determine TDS, there are two methods available: gravimetric and electrical conductivity. Gravimetric method involves filtering a measured amount of sample and then transferring the filtrate to a pre-weighed ceramic dish. The filtrate is allowed to evaporate in an oven at a certain temperature. The dried residues left after evaporation is weighed and the TDS is calculated. Although this method gives accurate TDS, it is laborious and difficult to perform, especially in the field. Another method which is less laborious and provides approximate value of TDS is electrical conductivity. Electrical conductivity is directly related to the ion concentration of dissolved solids. The ions are capable of conducting electric current which can be measured by conductivity with TDS function or TDS meter. Thus, this method requires a TDS meter and a conductivity electrode, making the measurement quicker and easier to perform. The TDS meters convert conductivity readings to TDS by multiplying with a conversion value called TDS factor. A TDS factor depends on the material(s) used or composition of the standard solution, which ideally should match the background of the sample.

TDS Computation

Gravimetric Method

$$\text{TDS (mg/L)} = \frac{(A-B) \times 1000}{V}$$

where:
A = weight of ceramic dish + dried residue (g)
B = weight of empty ceramic dish (g)
V = sample volume (L)

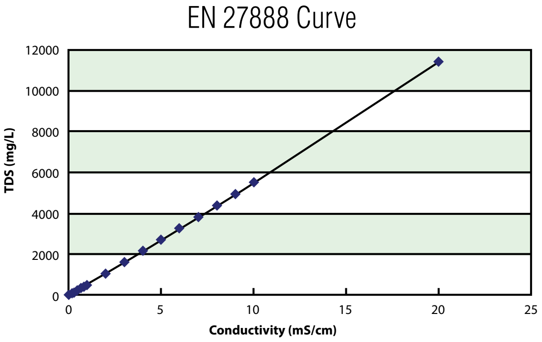
Conductivity Method

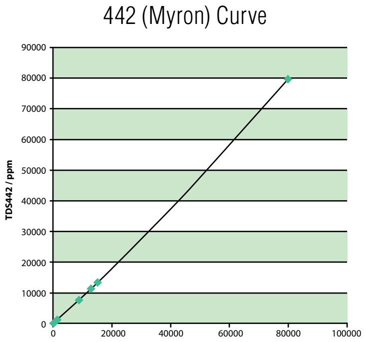
$$\text{TDS (mg/L)} = C \times k$$

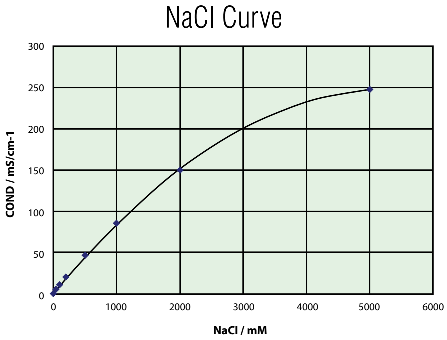
where:
C = conductivity at 25 °C (µS/cm)
k = TDS factor

HORIBA TDS meters derive TDS of a sample by multiplying the measured conductivity by a TDS factor, which is either pre-programmed into the meter (non-linear NaCl, 442, EN 27888) or manually set by the user (linear). The TDS factor depends on the solids dissolved in water. There are four TDS curves in TDS meters – NaCl, 442, EN 27888, and linear. User should select the appropriate curve based on their application.

> **“Electrical conductivity is directly related to the ion concentration of dissolved solids. The ions are capable of conducting electric current which can be measured by conductivity with TDS function or TDS meter.”**







- NaCl – This is based on the properties of sodium chloride (NaCl) and can be used for brines, seawater, brackish water, and other saline solution.

- 442 – This stands for 40% sodium sulfate (Na_2SO_4), 40% sodium bicarbonate ($NaHCO_3$), and 20% sodium chloride (NaCl) based on natural water. It can be used for boiler/cooling water, wells, water supply, streams, and lakes.

- EN 27888 – This is based on European environmental standard.

- Linear – This is for general application. The default TDS factor is 0.5 and can be adjusted from 0.40 to 1.00.

Salinity

Salinity is originally defined as a measure of the mass of dissolved salts in a given mass of solution. The gravimetric determination of salt content is tedious and difficult. Seawater provides variable and unreliable results due to decomposition of some of the salts and loss of some components so other methods have been investigated. Salinity results from indirect methods involving the measurement of a physical property such as conductivity, density, sound speed, and refractive index were obtained. Although conductivity responds only to ionic solutes, the conductivity method is most commonly used to determine the salinity in field and laboratory work because of its high sensitivity and precision. Salinity meters measure the conductivity of sample using conductivity electrode and convert the reading to salinity.

Seawater contains ions such as chloride (Cl^-), sodium (Na^+), sulfate (SO_4^{2-}), magnesium (Mg^{2+}), potassium (K^+), and calcium (Ca^{2+}) from dissolved salts. The relative ratios of the constituents of seawater are found to be approximately constant in the ocean. For seawater measurements, the Practical Salinity Scale 1978 (PSS-78) was developed relative to a KCl solution. A seawater with a conductivity, C, at 15°C equal to that of a KCl solution containing a mass of 32.4356 g in a mass of 1 kg of solution is defined having a practical salinity of 35. The salinity dependence of the conductivity ratio as a function of temperature of a given sample to a standard S=35 seawater is used to determine salinity. As salinity is defined in terms of the conductivity ratio, salinities are nowadays reported simply as numbers (unitless). The numbers represent gram per kilogram or parts per thousand by weight.

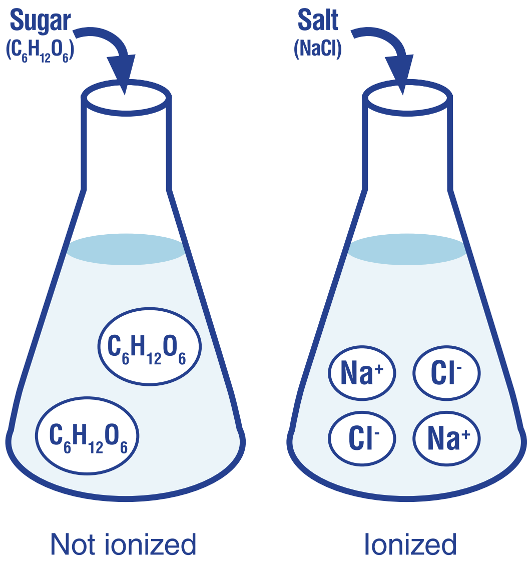
HORIBA salinity meters have two types of salinity curves – NaCl (non-linear) and seawater (based on PSS-78). The salinity units in the meters are parts per thousand (displayed as either ppt or unitless) and percentage (%). Calibration option is available in some models.

Theory of Ion

Ion Definition

Water is represented by the molecular formula H_2O. It dissolves many kinds of substances. However, some substances do not dissolve in water, as would be expected from the Japanese phrase “water and oil”, which is used to indicate things that do not mix because of their fundamentally different nature.

Let us look at the differences between the properties of aqueous solutions of sugar and salt. When sugar, particularly high-purity granulated sugar, is dissolved in water, the ease of how electric current flows through the sugar solution is almost the same as that of the original water. In contrast, electric current flows extremely easy through a salt solution. What is the reason for this difference? Sugar ($C_6H_{12}O_6$) does not turn into ions, whereas salt (NaCl) completely ionizes into sodium ions (Na^+) and chloride ions (Cl^-), allowing electric current to flow. Sodium atoms (Na), due to their nature, tend to release an electron e^- to become Na^+ sodium ions, and chlorine atoms (Cl) tend to accept an electron e^- to become Cl^- chloride ions. Na^+ and Cl^- electrically attract each other to form the compound known as salt (NaCl). A substance that is formed like this is called an ionic compound. Unlike salt, sugar is formed by carbon, hydrogen, and oxygen atoms sharing some of their electrons (valence electrons) and is called covalent compound. Even after dissolving in water, sugar molecules retain their form and do not turn into ions. Although sugar and salt seem to dissolve in water in the same manner, they differ greatly in their ionization/non-ionization behaviour in water.

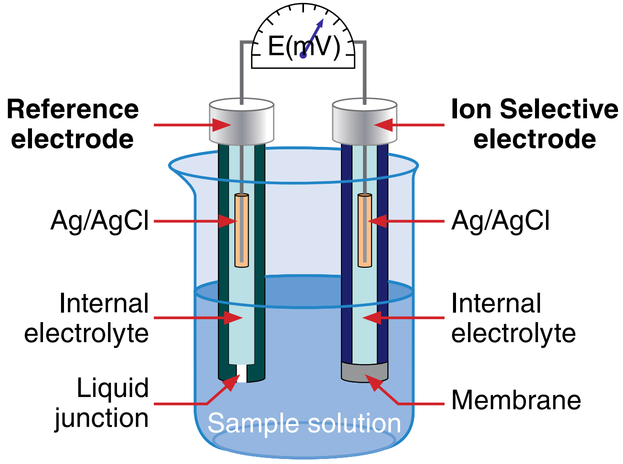


Sodium ions (Na^+), potassium ions (K^+), chloride ions (Cl^-), and bicarbonate ions (HCO_3^-) are present in human blood and lymph fluid and play important physiological roles such as controlling osmotic pressure. These ions are known as electrolytes, a technical term used in medicine and physiology. In physics and chemistry, “electrolyte” is a more general term which, briefly stated, can be said to indicate any type of ion.

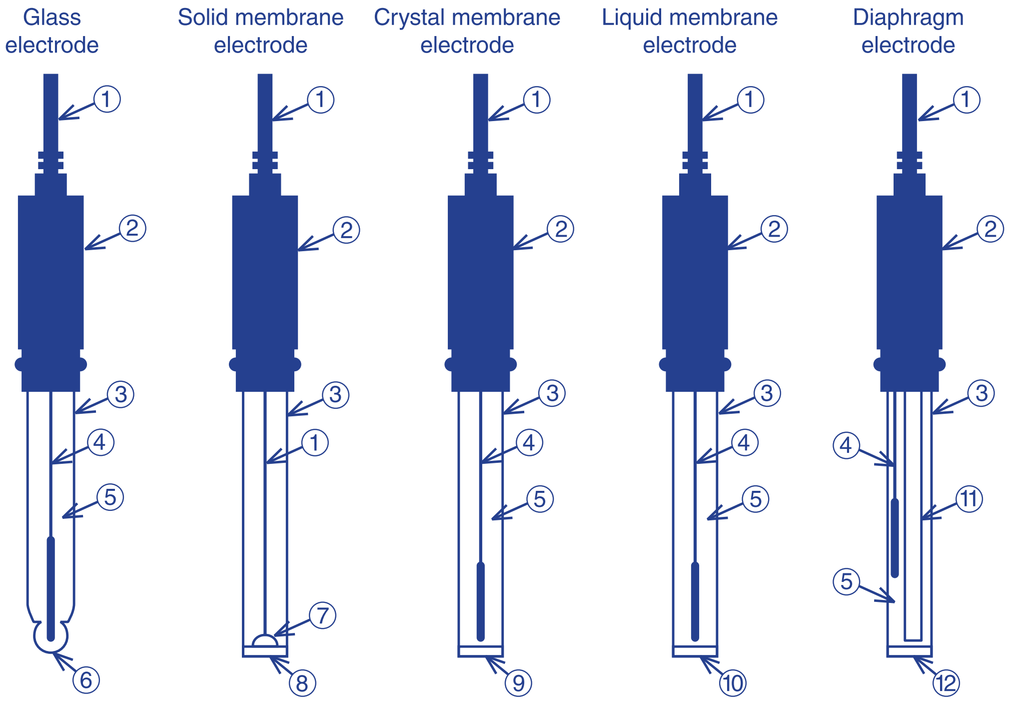
An ion carrying a positive charge is called a cation and one carrying a negative charge is called an anion. The number of electrons that a compound or atom accepts or releases when it becomes an ion is called its valency. Ions with valencies of one, two, and three are called univalent (or monovalent), divalent (or bivalent), and trivalent, respectively. For example, Na^+ is a monovalent cation, Cl^- is a monovalent anion, Ca^{2+} is a divalent cation, SO_4^{2-} is a divalent anion, Fe^{3+} is a trivalent cation, and PO_4^{3-} is a trivalent anion. Ions of larger valency also exist. Water always contains the same number of anions and cations, and looks electrically neutral when viewed from outside.

Ion Selective Electrodes

Researches on ion selective electrodes (ISEs) have been actively pursued starting 1960s. Since then, HORIBA have been developing and selling various types of ISEs. An ISE is a sensor that detects and converts the activity of a specific ion dissolved in a solution into an electrical potential, which is then measured and converted to concentration by an ion meter. A reference electrode with stable potential, either separate or built in the same body, is paired with the ion sensing part to give a potential difference that depends on the ion concentration in aqueous solution. In general, a silver-silver chloride (Ag/AgCl) electrode is used as a reference electrode. Nowadays, most ISEs are constructed with built-in reference electrode and are called combination ISEs.



The ISEs are categorized based on their sensing membranes which are glass (for Na^+ electrode), silver-salt based solid state (for CN^-, Cl^-, S^{2-}, I^-, Br^-, SCN^-, Cu^{2+}, Cd^{2+}, Pb^{2+} and Ag^+ electrodes), single crystal (for F^- electrodes), liquid and plastic solidification (for NO_3^-, K^+, Na^+, and Ca^{2+} electrodes), and diaphragm (for ammonia electrodes).



① Lead wire
② Cap
③ Stem
④ Internal electrode
⑤ Internal solution
⑥ Glass membrane
⑦ Conductive glue
⑧ Solid membrane
⑨ Single crystal membrane
⑩ Porous membrane
⑪ Internal sensor
⑫ Diaphragm

Type	Electrode Structure	Typical Ions Measured
Glass electrode	Sensing membrane is made of a thin glass.	Na^+, H^+
Solid membrane electrode	Sensing membrane is made of either single crystal or pressure-molded powder of poorly soluble metallic salt.	Cl^-, Br^-, SCN^-, CN^-, S^{2-}, Ag^+, Pb^{2+}, Cu^{2+}, Cd^{2+}
	F^- electrodes have sensing membrane composed of a single crystal of lanthanum fluoride LaF_3 and neutral internal solution containing F^- ions.	F^-
Liquid membrane electrode	Sensing membrane is made of porous or macromolecular material that acts as a support for polar organic solvent containing dissolved liquid ionic-exchanger. Also known as a plastic solidification membrane electrode.	NO_3^-, Ca^{2+}, K^+
Diaphragm electrode	Electrode is composed of a stem in which pH glass and reference electrodes have been inserted. It is filled with liquid solution and coated with a diaphragm.	NH_3

Ion Measurement

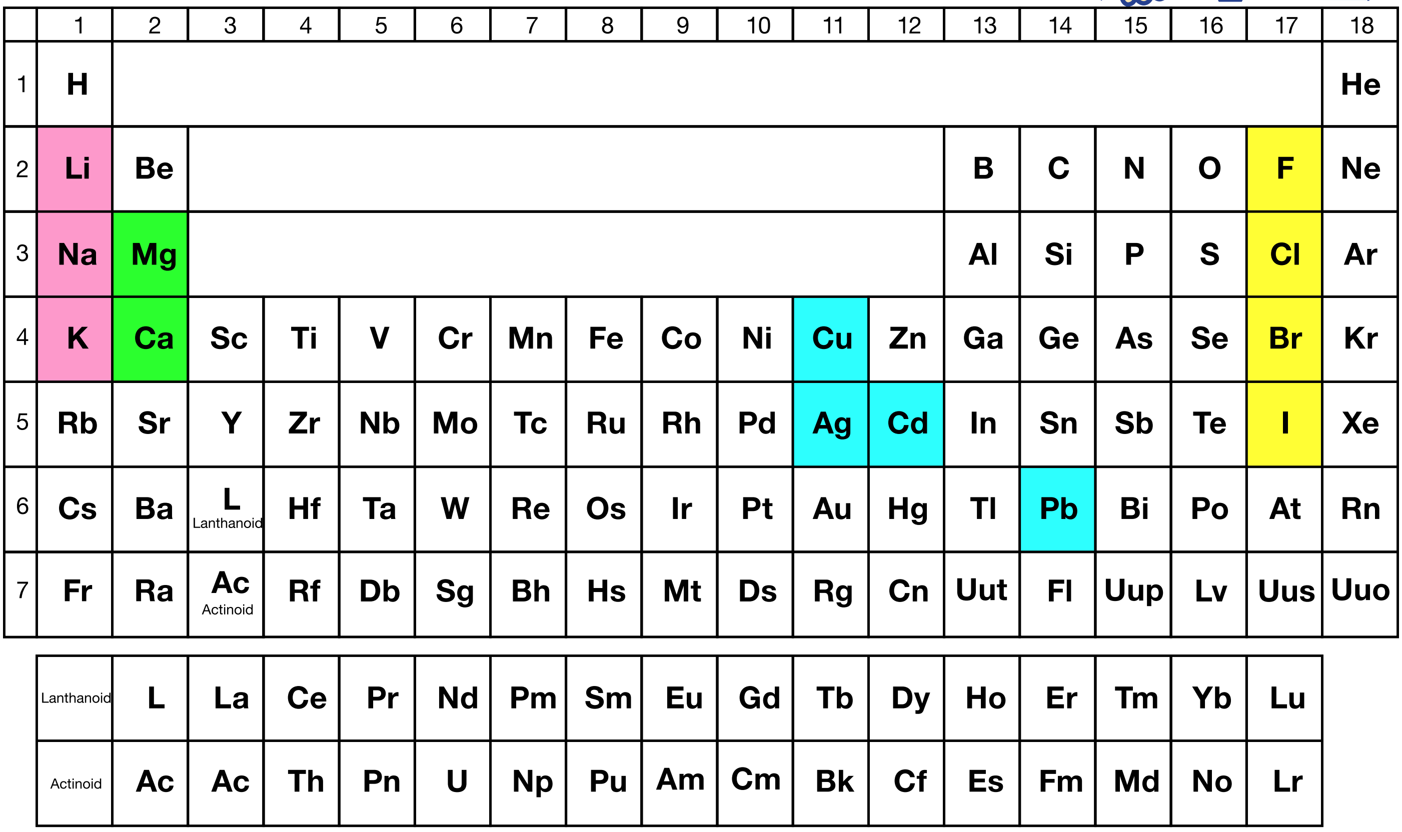
In order to measure concentration of a specific ion, an ISE and reference electrode, either separate or built-in the same body, are connected to an ion meter and immersed in solution. Prior to sample measurement, the electrodes and meter must be calibrated with two standard solutions that have ten-fold concentrations apart (e.g., 1ppm and 10ppm, 10ppm and 100ppm). Like the pH-sensitive glass electrode, the sensitivity of ISE is also affected by temperature, so measurement has to be carried out at constant temperature (e.g., 25°C).

Selectivity Coefficient

In general, it is common to most analytical methods that when atoms or ions of a different species but with similar properties are present together with ion of interest, they interfere with measurement. This also holds true for ion measurement using ISEs. An ISE responds not only to the specific ion of interest, but also to other ions which have similar characteristics, known as interfering ions. The selectivity coefficient is a measure of this effect.

The pH-sensitive glass electrode can be regarded as a hydrogen ion (H^+) electrode. The pH-sensitive glass electrodes are largely not affected by coexisting ions, but measurements of samples with pH over 12 suffer from a certain level of error called alkaline error. Alkaline error indicates that, in addition to responding to H^+ ions, pH-sensitive glass electrodes are also affected to some degree by alkaline metal ions such as Na^+ and K^+.

Do you recall the periodical table? Each column contains elements with similar properties. For example, Li, Na, and K etc. are the alkaline metals, which tend to form monovalent cations; Mg and Ca etc. are the alkaline-earth metals, which tend to form divalent cations; and F, Cl, Br, and I etc. are the halogens, which tend to form monovalent anions. In addition, the elements Cu, Ag, Cd, and Pb, which tend to form monovalent and divalent cations, are aligned relatively close to each other both vertically and horizontally within the table. When using the ion selective electrode method, care needs to be taken with regard to mutual interference within each of these groups.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	H																	He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg											Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	L Lanthanoid	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Ac Actinoid	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo

Lanthanoid	L	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Actinoid	Ac	Ac	Th	Pn	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

In addition, the effects of coexisting ions can be predicted to some extent from the ISE's sensing membrane material. For example, a solid-state membrane electrode can be seriously affected by coexisting ions that form insoluble compounds or complex salts with the material of its sensing membrane. A liquid membrane electrode can be affected by coexisting ions that form ionic associates with the components in its sensing membrane.

To understand the effect of interfering ion, let's take a look at potassium ion electrode. The degree of the effect of an interfering ion on potassium ion electrode can be expressed by selectivity coefficient K in the following formula:

$$E=Eo+\frac{2.303RT}{F}\log(a_{K^+}+K\,a_X)$$

where:

a_{K+} = potassium ion concentration

a_X = interfering ion concentration

K = selectivity coefficient

Selectivity coefficient is a concentration ratio of the interfering ion against the target ion measurement value. The smaller the value of K, the less the interference. The higher the concentration of target ions, the lower the effect of the interfering ions. Conversely, the lower the concentrations of target ions, the greater the effect of the interfering ions.

The selectivity coefficients of typical interfering ions for potassium ion are listed in the table below. Please note that the selectivity coefficient varies depending on the potassium ion concentration. The values in the table are for 10^{-3} mol/L K^+. The higher the potassium ion concentration, the lesser the interference.

Interfering Ion	Selectivity Coefficient
Rb^+	1×10^{-1}
Mg^{2+}	1×10^{-5}
NH_4^+	7×10^{-3}
Ca^{2+}	7×10^{-7}
Cs^+	4×10^{-3}
Na^+	3×10^{-4}
pH = 2 to 9 (at 10^{-3} mol/L K^+)	

Each ion selective electrode has operating pH range. In this range, the ion selective electrode is not affected by hydrogen ions (H^+) or hydroxyl ions (OH^-) and the target ions can exist as free ions. For example, metal ions tend to form hydroxides in the alkaline region. In practice, the pH range in which an ion selective electrode maintains a constant electromotive force is measured by changing the pH of a standard solution having fixed concentration of target ion (e.g., 10^{-3} mol/L or 10^{-4} mol/L) from acidic to alkaline.

Dissolved Oxygen

Dissolved oxygen refers to the gaseous oxygen dissolved in water – not to be confused with the bound oxygen atom in H_2O. The concentration of dissolved oxygen is crucial to aquatic animals as they depend on dissolved oxygen for respiration.

The sources of dissolved oxygen in water are the atmosphere, or as a product of photosynthesis. When any gas is in contact with water, some will dissolve. The amount that dissolves in water at a particular temperature depends on the partial pressure of the gas, and an equilibrium will be established.

Dissolved oxygen saturation

When the amount of dissolved gases is in equilibrium with the air above the water, assuming a stable body of water with no stratification, the water is considered to be at 100% air saturation. This means that the water is holding as many dissolved gas molecules as it can.

When the concentration of dissolved gases differ from the partial pressure of gases above the water, water will seek to re-establish equilibrium to 100% saturation via rapid forward and reverse reactions. As much as dissolved oxygen levels can decrease, as seen in the case of boiling water, it is also possible for air saturation to go above 100%, and this can occur during high activities of photosynthesis or aeration.

Dissolved oxygen sensors measure oxygen saturation as a percentage relative to the 100% saturation value at that temperature and measurement depth/elevation. The actual concentration of dissolved oxygen can then be calculated from the known values of 100% saturation. At sea level, oxygen saturated fresh water at 25°C has a dissolved oxygen concentration of 8.26 mg/L, hence 50% oxygen saturated fresh water at the same temperature and elevation contains 4.13 mg/L of dissolved oxygen.

Henry's Law

Henry's law is a gas law that states that the amount of a given gas that dissolves in a given type and volume of liquid at a constant temperature is directly proportional to the partial pressure of that gas in equilibrium with that liquid. Henry's law constant can be obtained from the equilibrium constant:

$$c_{gas} \rightleftharpoons P_{gas} + H_2O\,(l)$$

$$K_{eq} = \frac{P_{gas}\,[H_2O\,(l)]}{c_{gas}}$$

$$K_H \equiv \frac{K_{eq}}{[H_2O\,(l)]} \equiv \frac{P_{gas}}{c_{gas}}$$

$$P_{gas} = K_H c_{gas}$$

C_{gas} is the concentration of the gas at a particular temperature in water (units: M)

k_H is the Henry's law constant (units: atm/M)

P_{gas} is the partial pressure of the gas above the solution under equilibrium conditions (units: atm)

At equilibrium, concentration of gas dissolved in water is proportionate to the partial pressure of the gas above the surface of water.

Relationship between DO and temperature, pressure, and salinity

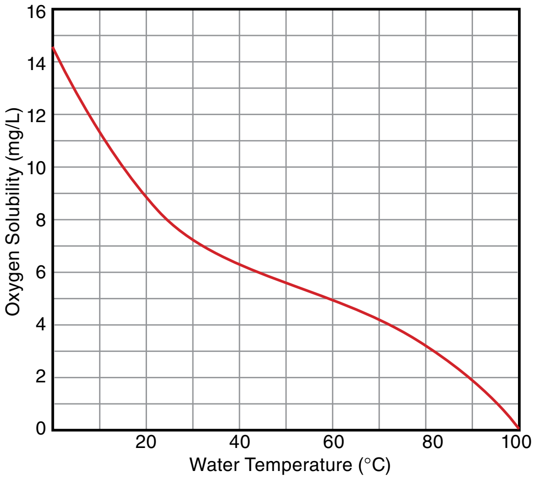
1. Pressure

Henry's law equation demonstrates that the partial pressure of the gas is directly proportional to concentration of gas dissolved in water. As partial pressure of gases correlates to atmospheric pressure, and atmospheric pressure decreases as altitude increases, the amount of dissolved gases water can hold decreases as altitude increases.

The K_H value for oxygen at 298.15K is 769.23 atm/M or 0.0013 M/atm, which the following graph illustrates the relationship between partial pressure and dissolved oxygen concentration:

2. Temperature

Boiling water removes dissolved gases in water – this is because the solubility of gases decreases as temperature rises. At higher temperatures, water at 100% saturation holds less dissolved oxygen, as seen from the graph below:



Graph obtained from www.engineeringtoolbox.com

By Le Chatelier's Principle, when a system experiences a disturbance, it will respond to restore a new equilibrium state. The equilibrium reaction for dissolution of a gas is as follows:

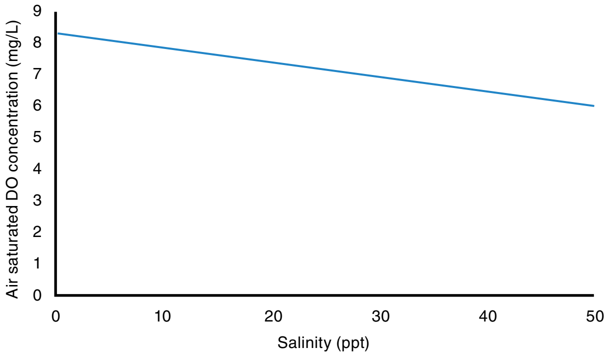
Gas (g) + Water (l) ⇋ Solution (aq) + Heat energy

When heat is applied to the system at equilibrium, the equilibrium position shifts to the left to counteract the effect of the applied heat, causing the gas to come out of solution and escape into the atmosphere, decreasing the concentration of dissolved gas and increasing its partial pressure. Likewise, when a system at equilibrium is cooled, the equilibrium position shifts to the right to offset the reduction in energy, allowing for more gases to dissolve in the water and thus increasing the concentration of dissolved gas.

3. Salinity

In general, the addition of electrolytes decreases the ability of water to dissolve gases as salt ions attract water molecules, thus leaving less hydrogen and oxygen ions available to capture and dissociate gas molecules. This can be illustrated by the addition of salt to a carbonated drink – the carbon dioxide will fizz out.

Concentration of dissolved oxygen decreases with increasing salt concentration, and at the same temperature and pressure saltwater holds about 20% less dissolved oxygen than freshwater. The graph below describes the relationship:



Analytical Methods

1. Winkler Titration

Developed by Ludwig Wilhelm Winkler in 1888, this method uses a Winkler bottle which has a conical top and a close fitting stopper to aid in the exclusion of air bubbles when the top is sealed.

The Winkler Method uses titration to determine concentration of dissolved oxygen, and is usually done in the field to prevent alteration of the sample's dissolved oxygen content due to equilibration with the atmosphere.

2. Clark cell electrodes

The first Clark cell electrode was developed in 1954 by Dr. Leland Clark, comprising of an anode and cathode behind a nonconductive polyethylene membrane. Clark-cell electrodes are also known as amperometric sensors as they produce an electric current as a function of analyte concentration.

There are two types of amperometric sensors, galvanic and polarographic. While a polarographic sensor requires a constant voltage to be added to it, a galvanic sensor is self-polarizing due to the electrode potential generated by the use of dissimilar metals. Both sensors utilize an anode and cathode confined in electrolyte solution by an oxygen permeable membrane, and dissolved oxygen molecules in the sample diffuse through the membrane to the sensor at a rate proportionate to the pressure difference across it. As oxygen is rapidly reduced or consumed at the cathode, it can be assumed that the oxygen pressure under the membrane is zero, and hence the amount of oxygen diffusing through the membrane is therefore proportionate to the partial pressure of oxygen outside the membrane. Moreover as oxygen is being consumed at the membrane, if there is stagnation of the water outside the membrane the dissolved oxygen readings will be artificially low, therefore flow around the sensor tip is required for accurate measurements.

2.1 Polarographic sensors

A polarographic sensor uses a noble metal electrode such as platinum or gold polarized with about -0.6 to -0.8 volts with respect to a silver reference electrode (also used as the anode). Hence, a 5-60 minute warm up period is required

upon turning on the machine to allow for the polarization of the electrodes before calibration or measurement. The instrument can be left powered on to skip the warm-up period – but this drains the batteries. Dissolved oxygen in the sample is reduced at the surface of the noble metal cathode.

Chemically, the oxidation and reduction reactions are as shown below:

Anode: $4Ag + 4Cl^- \rightarrow 4AgCl + 4e^-$

Cathode: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

Overall: $O_2 + 2H_2O + 4Ag + 4KCl \rightarrow 4AgCl + 4KOH$

Since the hydroxyl (OH^-) ions are constantly being produced by the reduction of oxygen, gradual alkalinisation of the electrolyte solution would occur, together with the gradual depletion of Cl^-. Increasing the pH also makes the electrolyte potential more negative and causes a zero shift. The electrolyte solution then has to be replenished, and depending on usage the probe electrolyte solution may have to be replaced as often as every two weeks.

After an extended period of time, silver chloride (AgCl) will also build up on the anode surface, and when it is completely covered the anode cannot be used until the silver chloride deposits are removed. Additionally, gaseous sulphur dioxide present may be reduced to hydrogen sulphite, which would attack the silver anode forming a silver-sulphite (Ag_2S) coating. This, as well as the silver chloride coating, would also have to be removed from the anode.

2.2 Galvanic sensors

A galvanic sensor works on the same principle as the polarographic sensor, using polarized electrodes to determine dissolved oxygen concentration. However, a galvanic sensor uses different electrode materials. The anode is made of lead or zinc, while the cathode is made of gold or silver. This combination of dissimilar metals generates an electromotive potential in the presence of an electrolyte solution enough to self-polarize and reduce oxygen molecules without an applied voltage. This eliminates the need for warm-up time. The electrolyte solution used can be sodium hydroxide, sodium chloride, or another inert electrolyte.

Electrons in the chemical reactions that occur travel internally from the anode to the cathode – the zinc or lead anode is oxidized and reduction of oxygen occur at the surface of the cathode. The cathode remains inert, serving only to pass on electrons and does not interfere in the reaction. The following chemical reactions occur, assuming a zinc anode is used:

Anode oxidation: $2Zn \rightarrow 2\,Zn^{2+} + 4e^-$

Oxygen reduction at cathode: $O_2 + 4e^- + 2H_2O \rightarrow 4OH^-$

Overall reaction: $2Zn + O_2 + 2H_2O \rightarrow 2Zn(OH)_2$

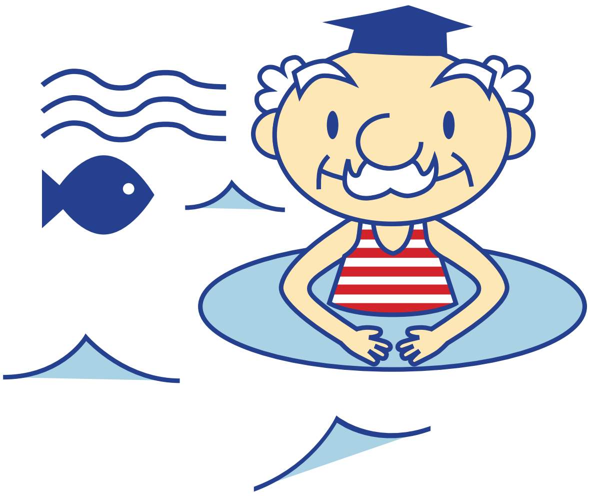
Similar to the two types of sensors mentioned earlier, the current produced by the reduction of oxygen is proportional to the partial pressure of oxygen in the water sample. The overall reaction produces zinc hydroxide, which is only slightly soluble in water, hence some of the product will precipitate out of solution. This precipitate can be seen forming at the tip of the sensor, and it does not affect the sensor's performance until the quantity becomes excessive. When this happens, conductivity between the cathode and anode is affected, which would cause the sensor output to be unusually low or result in unstable readings, and it would then be necessary to replace the electrolyte solution.

Due to the self-polarizing nature of a galvanic DO sensor, the oxidation of the anode continues to occur even when the instrument is not in use, hence reducing the lifespan of the electrodes. However, this also means the sensor has no warm-up time, and the instrument has a lower power consumption as an applied voltage is not required.

Using a galvanic sensor reduces electrolyte replacement due to the constant pH and concentration of the solution, and the electrolyte solution can be said to even last indefinitely. The problem of sulphite poisoning is also eliminated, as the silver cathode carries a net negative charge and hence repels any sulphite ions present. The electrolyte solution maintains a constant pH as hydroxide ions do not build up in solution due to the precipitation of $Zn(OH)_2$. Also, chloride ions are not consumed from the electrolyte solution.

3. Luminescence-based sensors

Luminescence-based sensors measure the interaction between oxygen and certain luminescent dyes. These dyes become excited when they are exposed to blue light and emit light (luminescence) as the electrons return to their normal energy state. Lifetime and intensity luminescence-based measurement methods are based on the principle that dissolved oxygen molecules quench both the lifetime and intensity of luminescence associated with luminescent chemical dyes. When no oxygen is present, the lifetime and intensity of the signal are at maximum. It can be said that the lifetime and intensity of the signal is inversely proportional to the partial pressure of oxygen present.



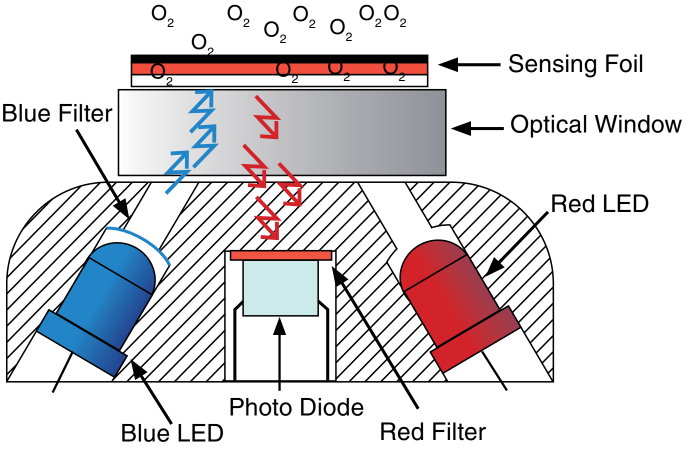


Diagram of a luminescence-based dissolved oxygen probe

Image obtained from: https://portal.geomar.de/documents/1174751/1174765/Optode+bild2.jpg/268fc2b7-933b-4c3e-9a13-debd54b14f03?t=1456682553751

A luminescence-based dissolved oxygen sensor consists of a sensing layer, light-emitting diode (LED), and a photodetector. The sensing layer contains luminescent dye that is immobilized in matrix such as sol-gel, xerogel, or polystyrene. Luminescent dyes that are quenched by oxygen are polycyclic aromatic hydrocarbons, transition metal complexes of Ru(II), Os(II), Rh(II), and phosphorescent porphyrins containing Pt(II) or Pd(II) as the central atom. The sensing layer is coated with a black layer for optical insulation and protection of the luminescent dye from photobleaching.

There is an inverse relationship between the oxygen pressure outside the sensor and the lifetime or intensity of the luminescence in the dye layer of the sensing element, which is generally quantified by the Stern-Volmer equation as shown below:

Where: $\mathbf{I_0}$ = Intensity or lifetime of dye luminescence without oxygen

$\mathbf{I}$ = Intensity or lifetime of dye luminescence in the presence of oxygen

$\mathbf{k_q}$ = Quencher rate coefficient

$\mathbf{t_0}$ = Luminescence lifetime of the dye

$\mathbf{[O_2]}$ = Oxygen concentration

The detection of dissolved oxygen in luminescence-based sensors is flow independent as no DO is consumed. However, as luminescence quenching is strongly temperature dependent, the sensor cap must be in temperature equilibrium with the sample, and an installed temperature probe is used to account for temperature. Emission of red light which is reflected by the dye layer to the photodiode provides an internal reference, allowing for correction of temperature or time induced changes in the phase measurement electronics.

Luminescence-based dissolved oxygen sensors are ideal for long-term monitoring programs due to their minimal maintenance requirements, as they can hold a calibration for several months and exhibit little calibration drift. Dissolved oxygen sensors also do not require any warm-up time, flow, or stirring when taking a measurement.

Advantages of luminescence-based sensors

As Horiba has both galvanic and luminescence based sensors, a comparison between the two is listed in the table below:

Comparisons of luminescence-based sensors (vs galvanic sensors)	
Advantages	**Limitations**
No warm up time required	Higher acquisition cost
Non-consumptive method – stirring not required	Higher power consumption
High calibration stability, little calibration drift	Slower response time
No membrane or electrode fouling	
Little maintenance required – no membranes or electrolyte solution to replace, no electrodes to clean	

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Application Notes

A number of application notes based on citation articles written by independent researchers and scientists and technical tips covering product usage, maintenance, and troubleshooting are available for download from our website to help our customers become experts in their measurements.

Nitrate Measurement in Turf Grass

Nitrate concentration in grasses can be used as an indicator of soil nitrogen (N) availability for their growth. Research at the University of Connecticut suggests verdure sap nitrate-N concentrations at 200-300 ppm as the optimum level.

Introduction

Grasses store nitrogen (N) as nitrate in the bases of stems and shoots. Research conducted by Guillard and Morris (2013) at the University of Connecticut suggests that nitrate accumulate in the shoot bases of perennial turf grasses during the fall (when new leaf blade formation declines), which could be a significant source of N for the turf plant at the onset of new growth in the following spring after winter dormancy. At the optimum critical level of nitrate-N concentration and beyond, the turf response will plateau or flatten out – increasing the fall verdure nitrate-N concentrations with more fertilizer beyond the optimum critical level will not increase the grass quality in the fall or the following spring; the maximum quality response has been reached.

Pocket-sized LAQUA twin Nitrate Ion meter was used to measure nitrate-N concentrations in verdure sap. It eliminates the need to transport samples to a laboratory for expensive analysis performed using either colorimetry or chromatography by trained analyst.

Method

Calibrate the LAQUAtwin Nitrate Ion meter according to manufacturer's instructions.

Sample Collection And Preparation

1. Mow the turf to desired height and remove mowed clippings.
2. Collect verdure samples—aboveground parts of the turf plant remaining after clippings removed. A golf-ball sized, compressed verdure sample is usually sufficient to produce adequate sap for the test.
3. Squeeze the sap from the verdure sample using a hydraulic or garlic-type press.

Sample Measurement

1. Place some drops of the extracted sap directly into the sensor.
2. Record the reading once stabilized—☺ appears.
3. After each sample, rinse the sensor with water and blot it dry with tissue.

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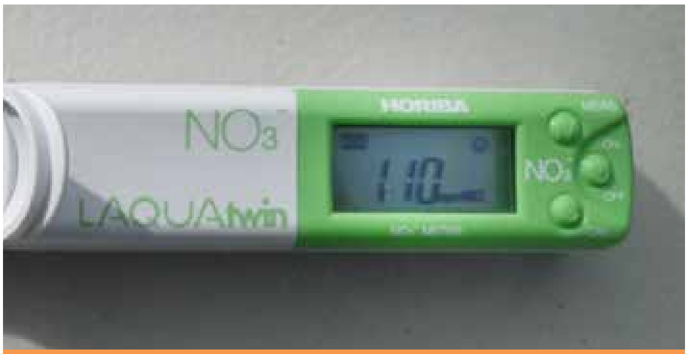
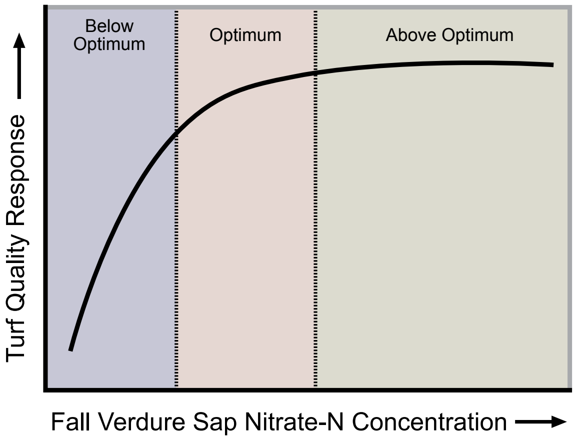
LAQUAtwin B-741 Product Page

> **It eliminates the need to transport samples to a laboratory for expensive analysis performed using either colorimetry or chromatography by trained analyst.**

Place some drops of the extracted sap directly into the sensor.



Record the reading once stabilized—☺ appears.



Results and Benefits

Research at the University of Connecticut suggests that no fertilizer is required in the fall if the verdure sap nitrate-N concentrations are 200-300 ppm or above during October through November in their climate (critical values were based on turf mowed to a height of 2¼ inches and test was conducted using Horiba's LAQUA twin Nitrate ion meter). If less than 200, it suggests that some nitrogen be applied to obtain optimum turf responses. When readings are between 100 to 200 ppm, 0.25 to 0.33 lbs N/1000ft2 can be considered. If readings are less than 100 ppm, then 0.33 to 0.50 lbs N/1000ft2 can be considered, provided that N is applied before the onset of winter.

REFERENCE
Guillard, Karl and Morris, Thomas. The Verdure Sap Nitrate Test To Guide Fall N Fertilization of Turf Sod. Sod Nutrient Management Technical Guide TG-0265-R1, June 2013

REV 0, 6 JULY 2015

Rapid In-Field Determination of Nitrogen in Onions

Fresh root sap analysis with LAQUAtwin nitrate ion meter offers cost-effective, rapid and easy solution to determine nitrogen status in onion plants. The nitrate-nitrogen (NO_3-N) concentrations in onion vary at different growth stages. The acceptable root sap NO_3-N concentration range for 0.5 to 1.5-inch onion bulbs is 350 to 500 ppm.

Introduction

Nitrogen is a nutrient taken up by plants in the form of ammonium and nitrate ions for their green leafy growth. When ammonium fertilizers are applied to plants, the ammonium is converted to nitrate by nitrification process. Also, organic matter broken down in soil is transformed into ammonium first and then eventually into nitrate. These circumstances result in more nitrate in soils. Thus nitrogen tests measure nitrate rather than ammonium.

Plant tissue such as leaf and petiole contain high levels of nitrate, which has been shown over many years to be a good indication of the nitrogen status of the plant. Testing laboratories analysing for nitrogen content of dry plant tissue usually require ample time for collecting, transporting, drying, grinding and analysis. They deliver results after several days. With modern technology, quick tests for determining the nitrogen content in plant tissue like handheld nitrate meters with ion selective electrode, chlorophyll meter, and nitrate test strips have been developed.

As a general rule for nitrate testing, twenty petioles of most recently fully expanded mature leaves from different plants in a field are required for a representative sample. However, with onions, roots are used to determine nitrate levels.[1]

The LAQUAtwin nitrate ion meter provides the easiest way to measure nitrate concentration in fresh plant sap. The sensor requires only few drops of sap, which can be quickly extracted using a garlic press. The meter analyses the sap in just few seconds and displays reading expressed as either nitrate (NO_3) or nitrate-nitrogen (NO_3-N) ppm units. Results can be obtained immediately in the field with much less effort and relatively low cost. These advantages over conventional laboratory testing are useful for onion growers in determining fertilization applications.

Method

Select mg/L or ppm NO_3-N in the LAQUAtwin nitrate ion meter set-up. Calibrate the meter according to manufacturer's instructions using the 150ppm and 2000ppm nitrate standards included in the kit. The readings of 150ppm and 2000ppm nitrate standards will be calibrated as 34 ppm and 450 ppm NO_3-N, respectively.

Sample Collection And Preparation

1. Collect root samples from 20-30 representative onion plants in the field. Use a small spade or other lifting tool to remove the plants.
2. Cut the roots from the bulbs and wash with distilled or deionized water to remove soil.
3. Blot the roots dry with a paper towel and mix them thoroughly.
4. Load a random sample of roots in a garlic press and squeeze the sap.
5. Place drops of sap onto the flat sensor until it is fully covered. Record the reading once it is stable.
6. After each use, rinse the sensor with distilled or deionized water and blot dry with soft tissue.

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LAQUAtwin B-743 Product Page

> **Onion roots display the greatest response to available nitrogen supply of any plant part. They are used in analysis because of the stable nitrate concentrations in the root xylem.**

7. Repeat the procedure two or three times with the remaining sample if possible. Calculate the average of the readings of the samples.

It is best not to take readings in areas of direct sunlight or high temperatures. Collect samples and bring them indoor for analysis. Allow the samples and standards to reach same temperature before proceeding with the analysis.

Refer to Technical Tip 2: LAQUAtwin Ion Sensor Maintenance Procedures for detailed information on conditioning, cleaning, and storing the nitrate ion sensor. The technical tip can be downloaded from the support section of our website www.horiba-laqua.com.

Results and Benefits

Onion roots display the greatest response to available nitrogen supply of any plant part.[2] They are used in analysis because of the stable nitrate concentrations in the root xylem. The LAQUAtwin nitrate ion meter has been successfully used in determining nitrate-nitrogen (NO_3-N) in onions and readings have been found correlated with lab results.[3]

When sampling, it is important to note the onion growth stage so you can determine the correct sufficiency guideline to apply with your analysis results. Sufficiency guidelines are generally expressed as nitrate-nitrogen (NO_3-N) values. The NO_3-N refers to the nitrogen portion of the nitrate molecule. The table below provides the general guidelines for acceptable root sap nitrate concentrations at various stages of onion plant growth.[4] Notice that the nitrate concentrations decline as the plant matures. For 0.5 to 1.5-inch onion bulbs, the acceptable root sap NO_3-N concentration range is 350 to 500 ppm.[1] You may use the table in interpreting the LAQUAtwin nitrate ion meter results. Record the initial analysis results and use them to compare future results.

Table 1: General Sufficiency Guidelines for Onion Root Sap

Onion Stage of Growth	Acceptable Onion Root Sap Concentration	
	NO_3^- (ppm)	NO_3-N (ppm)
Up to 5 leaves	3400-4300	768-972
5 to 7 leaves	2600-3400	588-768
Bulb Initiation	1300-2150	294-486
Bulb Bulking	850-1700	192-384

ppm is parts per million, equivalent to mg/L

References and Suggested Readings

1. Hartz, T., Jackson L., Schulbach, K., and Smith, R. Guide to Nitrogen Quick-Tests for Vegetables with the Cardy Nitrate Meter. Retrieved from https://www.cdfa.ca.gov/is/docs/Schulbach95.pdf
2. Sullivan, D.M., Shock, C.C., Horneck, D.A., Stevens, R.G., Pelter, G.Q. and Feibert, E.B.G. (2001). Nutrient Management for Onions in the Pacific Northwest. PNW 546. Retrieved from https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw546.pdf
3. McDonald, M.R., McKeown, A.W., Scott-Dupree, C.D., and Westerveld, S.M. Assessment of Chlorophyll and Nitrate Meters as Nitrogen Tests for Cabbage, Onions, and Carrots. HorTechnology, April-June 2004, pp 179-188. Retrieved from http://horttech.ashspublications.org/content/14/2/179.full.pdf+html
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5. Bevacqua, R. and Cardenas, T. (2002). Nitrogen Monitoring Techniques for Vegetable Crops. Circular 579. College of Agriculture and Home Economics New Mexico State University. Retrieved from http://aces.nmsu.edu/pubs/_circulars/CR579.pdf

Measurement of Potassium in Rice

Potassium is one of the essential plant nutrients supplied via fertilizer in most irrigated rice fields. Extracting sap from the lower stem of plant rice and analysing it with LAQUAtwin potassium meter provide indication of the current potassium status and help farmers adjust the fertilizer application.

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LAQUAtwin K-11 Product Page

Introduction

Potassium is a necessary nutrient for soil in which rice grain is grown, as it is critical in maximising yield.

In order to profitably produce rice, reliable information regarding the potassium content of the soil must be available to farmers. Thus, we can analyse the potassium content of the plant tissue in the roots of the rice grain.

To determine the potassium content, the Horiba LAQUAtwin K^+ ion meter can be used. This is an easy and quick method used to determine the potassium content of soil for the growth of rice crops.

Method

1. The above ground portion of the crop is separated from the root using shears.
2. The lower stem is washed of soil.
3. The stem is cut into 1 cm pieces.
4. The pieces of stem are frozen overnight
5. A frozen piece of stem is placed in a sap press to obtain the sap
6. A small sample of the sap is placed on the sensor of the LAQUAtwin K^+ ion meter and the potassium content is measured after one minute.
7. To repeat sampling, wash the sensor with tap water and pat dry with a paper tissue.

Results and Benefits

The use of the Horiba LAQUAtwin K^+ ion meter to measure the potassium content of soil around rice crops will improve farmers' knowledge of the potassium accumulation. Accordingly, farmers can fertilise their crops with optimal amounts of potassium.

The LAQUAtwin K^+ ion meter is small and compact, and convenient to carry for easy on-site testing. Its easy-to-use interface is simple for anyone to use the LAQUAtwin K^+ ion meter.

Average tissue K levels for rice plant parts at growth stages for K treatments, 2004.

Growth Stage	Plant Part	Tissue K %		
		0 lbs K/a	50 lbs K/a	200 lbs K/a
First tiller	Whole	2.53	2.99	2.62
Internode elongation	Whole	2.19	2.27	2.82
Internode elongation	Flag leaf	1.85	2.34	2.37
Internode elongation	Lowest leaf	1.62	1.99	2.24
Internode elongation	Stem	2.77	2.88	3.20
10% Heading	Whole	1.50	1.71	1.74
10% Heading	Flag leaf	1.60	1.56	1.73
10% Heading	Lowest leaf	1.45	1.39	1.37
10% Heading	Stem	1.47	1.28	1.49
10% Heading	Head	0.92	0.91	0.86

Dry matter and K uptake for K treatments at three rice growth stages, 2004

Growth stage	Pre-plant K treatment (lbs K/a)			Pre-plant K treatment (lbs K/a)		
	0	50	200	0	50	200
	...Dry matter (lbs/a)...			...K uptake (lbs K/a)...		
First tiller	131	154	220	3.5	4.5	5.7
Inter-node elongation	1770	2070	1853	33.1	44.7	52.8
100% heading	6734	7055	7660	101	120	131

David Dunn, Gene Stevens "Plant Mapping Potassium in Rice Tissue: What Part to Sample When?: Second Year (2004) Progress report" University of Missouri-Delta Center

Measurement of pH in Plant Tissue

An optimal pH value of 6.4 in plant tissue will encourage healthy growth and prevent insects and diseases attacking the plant. To measure pH, squeeze the sap of mature leaves with garlic press and place the sap onto the sensor of LAQUAtwin pH meter.

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LAQUAtwin pH Meters Product Page

Introduction

It is often necessary to measure the pH of plant tissue to determine plant health. At pH values above 6.4 plants can be prone to insect attacks and at pH values below 6.4 plants can be prone to specific diseases. Thus an optimal pH of 6.4 is desired. Whilst laboratory soil and tissue tests are beneficial tools, they often do not yield results for days or weeks. We can thus use an alternate method of diagnosing plant health using the LAQUAtwin pH meter.

The LAQUAtwin pH meter is used to determine the pH of plant tissue. This is an easy and quick method used to ensure that plant tissue is at the optimum pH.

Method

To measure, take a few leaves, roll them into a tight ball and squeeze out a few drops of sap using a garlic press. Be sure to use a good quality stainless steel garlic press.

Generally, the mature leaves of the plant give the most accurate picture of the plant's health.

The plant tissue can be measured using the LAQUAtwin pH meter. The plant tissue has sufficient moisture and can thus be placed on the sensor of the pH meter and measured. If the pH value is more than 0.5 away from the optimal 6.4 value, we can adjust as follows:

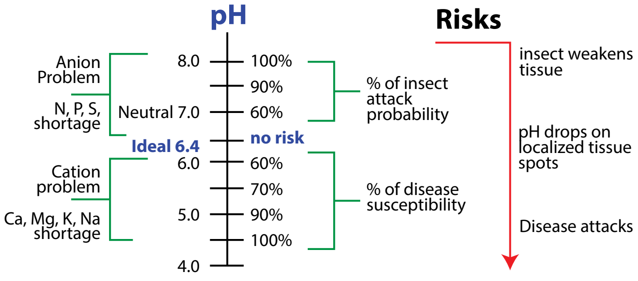
If the pH is >0.5 higher than 6.4: add small amount of phosphate fertilizer
If the pH is >0.5 lower than 6.4: add small amount of calcium/potassium fertilizer

After a week, repeat the test; ensure the pH of the plant tissue is close to pH 6.4 for optimal plant health.

Results and Benefits

The use of the Horiba LAQUAtwin pH meter to ensure an optimal pH of 6.4 in plant tissue will encourage healthy plant growth and prevent insects and diseases attacking the plant.

The LAQUAtwin pH meter is small and compact; convenient to carry around in your pocket for easy on-site testing. Its easy-to-use interface is simple for anyone to use the LAQUAtwin pH meter.



Potassium Determination in Plant Tissue

Comparison of LAQUAtwin Potassium Ion Meter and ICP Spectrometry

Trials revealed close significant correlation (r values were 0.80 and 0.93 for first trial and second trial respectively) between the LAQUAtwin Potassium Ion meter readings and ICP results obtained from plant's fresh petiole sap and dried tissue respectively. This suggested that LAQUAtwin Potassium Ion meter could be an appealing field method substitute for rapid determination of potassium concentration in plant.

Introduction

Plant tissue analysis has been used for evaluating the nutritional status of vegetable crops. The conventional laboratory method for plant tissue analysis is Inductively Coupled Plasma (ICP) spectrometry, which requires a dried plant tissue to be subjected to either wet digestion or dry ashing prior to analysis. Among the recent techniques for nitrate-nitrogen (NO_3-N) and potassium (K) management in vegetable crops has been the use of petiole sap analysis to determine supplemental fertilizer needs.

The LAQUAtwin Potassium Ion meter was used to measure K concentration in fresh petiole sap of pak choi (Brassica rapa, Chinensis group) plants, which were grown, applied with K and other nutrients, and harvested at University of Hawaii's Magoon Research facility. The results were compared to K concentration in dried tissue of the same plant analysed by wet digestion and ICP.

The pocket-sized LAQUAtwin Potassium Ion meter is ideal for on-site testing as it provides quick result with just a few drops of sample that doesn't require tedious preparation. It eliminates the need to transport samples to a laboratory for costly and time-consuming ICP spectrometry analysis.

Method

Sample Collection And Preparation

For LAQUAtwin Potassium Ion meter analysis, plant's petioles were collected immediately after harvest at 5 weeks after emergence and fresh weights were recorded. Petioles were pressed in a garlic press to extract sap. One (1) ml of sap was diluted with deionized water to a volume of 5ml. After calibrating the LAQUAtwin Potassium Ion meter according to manufacturer's instructions, few drops of the diluted sap were placed into the sensor of LAQUAtwin Potassium Ion meter to determine the potassium concentration.

For ICP spectrometry analysis, plants were placed in a conventional oven at 70°C and were dried for 72hrs. The dried weights were recorded. The dried samples were submitted to a laboratory for ICP spectrometry analysis to determine the potassium concentration.

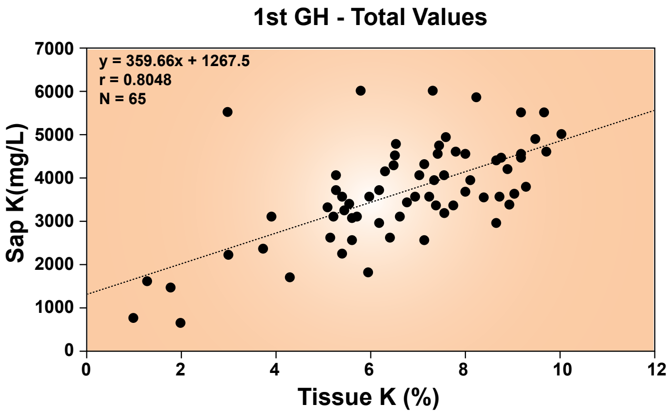


Figure 1: Relationship between K concentrations in fresh petiole sap and dried tissue of pak choi plant measured by LAQUAtwin Potassium Ion meter and ICP Spectrometry respectively for 1st greenhouse trial (n= 65)

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> **With these results, it was concluded that the LAQUAtwin Potassium Ion meter, which is easy to use and less expensive than standard laboratory analysis, is a valuable tool for onsite monitoring of plant's K status**

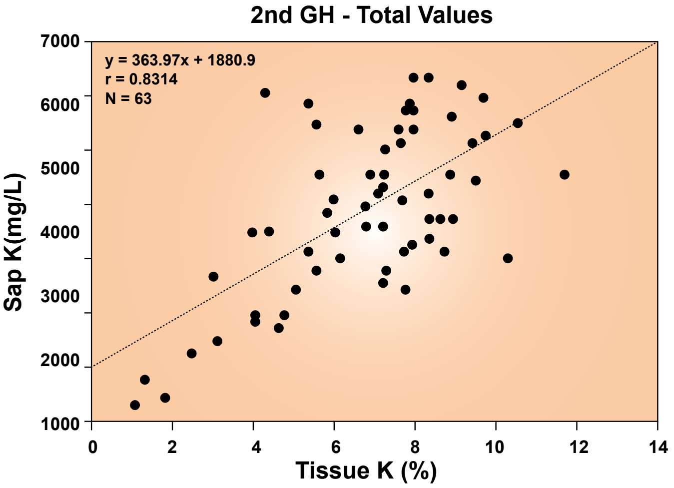

Figure 2: Relationship between K concentrations in fresh petiole sap and dried tissue of pak choi plant measured by LAQUAtwin Potassium Ion meter and ICP Spectrometry respectively for 2nd greenhouse trial (n= 63)

Results and Benefits

The K concentrations increased linearly in both the sap and dried tissue with increased amount of K applied (see figures 1 & 2) and the relationships were highly significant (P<0.0001). The correlation coefficient (r) was stronger between the LAQUAtwin Potassium Ion meter and ICP spectrometry results when totals of the replicates were used for correlation analysis – r values were 0.80 and 0.93 for first trial and second trial respectively. With these results, it was concluded that the LAQUAtwin Potassium Ion meter, which is easy to use and less expensive than standard laboratory analysis, is a valuable tool for onsite monitoring of plant's K status. It was also concluded that 4500-5000 mg K/L for fresh petiole sap and 7.5% tissue are critical levels for K concentration in pak choi plant.

Petiole Potassium Sufficiency Levels

(Source: University of Florida)

Crop	Growth Stage	K (ppm)
Tomato (field)	First Buds	3500-4000
	First Open Flowers	3500-4000
	First 1-inch Diameter	3000-3500
	First 2-inch Diameter	3000-3500
	First Harvest	2500-3000
	Second Harvest	2000-2500
Tomato (Greenhouse)	Transplant to second fruit cluster	4500-5000
	Second cluster to fifth fruit cluster	4000-5000
	Harvest Season (Dec.-June)	3500-4000
Bell Pepper	First Flower Buds	3200-3500
	First Open Flowers	3000-3200
	Fruits Half-Growth	3000-3200
	First Harvest	2400-3000
	Second Harvest	2000-2400
Eggplant	First Fruit (2-inches long)	4500-5000
	First Harvest	4000-4500
	Mid Harvest	3500-4000
Potatoes	Plants 8-inches Tall	4500-5000
	First Open Flowers	4000-5000
	50% of Flowers Open	4000-4500
	100% of Flowers Open	3500-4000
	Tops Falling Over	2500-3000

SUPPLEMENTARY INFORMATION

- Dilution – Undiluted sap can be analysed directly. However, sap for some crops has to be diluted to keep the determinations within the range of the calibrated standard curve. In another study conducted with LAQUAtwin Potassium Ion meter, it was found that sap diluted with water or 0.075M aluminum sulfate solution resulted in higher K recovery than undiluted one (Rosen et al). For testing sap diluted with 0.075M aluminum sulfate, 150ppm and 2000ppm K standard solutions with aluminum sulfate were prepared for calibration.
- Sap K Concentration - To determine K concentration of the undiluted sap, the meter reading obtained for the diluted sap should be multiplied by the dilution factor (final volume divided by original volume), which is '5' in the method described above. Alternatively, set the meter coefficient to 5.00 (default value=1.00). This meter feature eliminates manual computation for diluted or even concentrated sample by using a coefficient that can be set from 0.01-9.90. Refer to the Multiplying Compensation Setting of the meter's instruction manual.

References and suggested readings

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REV 0, 18 AUGUST 2015

Measurement of Potassium in Soil

In laboratories, potassium in soil is extracted with 1M ammonium acetate and analyzed with Atomic Absorption (AA) or Inductivity Coupled Plasma-Optical Emission Spectrometry (ICP-OES). LAQUAtwin potassium ion meter showed values higher than those of ICP-OES. However, with 0.01M ammonium acetate extraction, good correlation (r=0.981, r2=0.962) was obtained between ICP-OES and LAQUAtwin potassium ion meter.

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Introduction

Typically, Atomic Absorption (AA) or Inductivity Coupled Plasma-Optical Emission Spectrometry (ICP-OES) is used to measure potassium ion, by first extracting the potassium ion from sample soils by 1 mol/L ammonium acetate (CH_3COONH_4). These are the methods performed in laboratories.

A simpler method for a rapid measurement of potassium ion in soil uses the LAQUAtwin potassium ion meter B-731. The extraction method is the same as the lab method. The following procedure explains how you can measure K^+ with good correlation to analytical lab tests.

Method

1. Put 1g each of air-dried soils (four samples) in 100mL glass beakers, two beakers per soil sample.
2. Prepare two kinds of extraction per soil sample, one by adding 20 ml of 1mol/L CH_3COONH_4 to one beaker, and 20ml of 0.01mol/L CH_3COONH_4 to another beaker.
3. Shake the beakers around 1 hour to extract K^+ from the soil using a bench top shaker.
4. Calibrate LAQUAtwin B-731 with 150mg/L and 2000mg/L K^+ standard solutions included in the product.
5. Measure potassium ion concentration of the filtrated solution with calibrated B-731 and with ICP-OES (e.g. HORIBA Jobin Yvon. Model ULTIMA2).
6. Perform this measurement with 4 different samples.

Results and Benefits

The Laqua Twin B-731 allows for a simple on site determination of potassium which provides accuracy close to laboratory techniques.

[1]Table 1 shows the results from ICP-OES and LAQUAtwin K^+ extracted with 1 mol/L and 0.01 mol/L CH_3COONH_4.

*Extraction efficiencies will vary amongst soil samples.

Table [1]: K^+ concentrations measured by ICP-OES and LAQUAtwin exctracted with 1 mol/L CH_3COONH_4 and 0.01 mol/L CH_3COONH_4.

(Unit : mg/L)

Kind of soil	Extracted by the use of 1 mol/L CH_3COONH_4		Extracted by the use of 0.01 mol/L CH_3COONH_4	
	ICP-OES	LAQUAtwin K^+	ICP-OES	LAQUAtwin K^+
For vegetables (in house)	35	120	27	25
For Chinese cabbage (field)	16	76	14	14
For turnip leaf (Komatsuna)(field)	25	130	18	19
For potherb mustard (field)	21	93	17	16

Based on table 1, higher value against ICP-OES is detected by LAQUAtwin K^+ with 1 mol/L CH_3COONH_4 extraction, due to strong interference by NH+ of CH_3COONH_4. However, with 0.01 mol/L CH_3COONH_4 extraction, although the extraction efficiency is reduced by approximately 80%* (Figure 1), very good correlation (R=0.981, R2=0.962) is obtained between ICP-OES and LAQUAtwin (Figure 2).

Figure 1 shows the potassium extraction efficiency measured with ICP-OES. Setting 1 mol/L CH_3COONH_4 extraction as 100%, efficiency trend is plotted depending on different CH_3COONH_4 concentration.

Figure 2 shows the correlation between ICP-OES and LAQUAtwin K^+ measurements with 0.01 mol/L CH_3COONH_4 extraction.

Fig. 1 : Variation of extraction efficiency with CH_3COONH_4 concentration.

*Extraction efficiencies will vary amongst soil samples.

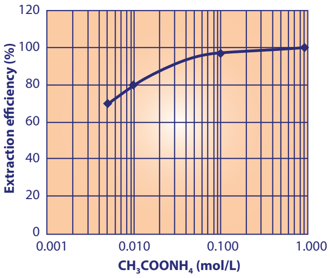
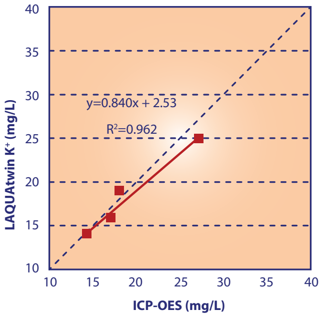


Fig. 2 : Relation between measured values of K^+ (mol/L) by ICP-OES and by LAQUAtwin.



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[1] Internal study by HORIBA labs, 2013

Measurement of Calcium in Soil

Calcium is one of the essential nutrients taken up by plants from soil for cell wall development. To measure calcium concentration in soil, extraction with 1M ammonium acetate and filtration should be performed prior to placing the filtrate onto the flat sensor of LAQUAtwin calcium ion meter.

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LAQUAtwin B-751
Product Page

Introduction

All plants need calcium rich soil to grow. The calcium is used by the plant in developing the plant cell walls and membranes. Furthermore, it is a non-leaching mineral (it will stay in the soil) and will improve water penetrability and reduce soil salinity. It is thus helpful to determine the amount of calcium contained in soil. Generally, Atomic Absorption Instruments (AA) or Inductivity Coupled Plasma-Optical Emission Spectrometry Instruments (ICP-OES) are used to measure the amount of calcium ions present in soil. An easier method involves extracting the calcium ion from sample soils with 1 mol/L ammonium acetate (CH_3COONH_4), and then by using the handy and affordable LAQUAtwin calcium ion meter B-751.

The LAQUAtwin Ca^{2+} meter is used as a quick check to determine the Calcium content of soil.

Method

1. Dry the soil for about a week, and sift it using a 2mm diameter net sieve.
2. Place 1g of test soil in 100mL glass beaker and add the 20 mL of 1mol/L CH_3COONH_4 to the beakers.
3. Shake the beakers (amplitude 40m/min, speed 250 rpm) for 1 hour to extract Ca^{2+} from the soil using a laboratory shaker (Recipro Shaker SR-IIW made by Taiyo Kagaku Kogyo Company of Japan).
4. Filter the liquid through JIS No.6 filter paper.
5. Calibrate LAQUAtwin B-751 with 150mg/L and 2000mg/L Ca^{2+} standard solutions which contain the same concentration of CH_3COONH_4 as in the filtered samples. (Do not use the standard solutions packed with the instrument)
6. A small sample of the filtered solution is placed on the sensor of the LAQUAtwin Ca^{2+} and measured. To repeat sampling, wash with tap water and pat dry with a paper tissue.

Results and Benefits

The use of accurate Calcium ion testing in controlling the calcium content of soil ensures that the plants which are grown in the soil are given the necessary minerals and can easily absorb water. The table below shows that the results given by the LAQUAtwin Ca^{2+} pocket meter are comparable to those from Inductivity Coupled Plasma-Optical Emission Spectrometry Instruments (ICP-OES).

Soil types	Measured Ca2+ concentration (mg/L)		CaO converted values (mg/100g of air-dried soil)	
	ICP-OES	LAQUAtwin B-751	ICP-OES	LAQUAtwin B-751
For bell pepper	130	140	360	390
For tomato	110	120	310	340
For spinach	82	88	230	240
For lettuce	88	97	240	270
For kale	59	68	160	190

The LAQUAtwin Ca^{2+} pocket meter is small and compact; convenient to carry around in your pocket for quick on-site testing. Its easy-to-use interface is simple for anyone to use the LAQUATwin Ca^{2+} pocket meter.

Soil Salinity and Impact on Yield of Sugar Cane

Soil salinity adversely affects the growth of sugar cane crops. To help optimize sugar cane yield, check the sodium content in soil by mixing it with water in 1:5 ratio and measuring the resulting solution with LAQUAtwin sodium ion meter.

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LAQUAtwin Na-11 Product Page

Introduction

Sugar cane is a major source of sugar used in the food industry today. The growth of sugar cane crops is impacted adversely by soil salinity. Thus, it is necessary to determine the sodium content of the soil in areas where sugar cane crops are being grown.

Sodium is a mineral constantly present in soil, but an excess of it can cause the yield of sugar cane to dwindle. Thus, it is beneficial to measure the salinity of soil on which sugar cane crops are grown.

To determine the sodium content of soil, the Horiba LAQUAtwin Na^+ meter can be used. This is an easy and quick method used to consider the sodium content of canned products.

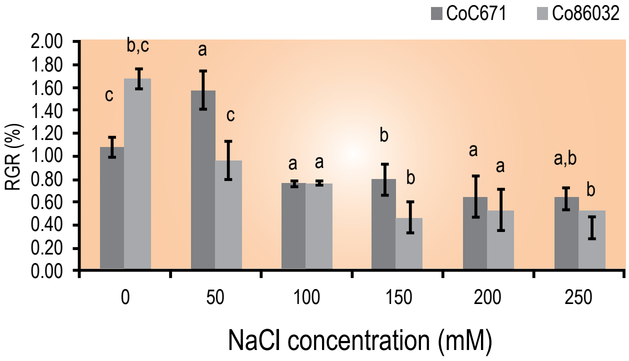
Method

1. Sodium is water soluble, thus 1g soil samples can be mixed with 4g of warm water and shaken thoroughly.
2. After 5 minutes, the resultant mixture can be strained to produce a saltwater sample from the soil.
3. A small sample can be extracted via pipette
4. This is placed on the sensor of the LAQUAtwin Na^+ meter and the sodium content is measured after one minute.
5. To repeat sampling, wash the sensor with tap water and pat dry with a paper tissue.

Results and Benefits

The use of the Horiba LAQUAtwin Na^+ meter to measure the sodium content of soil will improve farmers' knowledge of the best land to grow sugarcane crops and hence enable optimized yield.

The LAQUAtwin Na^+ meter is small and compact; convenient to carry around in your pocket for easy on-site testing. Its easy-to-use interface is simple for anyone to use the LAQUAtwin Na meter.



Effects of NaCl stress on the physiological and biochemical responses in sugarcane; relative growth rate

Avinash Karpe, Ashok A. Nikam, Krunal P. Chimote, Sachin B. Kalwade, Prashant G. Kawar, Harinath Babu, Rachayya M. Devarumath, and Penna Suprasanna "Differential responses to salinity stress of two varieties (CoC 671 and Co 86032) of sugarcane (Saccharum Officinarum L.)" African Journal of Biotechnology Vol. 11(37), pp. 9028-9035, 8 May, 2012

Conductivity and Elephant's Foot Testing

Elephant's foot is a physiological disorder in sweet pepper (Capsicum annuum L.), where the base of the plant's stem becomes swollen below the cotyledon level and wounds develop at the base of the stem's epidermis because of salt accumulation. LAQUAtwin conductivity meter can be used to measure conductivity of soil and help farmers choose the best land to grow sweet pepper crops.

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LAQUAtwin Conductivity Meters Product Page

Photo Credit: Elio Jovicich, University of Florida.

Introduction

A physiological disorder in greenhouse hydroponic sweet pepper (Capsicum annuum L.), where the base of the plant's stem becomes swollen below the cotyledon level and wounds develop at the base of the stem's epidermis has been named "Elephant's Foot".

Sodium is a mineral constantly present in soil, but an excess of it concentrated at the base of the plant stem has been shown to have a correlation with Elephant's Foot in plants. It is necessary to analyse the conductivity of soil in which hydroponic sweet pepper is grown to consider the extent to which the stem of the plant has accumulated salt.

To determine the conductivity of the soil, the Horiba LAQUAtwin Conductivity meter can be used. This is an easy and quick method used to measure the conductivity of soil.

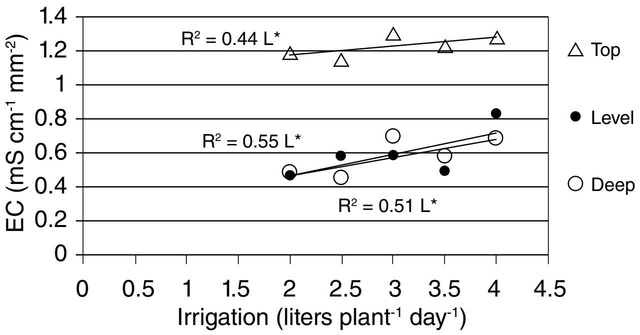
Method

1. A small 5g soil sample is watered down with 20 ml of water.
2. The water and soil mixture is shaken, thus 'washing' the soil.
3. A small sample can be extracted via pipette
4. This is placed on the sensor of the LAQUAtwin Conductivity meter and the conductivity is measured after one minute.
5. To repeat sampling, wash the sensor with tap water and pat dry with a paper tissue.

Results and Benefits

The use of the Horiba LAQUAtwin Conductivity meter to measure the conductivity of soil will improve farmers' knowledge of the sodium accumulation and hence choose the best land to grow sweet pepper crops and avoid Elephant's Foot disorder.

The LAQUAtwin Conductivity meter is small and compact, and convenient to carry for easy on-site testing. Its easy-to-use interface is simple for anyone to use the LAQUAtwin hand held Conductivity meter.



Salt accumulation on the stem base (measured by EC) and volumes of nutrient solution per plant per day at the three transplant depths: "Top": plants transplanted to half of the container height, "Level": plants transplanted to the cotyledons level, and "Deep": plants transplanted to the 2nd node. Electrical conductivity values for each transplant depth and irrigation volume average four soilless media type (coconut coir, peat mix, perlite, and pine bark). L*, linear polynomial effect at 5% level of significance.

Jovicich, E. and Cantliffe, D.J. 2001. "Transplant Depth, Irrigation, And Soilless Media Effect On 'Elephant's Foot' Plant Disorder In A Hydroponic Greenhouse Sweet Pepper Crop". Acta Hort. (ISHS) 559:515-520

Soil Salinity Measurement in Almond Orchard

Crops have different levels of tolerance to salinity. Testing soil salinity is the best way to check soil condition in the orchard before salt damage occurs. The $EC_{1:5}$ test is used to estimate soil salinity (EC_e). The soil salinity threshold value for almond is 1.5 mS/cm.

Introduction

Soils with high concentration of salts can induce salinity stress and restrict the growth of salt-sensitive plants. Among the factors that can cause salinity stress (See Figure 1), toxicity of ions, usually sodium (Na), chloride (Cl), and boron (B), is the most common that result in leaf tissue damage. In the orchard, the most typical salt damage observed is "leaf-tip burn" (See Figure 2) and the best way to prevent it is by monitoring the soil salinity. The advantage of soil salinity monitoring is remedial action can be performed on soil before symptoms on leaf tissue appear. Annual testing of soil samples from selected locations in the orchard should be part of every growers' management program.

Figure 1: Components of Salinity Stress
Source: Rosenzweig, B. (2016). Soil Salinity Management.

Figure 2: Leaf-tip Burn in Almond Orchard
Source: Rosenzweig, B. (2016). Soil Salinity Management.

Electrical conductivity (EC) is the method used to measure soil salinity, which is influenced by the concentration and composition of dissolved salts. Salts increase the ability of a solution to conduct an electrical current, so a high EC value indicates high salinity. The LAQUAtwin EC 11, 22 and 33 conductivity pocket meters measure electrical conductivity in drops or micro-volume samples and display reading in just few seconds. The replaceable sensor is made of two flat titanium metals coated with platinum black that resist corrosion. The meters are programmed with standard recognition function for automatic calibration and automatic temperature compensation (ATC) function for accurate measurement.

Based on the Australian Soil Fertility Manual published by Commonwealth Scientific and Industrial Research Organization (CSIRO), sodium chloride (NaCl) is the major offender in the development of saline soils in Australia. The LAQUAtwin Salt 11 pocket meter can be used to measure NaCl concentration in soils. The meter measures the conductivity of the sample and converts it to salinity reading in either parts per thousand (g/L) or percentage (%) unit.

Method

A. Soil Sample Collection

Select representative sites in the orchard for routine sampling.

Drip Irrigated Orchards

Collect double handful of soil from two locations—20cm from the dripper and on the edge of the wetted area ~ approx. 60cm from the dripper. Soil should be drawn from two or three depths in the root zone—every 30cm down to 1m. Place soil sample from each depth/location in a bag for analysis.

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LAQUAtwin Conductivity Meters Product Page

LAQUAtwin Salinity Meters Product Page

Sprinkler Irrigated Orchards

The sampling is similar to that of drip irrigated orchards, except three locations are sampled—2meters of a sprinkler, 1/3 distance between sprinklers on a diagonal, and middle of the sprinkler pattern. If the irrigation system has a designed and measured distribution uniformity of ≥ 80% or salinity results from 2 or more years indicate there is no variation by location, then the number of locations could be decreased.

B. Soil Salinity Measurement

1. Allow the soil sample to dry by leaving the sample bag or container open for at least a day. It can be oven-dried on a tray in a cool oven.
2. Crush dried sample with a mortar and pestle, rolling pin or hammer so there are no large aggregates (clods of soil 2mm or larger). Remove any foreign matter, plant matter, and stones from the sample.
3. Add 1 part soil for every 5 parts distilled or deionized (DI) water. For example, mix 50g soil and 250ml DI water in a container.
4. Shake the container for 3 minutes to dissolve the salts. For clay loams and clay soils, more shaking (for 1 minute every 3 minutes, repeat 3 times) will dissolve more salts and increase the accuracy of the test.
5. While allowing the solution to settle for a minute before testing, calibrate the LAQUAtwin EC 11, 22 or 33 pocket meter with 1413µS/cm and 12.88mS/cm conductivity standards included in the kit. Rinse the conductivity sensor with DI water and blot dry with soft tissue between standards and after calibration.
6. Immerse the conductivity sensor in the solution (without touching the soil in the bottom of the container) and record the **$EC_{1:5}$** reading once it has stabilized. Alternatively, place drops of solution onto the sensor using the pipette included in the kit.
7. Rinse the conductivity sensor with DI water and blot dry with soft tissue.
8. Convert the **$EC_{1:5}$** reading to actual soil salinity (**EC_e**) by multiplying the value by the conversion factor based on the texture of the soil sample (Refer to Table 1 below).

Table 1: $EC_{1:5}$ to EC_e Conversion Factors

Soil Texture	Multiplication Factor
Sands	17
Sandy Loams	13.8
Loams	9.5
Clay Loams & Light Clays	8.6
Medium & Heavy Clays	7

Note: These factors are calibrated for southern NSW (AU) soils
Source: Gibbs, S. (2000).Salinity Notes: How to Texture Soils & Test for Salinity.

Results and Benefits

Monitoring soil salinity can help identify the current soil conditions, predict problems, and establish baseline for management decisions. Crops have different levels of tolerance to salinity. The soil salinity threshold value for almond is 1.5 mS/cm. Table 2 below shows the salt tolerance data for selected crops.

Soil salinity derived from electrical conductivity (EC) measurements in the field or laboratory are often reported with subscript abbreviations to indicate the origin of the sample tested and the method used to determine the salinity. Common abbreviations and their descriptions are explained below.

- **$EC_{1:5}$** – test used to estimate soil salinity (**EC_e**). It is determined by mixing 1 part soil with 5 parts DI water. After mixing the sample and allowing the sediments to settle, the electrical conductivity of the solution is tested.
- **EC_e** – the estimated amount of salt in the soil. **EC_e** = **$EC_{1:5}$** x conversion factor (based on soil texture)
- **EC_{se}** – the electrical conductivity of a saturated soil extract, which should be conducted by a National Association of Testing Authorities, Australia (NATA) accredited laboratory. **$EC_{se} = EC_e$**

A soil salinity test gives an indication on the soil conditions around the plant roots, taking into account the influence of soil texture. Texture is an estimate of the relative amounts of sand, silt, and clay particles in a soil. It affects fertility, water holding capacity, internal drainage, irrigation scheduling, and soil workability for tillage. Soil texture usually changes with depth. To guide you identify soil texture, refer to *Salinity Notes: How to Texture Soils & Test for Salinity by Simon Gibbs.*

Table 2: Salt Tolerance Data for Selected Crops

Crop	Soil Salinity EC_{se} (mS/cm)*			
	0% Yield Loss	10% Yield Loss	25% Yield Loss	50% Yield Loss
Almond	1.5	2.0	2.8	4.1
Avocado	1.3	1.8	2.5	3.7
Citrus	1.7	2.3	3.3	4.8
Date Palm	4.0	6.8	11.0	18.0
Lucerne	2.0	3.4	5.4	8.8
Olive	2.7	3.8	5.5	8.4
Onion	1.2	1.8	2.8	4.3
Pistachio	4.0	4.5	5.0	6.0
Pomefruit	1.7	2.3	3.3	4.8
Potato	1.7	2.5	3.8	5.9
Stonefruit	1.7	2.2	2.9	4.1
Tomato	2.5	3.5	5.0	7.6
Vine	1.5	2.5	4.1	6.7
Beans	1.0	1.5	2.3	3.6
Eggplant	1.1	2.5	4.7	8.3
Cucumber	2.5	3.3	4.4	6.3
Capsicum	1.5	2.2	3.3	5.0

*Equivalent to dS/m
Source: Irrigation Management Training. Measuring Soil Salinity.

References and Suggested Readings

1. Rosenzweig, B. (2016). Soil Salinity Management. Available at https://growing.australianalmonds.com.au/2016/02/28soil-salinity-management/ (Accessed 30 December 2016).
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4. Irrigation Management Training. Measuring Soil Salinity. Available at http://www.growingcapsicums.com.au/pdf/6_salinity/measuring_soil_salinity.pdf. (Accessed 23 January 2017)

Revision 1.0, 23 January 2017

Soil Nitrate Measurement for Determination of Plant-Available Nitrogen

Nitrate concentration in soil is a good indicator of available nitrogen to plants. The required soil nitrate-nitrogen (NO_3-N) for specific crops varies from crop to crop but in general, a concentration range of 10-50 mg/kg is desired.

Introduction

Soil testing has been used effectively over the years in determining the availability of nutrients for plants. Nitrogen is one of these essential nutrients, which is converted to amino acids and then utilized in producing necessary enzymes and structural parts of the plant.

The LAQUA twin Nitrate Ion meter can be used to measure NO_3-N concentration in soil samples. It is an easy-to- use pocket-sized meter that provides quick results for on-site testing, thus eliminating the need to transport samples to a laboratory for colorimetric or chromatography analysis performed by trained analyst.

Method

Sample Collection And Preparation

1. Collect dry soil samples and pass through a 2mm sieve.
2. Prepare soil extract by mixing soil and water or extractant in 1:5 ratio (e.g., 5g soil and 25mL water or extractant). Shake for 1 minute. Allow the sample to settle for 5 minutes or filter it using filter paper and funnel.

Calibration

Calibrate the LAQUAtwin Nitrate Ion meter using two NO_3-N calibration standards according to manufacturer's instructions. Make sure that the meter measurement unit is set to ppm NO_3-N.

Sample Measurement

1. Place some drops of unused water or extractant into the sensor.
2. Record the reading as the blank. Blank is only required once for each batch of samples.
3. Rinse the sensor with water and blot it dry with tissue.
4. Place some drops of clear liquid taken from the top layer of soil extract (or filtrate, if filtered sample).
5. Record the reading once stabilized.
6. After each sample, rinse the sensor with water and blot it dry with tissue.

Collect dry soil samples and pass through a 2mm sieve.

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LAQUAtwin B-742 Product Page

> **As temperature affects pH, it is important to use a pH electrode integrated with temperature sensor (3-in-1) for accurate pH measurement.**

Results and Benefits

To express the results in NO_3-N mg/kg in soil, use the formula: NO_3-N mg/kg in soil = (soil extract reading - method blank) ppm NO_3-N × 5. If a different ratio is used in soil extract, substitute ‘5’ with the appropriate ratio.

Nitrate-nitrogen (NO_3-N) measures the amount of available nitrogen in the soil that can be absorbed immediately by plants. The amount required in the soil for specific crops varies from crop to crop, but in general the levels should not fall below 10 mg/kg and should not exceed 50 mg/kg. However, nitrate varies with soil water and so levels can fluctuate widely depending on soil water movement.

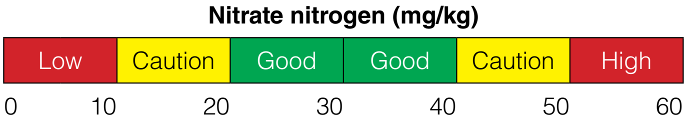

Figure 1: Guide to the interpretation of nitrate-nitrogen values for soils (Source: Soil health for vegetable production in Australia—Part 4)

To determine the amount of nitrogen fertilizer needed to meet crops’ demand, the NO_3-N concentration is being subtracted from the nitrogen requirement of the crop.

Supplementary Information

- **Soil** – Wet samples will need to be air dried by spreading thin layer of soil in a sheet of plastic under the sun. This is to eliminate the effect of the soil’s moisture content. Samples that have too much clay will need to be crushed.
- **Extractant** - Water or dilute salt solutions can be used to extract nitrate from most soils because essentially all the nitrate in soils with low anion exchange capacities is water soluble. The main disadvantage of water is its low ionic strength which can cause dispersion and result in cloudy filtrates. Extractants containing chloride cause problems if NO_3-N is measured by ion chromatography or ion selective electrode because chloride can interfere with analysis of NO_3-N by these methods. 0.04 M ammonium sulfate, $(NH_4)_2SO_4$ is the preferred extractant for nitrate selective electrode (Griffin et al., 1995). Other extractants include 0.025M $Al_2(SO_4)_3$, 1% $KAl(SO_4)_2$, 0.025M $Al_2(SO_4)_3$ – 0.025M Ag_2SO_4 – 0.005M H_3BO_3 (pH3), 0.01M $CuSO_4$, 0.2% or saturated $CaSO_4$, 0.01M sodium citrate and 0.05M K_2SO_4 (Thomas, 1986).
- **Nitrate standard** – Check the NO_3-N concentration indicated on the label of nitrate standard when calibrating NO_3-N (e.g., 150ppm NO_3- standard is 34ppm NO_3-N).
- **Measurement unit** – The nitrate meter can be set to ppm (equivalent to mg/L) NO_3- or NO_3-N. Refer to meter manual for the measurement unit setting. If the meter measurement unit is set to ppm NO_3-N and 150ppm NO_3- standard is placed into the sensor, 34ppm NO_3-N reading will be displayed during calibration.

Reference

1. Bagshaw, J., Moody, P., and Pattison T., (2010) Soil health for vegetable production in Australia—Part 4: Measuring soil health. The State of Queensland, Department of Employment, Economic Development and Innovation
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REV 0, 4 AUGUST 2015

Agriculture
Application Notes

Soil pH and Nutrient Availability

The desirable soil pH range for optimum plant growth varies among crops. Generally, soil pH 6.0-7.5 is acceptable for most plants as most nutrients become available in this pH range. Soil pH can be determined by mixing soil sample with water and then measuring the resulting aqueous solution.

Introduction

Soil pH is a measure of the acidity or alkalinity in soils. In the pH scale, pH 7.0 is neutral. Below 7.0 is acidic and above 7.0 is basic or alkaline. Soil pH affects nutrients available for plant growth. In highly acidic soil, aluminum and manganese can become more available and more toxic to plant while calcium, phosphorus, and magnesium are less available to the plant. In highly alkaline soil, phosphorus and most micronutrients become less available.

Soil pH	Plant Growth
> 8.3	Too alkaline for most plants
7.5	Iron availability becomes a problem on alkaline soils
7.2	6.8 to 7.2 – near neutral 6.0 to 7.5 – acceptable for most plants
7.0	
6.8	
6.0	
5.5	Reduced soil microbial activity
< 4.6	Too acid for most plants

(Source: Colorado State University – CMG Garden Notes #222)

When designing or planting new garden or landscape, it is helpful to check the soil pH as different plants thrive in different soil pH ranges. pH determination can give indication whether soil is suitable for the plants to be grown or it needs to be adjusted to produce optimum plant growth.

Soil pH can be measured easily and inexpensively at home or on-site using LAQUAtwin pH meters. There are three (3) LAQUAtwin pH meter models available, namely pH 11, 22, and 33. These pocket-sized compact meters allow two to five calibration points using either NIST or USA pH buffers. Among the above-mentioned models, the pH 33 meter has built-in temperature sensor that measures and displays temperature reading and automatic temperature compensation feature (ATC) that performs automatic calibration to the exact pH of the buffer at the measured temperature. Refer to the specifications of each meter model for more information.

Method

Calibrate the LAQUAtwin pH meter according to manufacturer's instructions using at least two pH buffers that bracket the expected sample pH.

Sample Preparation And Measurement

The method described below is based on US EPA Method 9045D. This is also applicable for measuring pH of waste samples, which may be solids, sludges, or non-aqueous liquids. If water is present, it must constitute less than 20% of the total volume of the sample.

1. Add 20ml of pure water to 20g sample in a beaker or container. Stir for 5 minutes then cover.
2. Let the soil suspension stand for about 1 hour. Alternatively, filter or centrifuge off the water phase.
3. Measure the pH of water phase. Record the pH value and the temperature.

To obtain accurate results, standard buffer solutions and samples should be measured at the same temperature. If the electrode is coated with oily material from a sample, clean it with detergent and warm water.

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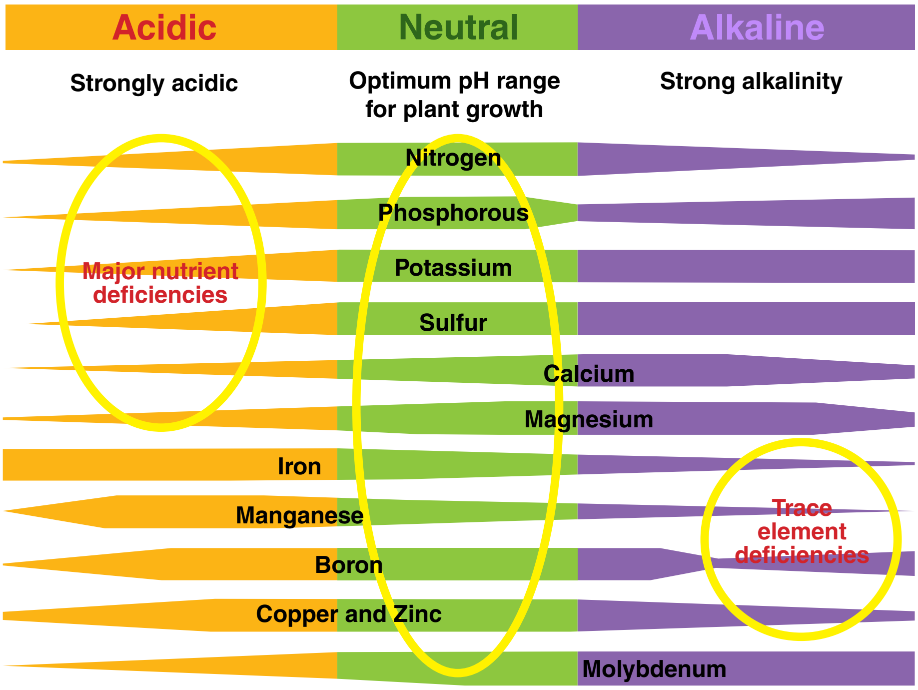
LAQUAtwin
pH Meters
Product Page

pH 4.0-6.0	pH 5.0-6.5	pH 6.0-7.5	pH 5.0-7.5	pH 6.0-8.0
Potato	Apple	Apricot	Banana	Avocado
	Blackberry	Cherry	Rhubarb	Asparagus
	Cranberry	Grapevine	Strawberry	Ginger
	Gooseberyy	Grapefruit	Rasberry	Leek
	Mango	Hazelnut	Carrot	Mint
	Melon	Hop	Cauliflower	Paprika
	Pineapple	Lemon	Sweet corn	Watercress
	Pomegranate	Lychee	Cucumber	
	Watermelon	Mulberry	Garlic	
	Basil	Nectarine	Lentil	
	Chicory	Peach	Parsley	
	Fennel	Plum	Pepper	
	Olive	Quince	Pumpkin	
	Peanut	Artichoke	Shallot	
	Sweet potato	Bean	Spearmint	
	Rice	Beetroot	Thyme	
	Rosemary	Broccoli	Tomato	
	Sage	Brussels sprouts	Turnip	
	Soybean	Cabbage		
		Calabrese		
		Celery		
		Chinese cabbage		
		Chives		
		Lettuce		
		Millet		
		Mushroom		
		Mustard		
		Onion		
		Pea		
		Peppermint		
		Radish		
		Spinach		

(Source: Gurumaganize.org)



Soil pH and Nutrient Availability
(Source: Bluedale - http://www.bluedale.com.au)

Results and Benefits

The desirable soil pH range for optimum plant growth varies among crops. Generally, soil pH 6.0-7.5 is acceptable for most plants as most nutrients become available in this pH range. Soil pH is important because it affects the availability of nutrients to plants. Nitrogen, phosphorus, and potassium are the primary nutrients needed in fairly large quantities. Calcium, magnesium, and sulfur are secondary nutrients required by the plant in lesser quantities. Zinc and manganese are micronutrients required by the plant in very small amounts. Most secondary and micronutrient deficiencies are easily corrected by keeping the soil at the optimum pH value.

Soil pH also affects activity of soil microorganisms. The population of bacteria that decompose organic matter declines and their activity is hindered in highly acidic soil, which results in accumulation of organic matter and the bound nutrients, particularly nitrogen.

Increasing Soil pH

Applying a material that contains some form of lime (calcium carbonate) like the ground agricultural limestone and wood ashes can increase the soil pH. The finer the limestone, the more rapid it becomes effective. Different soils will require a different amount of lime to adjust the soil pH. Wood ashes contain high amounts of potassium and calcium, and small amounts of phosphate, boron and other nutrients. Although not as effective as limestone, these can drastically increase the soil pH with repeated use.

Decreasing Soil pH

Aside from ammonium-based fertilizers and organic matter, aluminum sulfate and sulfur are common materials used for decreasing soil pH. Aluminum sulfate is preferred as it changes the soil pH as soon as it dissolves in the soil because of the aluminum. However, too much of this is toxic to plant. Sulfur takes some time to produce effect as it needs to be converted to sulfuric acid by soil bacteria.

References And Suggested Readings

1. US Environmental Protection Agency Method 9045D Soil and Waste pH, Revision 4, November 2004
2. Changing the pH of your Soil. Clemson University Cooperative Extension. www.clemenson.edu

Determination of Nutrient Concentrations in Soil Solution and Tomato Plant Sap

Fertigation management requires rapid and accurate methods to determine nutrient concentrations in soil solution and plant sap. Folegatti et al (2005) found that the concentrations of nitrate, potassium, and sodium ions in soil solution and tomato plant sap determined by LAQUAtwin ion pocket meters showed good correlations with those obtained in soil solution and in leaf dry matter, respectively, determined by standard methods in laboratory, and concluded that LAQUAtwin ion pocket meters are useful low-cost tools in fertigation management.

Introduction

Plants take nutrients from soil for their growth. Nutrient levels in soil and plant tissues give an indication of the nutrient requirements of crop. Folegatti et al (2005) developed a study to evaluate the performance of Cardy ion meters on the determination of nitrate (NO_3^-), potassium (K^+), and sodium (Na^+) ion concentrations in soil solution and tomato plant sap for fertigation management purposes. The sodium ion (Na^+) is not an important ion for tomato, but its concentration in soil solution and plant sap gives valuable information when using saline irrigation water.

Cardy ion meters were superseded by LAQUAtwin B-700 series ion pocket meters, which have replaceable sensors, upgraded software, and enhanced user interface. The LAQUAtwin B-722, B-731, and B-743 ion pocket meters measure sodium ion (Na^+), potassium ion (K^+), and nitrate ion (NO_3^-), respectively. Like Cardy ion meters, the LAQUAtwin B-700 series ion pocket meters require only few drops or micro-volume of sample and deliver results in just few seconds. These advantages allow users to analyze a large number of samples in a short period of time while in the field.

Method

Tomato was cultivated in a greenhouse in Piracicaba, SP, Brazil with different levels of nitrogen (N), potassium (K) and salinity in the irrigation water. Fertilizers and salts used were ammonium nitrate (NH_4NO_3), potassium chloride (KCl), calcium chloride ($CaCl_2$), and sodium chloride (NaCl), which were applied by drip fertigation. Soil solution samples were collected every 15 days (on average) beginning 24 hrs after irrigations by suction at the 15 cm depth with porous ceramic cups and the concentrations of nitrate (NO_3^-), potassium (K^+), and sodium (Na^+) ions were determined by Cardy ion meters. The results were compared with those determined in laboratory by standard methods—flame photometry for K^+ and Na^+ and steam-distillation for NO_3^- .

Fifty samples of young fully expanded leaves corresponding to the different treatments were also collected. The base of the petioles was squeezed using a garlic press and nutrients in sap were determined by Cardy ion meters. The leaves were oven-dried at 60°C for 48 hrs and the total N, K, and Na^+ were determined in laboratory by methodology proposed by Malavolta et al (1997). Concentrations of the nutrients in petiole sap were compared with those in leaves.

Cardy ion pocket meters were calibrated with two standard solutions before use and after every 10 samples. To prevent contamination by carry-over, sensors were washed with distilled water between samples.

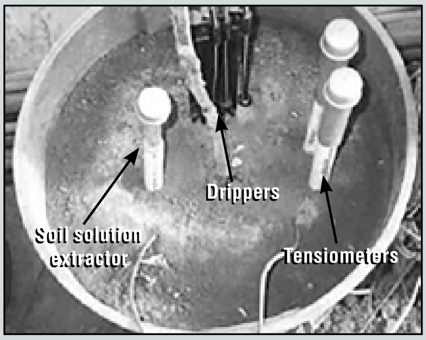


Figure 1A: Greenhouse experimental pot

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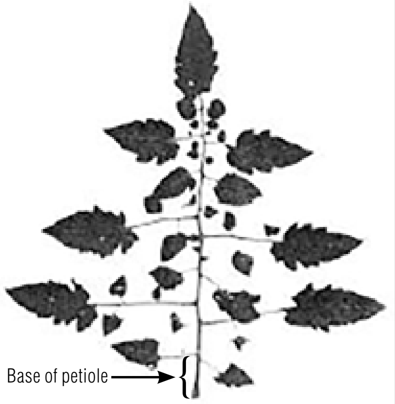

Figure 1B: Base of petiole used for sap nutrient determination

Results and Benefits

Concentrations of NO_3^-, K^+, and Na^+ in soil solution determined by Cardy ion meters and by standard methods in laboratory were found strongly correlated (Figure 2). The NO_3^- concentrations measured by Cardy ion meters were about 39% lower than those determined by distillation method, while the K^+ and Na^+ concentrations were 21% and 67% higher, respectively, than those determined by flame photometry. The coefficients of determination (r^2) were high for all ions and the relationships were significant at 1% (Table 1).

Concentrations of NO_3^-, K^+, and Na^+ in petiole sap determined by Cardy ion meters were reasonably well correlated with those determined in leaf dry matter and relationships were significant for all ions (Table 1). The values of r^2 for the concentrations in the petiole sap and in leaf dry matter were close to those observed by other studies. Comparisons of Na^+ measured in petiole sap and dry matter were not found in the available literature.

Discrepancies observed between the Cardy ion meters and standard method measurements were probably due to the influence of other ions present in soil solution and plant sap. Nevertheless, Folegatti et al (2005) concluded that the Cardy ion meters, now called LAQUAtwin ion pocket meters, which were found to give good correlations with the values obtained by standard methods, are suitable for determining nutrient concentrations in soil solution and petiole sap. 💧

Table 1 - Values of paired-t test for concentrations of NO_3^-, K^+ and Na^+ determined by CIM and by standard methods, in the soil solution and tomato petiole sap.

Statistic	NO_3^-	K^+	Na^+
		Soil solution	
t	-12.1**	12.3**	26.4**
		Petiole sap	
t	13.4** ξ	13.9**	14.0**

**Significant at 0.01.

ξNO_3^- in sap tested against total-N in leaf dry matter.

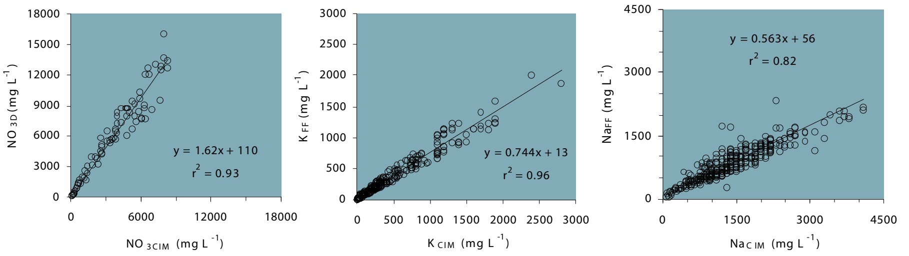

Figure 2 - Relationships between concentrations of nitrate, potassium and sodium in the soil solution measured by cardy-ion meters (CIM) and by standard methods. FF = flame fotometry; D = steam-distillation.

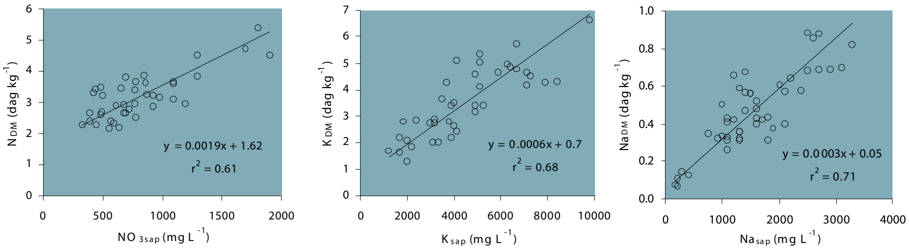

Figure 3 - Relationships between the concentrations of nitrate, potassium and sodium in petiole sap and total-N, potassium and sodium in the dry matter (DM) of tomato leaves, hybrid Facundo.

References and Suggested Readings

1. Folegatti, M.V., Blanco, F.F., Boaretto, R.M. and Boaretto, A.E. (2005) Calibration of cardy-ion meters to measure nutrient concentrations in soil solution and in plant sap. Sci. Agric. (Piracicaba, Braz.), v.62, n.1, pp 8-11.
2. Malavolta, E., Vitti, G.C.; Oliveira, S.A. Avaliação do estado nutricional das plantas: princípios e aplicações. 2.ed. Piracicaba: POTAFOS, 1997. 201p.

pH and Conductivity Measurements in Coconut Coir Substrate

Coconut coir testing involves extracting a sample solution with distilled water and measuring the pH and conductivity of the extract. The acceptable conductivity ranges for 1:2 (v/v) dilution and pour thru sampling methods are 0.26-0.75 mS/cm and 1.0-2.6 mS/cm, respectively. The ideal pH range is 5.4-6.2 for both methods.

Introduction

Coir is the fibrous material found between the hard, internal shell and the outer coat of the coconut. Ripe coconuts have thick, strong brown coir, which is typically used in upholstery padding, sacking and horticulture. Unripe coconuts have fine, white or light brown coir, which is used in producing household products such as mats, brushes, strings, ropes and fishing nets to name a few. To harvest coir traditionally, the fibrous husks are soaked in pits or in nets in either fresh water or sea water or both to swell and soften the fibers prior to extraction.

The brown coconut coir has become popular growing substrate or medium in horticulture due to its high lignin content, which lasts long, holds more water, and does not shrink when dry allowing for easy re-wetting. Most commercially available coir is washed thoroughly to remove high sodium and potassium content that can damage crops. After washing, some suppliers treat coir with calcium buffering solution to adjust its cation exchange capacity (refers to the ability of substrate to absorb and release positively-charged cations, thus buffering the substrate against sudden changes in pH or nutrient levels). Good quality coir is essential to achieve optimum growth for your crops. To determine if the coconut coir that you purchased is suitable for growing crops, measure the pH and conductivity before using it.

The LAQUAtwin pH meters and conductivity meters provide direct readings with micro-volume samples in just few seconds. These waterproof pocket meters are programmed with automatic calibration and temperature compensation to ensure accurate measurement. Both meters come in three different models and each is packed with two standard solutions for calibration.

Method

Calibrate the LAQUAtwin pH meter and conductivity meter using standards that bracket the expected sample values according to manufacturer's instructions.

Sample Preparation and Measurement

Two sampling methods are described below.

1:2 (V/V) Dilution Method

1. Combine 1 part of coconut coir with 2 parts of distilled water (neutral pH, without mineral content) in a clean beaker or container. For example, 50 ml coir with 100 ml distilled water or 1 cup coir with 2 cups water.
2. Mix and let the sample stand for 30 minutes to equilibrate.
3. Pour the mixture into a clean funnel lined with a filter paper.
4. Collect the extract in a clean container, mix again, and place drops of extract onto the calibrated pH sensor and conductivity sensor.

Pour Thru Method

1. Place a container under the coconut coir sample and apply 100ml distilled water.

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> **The substrate's chemical properties such as pH and conductivity must be suitable to the crop that you intend to grow. Each crop has specific pH and conductivity values for substrate to achieve optimum growth.**

2. Collect 50ml leachate, mix and place drops of extract onto the calibrated pH sensor and conductivity sensor.

Refer to Technical Tip 01 LAQUAtwin pH Sensor Maintenance Procedures and Technical Tip 03 LAQUAtwin Conductivity Sensor Maintenance Procedures for conditioning, cleaning, and storing the sensors. The tips can be downloaded from the support section of www.horiba-laqua.com.

Results and Benefits

Growing substrate or medium serves as an environment for the root system of a plant to grow and function. The substrate's chemical properties such as pH and conductivity must be suitable to the crop that you intend to grow. Each crop has specific pH and conductivity values for substrate to achieve optimum growth.

pH affects the amount of nutrients available to plants and all are readily available at pH 5.4 to 6.2. Conductivity indicates the nutrients or salt levels (salinity) affecting the development and health of crops. The substrate conductivity ranges suitable for seedlings, bedding plants, and salt-sensitive plants are 0.26 to 0.75 mS/cm by 1:2 dilution method and 1.0 to 2.6 mS/cm by pour thru method.

As your crop grows, monitor the pH and conductivity values of substrate every 2 to 3 weeks by random sampling since they tend to change over time. In this case, 1:2 (v/v) dilution method requires sampling from the bottom 2/3rd of the pot. This disturbs the roots and care must be taken. The pour thru method samples the entire root without disturbing it, but the results are variable. Choose a sampling method and use it throughout your monitoring program.

References And Suggested Readings

1. Coir – Wikipedia. Available at: https://en.wikipedia.org/wiki/Coir
2. Argo, B. (2004). Understanding pH Management and Plant Nutrition Part 4: Substrates. Journal of the International Phalaenopsis Alliance, Vol. 13 (3). Available at: http://www.atlantaorchidsociety.org/wp-content/uploads/2012/02/Part-4-substrates2.pdf
3. Camberato, D., Lopez, R. and Mickelbart M. pH and Electrical Conductivity Measurements in Soilless Substrates. Commercial Greenhouse and Nursery Production. Purdue Extension HO-237-W. Available at: https://www.extension.purdue.edu/extmedia/ho/ho-237-w.pdf

REV 1.0, 11 April 2016

Agriculture
Application Notes

Quick Nutrient Analysis in Strawberry Production

Regular monitoring of nutrient levels such as nitrate (NO_3^-), potassium (K^+) and calcium (Ca^{2+}) in plant petioles, soil solution, irrigation water, and drain water produces not only good yield and fruit quality, but also reduces fertilizer cost and mitigates environmental hazards. The LAQUAtwin pocket meters are the perfect tools for testing as they directly measure samples and provide results in just few seconds, allowing growers to identify and correct any nutrient deficiency or excess immediately.

Introduction

Strawberry production requires a root environment with good availability of essential nutrients to achieve optimum plant growth, fruit quality, and yield. Soil pH influences the availability of nutrients such as nitrate (NO_3^-), potassium (K^+) and calcium (Ca^{2+}) ions, which have specific roles in strawberry fruit quality - NO_3^- determines the size, K^+ influences the taste, and Ca^{2+} affects the firmness. The nutrients should be present in a right balance to avoid competition or improper plant uptake. Aside from maintaining the correct soil pH for nutrient availability, the conductivity should also be closely and frequently monitored, as strawberry plants do not tolerate high conductivity value.

Plant sap analysis has been used by growers to manage crop nutrient content and fertilization strategies. A plant sap test gives a view of the nutrients available for the plant, at that time, for growth or development. It directly shows if a crop suffers from a nutrient deficiency or an excess. Soil solution analysis is also important for growers. It gives a view of the nutrient and salinity levels in the soil and nutrient leaching past the root zone. Soil solution is the water held in the soil, which contains a mixture of nutrients taken up by roots.

HORIBA offers LAQUAtwin pocket meters which provide reliable and accurate results for plant sap and soil testing parameters such as pH, conductivity (EC), nitrate (NO_3^-) / nitrate-nitrogen (NO_3-N), potassium (K^+), calcium (Ca^{2+}) and sodium (Na^+). Several research studies have proven that results obtained with LAQUAtwin pocket meters are strongly correlated with those of traditional laboratory analyses. With their unique and compact design, the LAQUAtwin pocket meters allow direct measurement of micro-volume sample (as low as 0.1ml) and deliver results in just a few seconds. These advantages enable growers to make fertilization and irrigation decisions quickly.

Method

Calibrate the LAQUAtwin pocket meters according to manufacturer's instructions.

A. Plant Sap Analysis

For sampling, it is critical to always follow the same protocol and collect the correct tissue in order to get consistent and reliable results. The most recent mature trifoliate leaf is the best indicator of the most essential nutrients for plant growth (e.g., P, K, Ca, etc.) and the petiole from this leaf is the best indicator of NO_3-N. Plant temperature should be within 20 to 25°C.

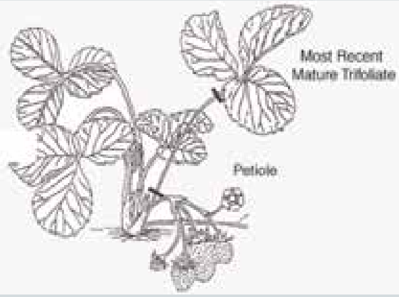

Figure 1: Proper leaf and petiole samples ensure reliable results.

Source: Casteel, S. (2004). Strawberry Fertility and Nutrient Management.

1. Collect 2 most recent mature trifoliate leaves and the associated petioles from 20 different strawberry plants to get a representative sample. The petiole must be detached from the plant near the crown.

2. Separate the petioles from the leaves and cut them into small pieces.

3. Load the small pieces of petioles into a garlic press or hydraulic sap press and squeeze them to extract sap.

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Pocket Meters
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1. Place the sap directly onto the respective sensors of LAQUAtwin nitrate and potassium pocket meters.

2. Compare the results with the reference values in Table 1 to evaluate the current nutritional condition of the plants and implement the best course of action.

3. Rinse the sensors with clean water before testing another sample or storing them.

Table 1: Reference Nutrient Levels for Petiole Sap in Strawberry Cultivation

Days after sowing	NO_3-N	P	K
	ppm		
30	500 – 700	150 – 350	4000 – 5000
60	550 – 750	150 – 350	4000 – 4500
90	400 – 600	150 – 350	4000 – 5000
110	500 – 300	150 – 350	4000 – 5000

Source: Carlos Cadahia, Ediciones Mundi-Prensa. La Savia como índice de fertilización, 2008, page 246

B. Soil Solution Analysis

Soil solution for pH, salinity (usually reported as conductivity), and nutrient analysis can be extracted through lysimeters installed in the field – at 15-20cm depth, where strawberries have the bulk of their roots and at 50-60cm depth below most of the roots. Lysimeters are installed under vacuum pressure and pull water from the soil similar to the root of the plant. To extract suitable samples, the soil must have been recently wetted with rainfall or irrigation water.

1. Place the sample of extracted soil solution directly onto the respective sensors of LAQUAtwin pH, conductivity, sodium, nitrate, potassium, and calcium meters.

2. Record the results and monitor the nutrients on a weekly basis.

3. Rinse the sensors with clean water before testing another sample or storing them.

Results should be interpreted by comparing trends from season-to-season and block-to-block with strawberry performance indicators such as yield and fruit quality. Irrigation and drain water can also be analysed directly with LAQUAtwin pocket meters.

Strawberries have salt tolerance threshold of 1.0 mS/cm and will grow best in soil pH range of 5.5 to 6.5.

Results and Benefits

Plant sap analysis provides information on the current nutritional status of the plant. This information makes it possible to fine-tune N application, to maximize yield and quality, and to extend the fruiting season. The plant sap analysis complements soil solution analysis.

Soil solution analysis can help growers make decisions about their irrigation and nutrient management program. It should be used to enhance nutrient management and not as a measure of overall soil nutrient status. Nitrate and salinity levels are the key focus of soil solution monitoring. As nitrate is a highly mobile nutrient, soil solution can help identify incorrect nitrogen application, which could result in nitrate accumulation within the root zone and nitrate leaching below the root zone. Potassium and calcium are bound to soil and their levels in soil solution do not provide a reliable indication of their supply and availability to the crop. However, potassium, calcium, and sodium levels in soil, irrigation water, and drain water should be checked regularly. Salinity levels measured in soil solution allow growers to perform corrective action (e.g., increase irrigation to maintain salinity levels) before symptoms appear on leaves, yields or crop quality. Overwatering leaches fertilizer out of the root zone and results in environmental hazard (e.g., groundwater contamination). Soil solution analysis can be tested throughout the growing season.

References and Suggested Readings

1. Castellanos, J. Manual de producción de tomate en invernadero. México 2009, p.200-201.
2. Ginés y Simón Navarro García. Química Agrícola, Tercera Edición 2013, p.245
3. Carlos Cadahia, Ediciones Mundi-Prensa. La Savia como índice de fertilización, 2008, page 246
4. Casteel, S. (2004). Strawberry Fertility and Nutrient Management. Available at: http://bit.ly/2m1dsqr (Accessed: 27 February 2017).
5. Falivene, S. Soil Solution Analysis. Available at: http://bit.ly/2lNtukB (Accessed: 5 March 2017).
6. Singh, P. Soil Analysis in Strawberry Farm at Holleta, Ethiopia.
7. FAO Crop Salt Tolerance Data. Available at http://www.fao.org/docrep/005/y4263e/y4263e0e.htm

Revision 1.0, 6 March 2017

Figure 2: Cutting of petioles into small pieces.

Figure 3: Loading of petioles into the chamber of garlic press for sap extraction.

Figure 4: Placing sap directly onto LAQUAtwin nitrate sensor.

Figure 5: pH and conductivity testing on soil solution.

Figure 6: Irrigation wáter testing with LAQUAtwin pocket meters.

Aquarium Water Testing

Testing aquarium water such as freshwater and saltwater (either natural or artificial seawater) with reliable instruments is necessary to create a clean and safe environment for your aquatic species. The LAQUAtwin pocket meters require only few drops of water and deliver the results in just a few seconds.

Introduction

Aquarium water chemistry is of vital importance to the health of fishes and other aquatic species. Aquariums may have freshwater or saltwater. Saltwater, either natural or artificial seawater, is used in fish-only, fish-only with live rock (FOWLR) and reef tanks while freshwater is used in planted, biotope, cichlid, brackish and predator tanks. In general, the former is more expensive and more difficult to maintain as additional equipment and frequent testing is needed.

To ensure good water quality, maintenance (filtration, water changes, and testing) is required on a regular basis. For testing, the saltwater parameters for reef aquarium, taken from Reefkeeping Online Magazine, are summarized in Tables 1 and 2 and some of them are explained below.

Calcium

Calcium is an essential element for coral health in a saltwater aquarium. It is used by corals to form their skeletons, composed primarily of calcium carbonate. When calcium level drops below 360ppm or depleted in water, it becomes difficult for corals to collect calcium for their growth. In this instance, calcium chloride ($CaCl_2$) can be added to water to raise the calcium level.

Alkalinity

Alkalinity, also called carbonate hardness, is caused by carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) anions.

It is expressed as either parts per million (ppm or mg/L) or degree KH (dKH). One dKH is equal to 17.848 ppm $CaCO_3$. Like calcium, alkalinity is also essential for the skeletons of corals. It is believed that corals take up the bicarbonate, convert it to carbonate then use that to form calcium carbonate skeletons. Balanced calcium and alkalinity additive system like limewater, calcium carbonate, and the two-part additive systems are recommended for routine maintenance while baking soda or washing soda is recommended for quick alkalinity correction.

Salinity

Salinity is the measure of all the salts dissolved in water. It is related to the concentration of dissolved salts in seawater. The main difference between fresh water and salt water is the salinity content. Fresh water contains only small amount of salts. Too much or too little salt will adversely affect the health of fishes. The recommendation is to target the natural seawater salinity value, which is 35 ppt. To create this natural environment, add more fresh water if salinity is high or increase the amount of salt mixture if salinity is low.

Salinity can be measured directly with a salt meter or indirectly with a conductivity meter. The 35 ppt salinity value (specific gravity = 1.025) of seawater is equivalent to 53 mS/cm conductivity.

Temperature

The best water temperature depends on the species in the aquarium. In general, tropical fishes are healthy in the range of 24 – 28°C. Cold water fishes, like goldfish, enjoy water below that temperature range. Ensure a stable temperature as rapid, drastic and frequent temperature changes throughout the day are stressful for fishes.

Another important factor to note is the oxygen availability to fishes. Oxygen is less soluble in water at higher temperature.

pH

pH, stands for power of hydrogen, is the measurement of hydrogens ions in a solution. This gives us the acidity or alkalinity of water from a scale of 0 to 14. The carbonate hardness and calcium level in water affect the pH value. The optimal pH also depends on the species in the aquarium. For most species to survive, the pH of water should be close to pH 8.2 of natural seawater.

There are several ways to adjust the pH. To raise pH, add crushed corals, limestones, or baking soda or perform aeration. To lower pH, add driftwood or peat. Remember to adjust the pH slowly as rapid, drastic and frequent pH changes could kill your species.

Magnesium

Magnesium is another element used by corals for growing their calcium carbonate skeletons and coralline algae for their calcium carbonate deposits. This ion is abundant in natural seawater. Magnesium should be measured, particularly if the aquarium's calcium and alkalinity levels seem difficult to maintain. The magnesium concentration should be close to 1280ppm of natural seawater.

Phosphate

High level of phosphates inhibits calcification or building-up of calcium carbonate skeletons of coral and coralline algae. Above 0.03 ppm, algae growth is uncontrollable. Thus, keeping the phosphate concentration below 0.03ppm will deter algae growth.

To maintain low levels of phosphate, apply phosphate export mechanisms, such as growing and harvesting macroalgae or other rapidly growing organisms. Another way is to use limewater, phosphate binding media, or foods without excessive phosphate.

Ammonia

Ammonia is excreted by all aquatic animals and is considered toxic to them even as low as 0.2ppm. The ammonia level in water increases as the pH level rises. In this instance, transfer the fishes to cleaner water or treat the aquarium with ammonia-binding product.

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The LAQUAtwin pocket meters are used to measure and monitor freshwater or saltwater in aquarium. The meters have flat sensors for quick, direct and accurate measurement of micro volume water samples without adding any chemicals.

Method

Calibrate the LAQUAtwin pocket meters according to manufacturer's instructions using the standard solutions included in each kit.

Sample Measurement
Place a sample of aquarium water onto the sensor by using a pipette or by opening the sensor cap and scooping water directly from the aquarium. Alternatively, perform direct measurement by opening the sensor guard and immersing the sensor into the aquarium. Rinse the sensor with DI water and blot dry with soft tissue between samples.

When measuring sample, you may allow the meter to lock the stable reading by pressing MEAS button. This activates the auto-hold function—MEAS will blink until the reading is stable and ☺ will appear. Press MEAS button again to deactivate auto-hold function. Note: For pH, salt, and conductivity meters, make sure to set auto-hold (AH) in the meter settings prior to measurement.

Refer to Technical Tip nos. 1, 2 and 3 for detailed information on conditioning, cleaning, and storing the sensors. The technical tips can be viewed and downloaded from the support section of our website www.horiba-laqua.com.

Results and Benefits

Table 3 shows the results of LAQUAtwin pocket meters in artificial seawater measurement. The results were compared against the values indicated in the product label.

Table 1: **Critical Parameters for Reef Aquarium Water**

Parameter	Recommended Value	Typical Ocean Value
Calcium	380 - 450 ppm	420 ppm
Alkalinity	7 - 11 dKH 125 – 200 ppm $CaCO_3$ equivalents 2.5 - 4 meq/L	7 dKH 125 ppm $CaCO_3$ equivalents 2.5 meq/L
Salinity	34-36 ppt	35 ppt
Temperature	24 – 28 °C / 76 – 83 °F	Variable
pH	7.8 – 8.5 Good 8.1 – 8.3 Better	8.0 – 8.3 (can be lower or higher in lagoons)
Magnesium	1250 – 1350 ppm	1280 ppm
Phosphate	< 0.03 ppm	0.005 ppm
Ammonia	< 0.1 ppm	Variable (typically < 0.1 ppm)

Source: Reefkeeping Online Magazine (http://reefkeeping.com/issues/2004-05/rhf/)

Table 2: **Non-Critical Parameters for Reef Aquarium Water**

Parameter	Reef Aquaria Recommended Value	Typical Ocean Value
Silica	< 2 ppm, much lower if diatoms are a problem	< 0.06 – 2.7 ppm
Iodine	Control not recommended	0.06 ppm total of all forms
Nitrate	< 0.2 ppm	Variable (typically below 0.1 ppm)
Nitrite	< 0.2 ppm typically	Variable (typically below 0.0001 ppm)
Strontium	5 – 15 ppm	8 ppm
ORP	Control not recommended	Variable
Boron	< 10 ppm	4.4 ppm
Iron	Below detection limit	0.000006 ppm

Source: Reefkeeping Online Magazine (http://reefkeeping.com/issues/2004-05/rhf/)

Table 3: **Artificial Seawater Measurement Results using LAQUAtwin Pocket Meters**

Parameter	Expected Value*	Result	Error
Conductivity (EC)	——	49 mS/cm	——
Salinity	——	32.0 ppt	——
pH	8.1 - 8.2	8.0	< 10%
Calcium Ion (Ca^{2+})	416 ppm	380 ppm	< 10%
Sodium Ion (Na^{+})	9651 ppm	9800 ppm	< 10%
Potassium Ion (K^{+})	366 ppm	400 ppm	< 10%

*According to product label

Table 4: **Practical Salinity of 1978 (PSS-78) Conversion Table**

Conductivity (mS/cm)	Seawater Salinity (ppt)
45	29.1
46	29.8
47	30.5
48	31.3
49	32.0
50	32.7
51	33.5
52	34.2
53	35.0
54	35.7
55	36.4

pH

The pH 11, 22 or 33 meters have temperature compensation function, but only pH33 meter displays the temperature reading. For accurate measurement, calibrate the meter with at least two pH buffers that bracket the expected sample pH. If the expected pH is 8.0, select USA buffer setting and calibrate the meter using pH 7.00 and 10.01 buffers or select NIST buffer setting and calibrate using pH 6.98 and 9.18 buffers.

Salinity and Conductivity

The Salt 11 meter is programmed with sodium chloride (NaCl) and seawater curves. For this application, seawater curve is suitable. The meter displays both salinity and temperature readings.

The EC 11, 22, or 33 conductivity meters can be used to determine salinity indirectly. After obtaining the conductivity value, refer to Table 4 to check the corresponding salinity value.

Calcium, Sodium, Potassium, and Nitrate Ions

The B-722 meter, B-731 meter, and B-751 meter measure the free sodium ion, potassium ion, and calcium ion, respectively. All the results obtained in artificial seawater measurement have less than 10% error.

In nitrate ion measurement, chloride ion in seawater is one of the interfering ions. The chloride ion concentration in seawater is around 20,000ppm and will affect the nitrate ion concentration. The target nitrate concentration in aquarium water is less than 0.2ppm, but the B-743 meter measures nitrate in 62 to 6200 ppm range.

References and Suggested Reading

1. Saltwater Versus Freshwater Aquariums by Katherine Barrington http://www.ratemyfishtank.com/blog/saltwater-versus-freshwater-aquariums
2. Reef Aquarium Water Parameters by Randy Holmes-Farley http://reefkeeping.com/issues/2004-05/rhf/
3. AquariumDetective.com http://aquariumdetective.com/articles/watertest.php

Revision 1.0, 10 October 2016

pH and Conductivity for Testing Acrylic Paint Films and Paper Supports and Formulating Aqueous Cleaning Solutions

New aqueous cleaning system for acrylic paint films on paper supports has been developed. Isotonic aqueous cleaning solutions that match the pH and conductivity readings of acrylic paint films and paper supports obtained from agarose gel pellets have been shown to be effective in reducing or removing dirt, dust, active mold growth and associated stains, tide line stains, and discoloration.

Introduction

Acrylic paint is fast-drying paint made of pigment suspended in acrylic polymer emulsion. The composition varies from brand to brand, and even from pigment to pigment. The typical ingredients of wet acrylic emulsions are water (around 65% volume), acrylic polymer, pigments, surfactants, dispersants, biocides, thickeners, and inorganic components, as well as other materials added by artists. Acrylic paints are water-soluble, but become water-resistant when dry. After aging and during cleaning, the colors of various acrylic paint films react differently.

Acrylic works of art on paper are sensitive to aqueous cleaning methods. The two primary risks are paint film swelling and surfactant or pigment disruption. New aqueous cleaning system that use LAQUAtwin pH and conductivity pocket meters to mitigate the above-mentioned risks was demonstrated at the 2011 Cleaning of Acrylic Painted Surfaces (CAPS) workshop. The LAQUAtwin pH and conductivity meters were used to test acrylic paint surfaces and to formulate customized aqueous cleaning solutions.

In CAPS aqueous cleaning system, pellets of agarose gel are prepared and applied to evaluate the surface pH and conductivity of acrylic paint films and paper supports. The readings are then used to formulate isotonic aqueous cleaning solutions, which are adjusted to the approximate pH and conductivity of the acrylic paint films and paper supports.

The LAQUAtwin pH and conductivity meters have flat sensors that analyse micro volume samples in just few seconds. These waterproof pocket meters are programmed with automatic buffer recognition function for automatic calibration and automatic temperature compensation (ATC) function for accurate measurement. Both meters come in three different models and each is packed with two standard solutions for calibration.

Method

A. Preparation of 2% (w/v) Agarose Pellets

Ingredients:

- 100 ml distilled or deionized water
- 2.0 g Agarose Type VII, low gelling temperature
- 2 drops Germaben II, preservative for longer shelf-life (optional)

1. Heat 100 ml of DI water to 198°F (92°C).
2. Remove from heat and stir in 2.0 g of agarose powder.
3. Stir for 5-10 minutes until there are no lumps. Replace on hot plate as needed to keep the temperature constant.
4. Cool to approximately 140°F (60°C), then stir in 2 drops of Germaben II.
5. Immediately pour the mixture into 4 sterilized petri dishes.
6. Allow the petri dishes to cool until gelling is complete, approximately 20 minutes.

7. Extract cylindrical pellets from the cooled gel using a 3 mm biopsy punch.

For tide line stains on paper supports, increase the weight of agarose to make a 4% or 5% (w/v) gel and use pre-mixed pH- and conductivity-adjusted water solutions, instead of DI water. Highly concentrated gel delivers moisture at a significantly reduced rate, consequently mitigating or eliminating the formation of tide lines around the test area. By increasing ionic activity at the stain site via appropriate water adjustment, paper swelling is limited and absorbency controlled.

B. Sampling of Acrylic Paint Films or Paper Supports

At room temperature, apply individual agarose pellets to acrylic paint films or paper supports (See Figure 1).

Figure 1: An agarose pellet resting on the surface of an acrylic paint film.

For sampling paint films, select colors that represent 80% of the pure colors and color mixtures. Allow the pellets to rest on the surface for 45 to 60 seconds. For sampling paper supports with tide line stains, apply

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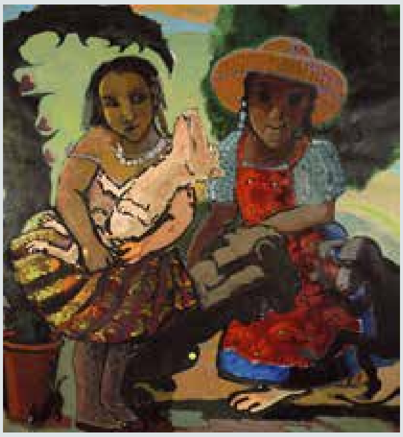

Figure 2: Paula Rego, In the Garden, 1986, acrylic on paper lined to canvas.

3 pellets with different conductivities and leave for 2-10 minutes.

C. Calibration of Meters

Calibrate the LAQUAtwin pH and conductivity meters according to manufacturer's instructions using their respective standard solutions included in kits.

D. Conductivity Analysis of Agarose Pellets

Place the 3-mm agarose pellet onto the well of the conductivity sensor using blunt tweezers. The pellet must be carefully pushed to the back of the meter to allow direct contact with the two titanium/platinum black metals. The tweezers must not touch the metals to avoid damaging them. Record the conductivity reading once it is stable. Rinse the sensor with DI water before testing another pellet.

E. pH Analysis of Agarose Pellets

After conductivity analysis, place the same 3-mm agarose pellet onto the pH sensor using blunt tweezers. Moisten the pellet with a drop or two of DI water to release the soluble components into the flat glass sensor. Make sure that the whole flat glass sensor is covered with mixture of agarose gel and DI water. Record the stable pH reading after 1 minute equilibration time. Rinse the sensor with DI water before testing another pellet.

F. Formulation of Aqueous Cleaning Solutions

Prepare aqueous cleaning solutions that match the pH and conductivity of the readings taken from acrylic paint films or paper supports by following the procedure below. Each solution should be within a few tenths of the pH reading, and within approximately 500 µS of the conductivity reading.

Table 1: Volume of Ingredients for pH-Adjusted Water at 1000 µS/cm

pH	Volume of CH_3CO_2H (ml)	Volume of DI Water (L)	Volume of 10% NH_4OH (ml)
5.0	0.5	0.5	5
5.5	0.5	0.5	8
6.0	0.5	0.5	9
6.5	0.5	0.5	10
7.5	0.5	0.5	12

Table 2: Volume of Ingredients for pH-Adjusted Water at 6000 µS/cm

pH	Volume of CH_3CO_2H (ml)	Volume of DI Water (ml)	Volume of 10% NH_4OH (ml)
5.0	1	100	6-7
5.5	1	100	10
6.0	1	100	11
6.5	1	100	12

Tables 1 and 2 show the ingredients for pH-adjusted waters at 1000µS/cm and 6000µS/cm, respectively. If solutions in these tables will be prepared, follow the indicated volumes of acetic acid, DI water, and ammonium hydroxide for steps 1 and 2.

Ingredients:

- distilled or deionized water
- glacial acetic acid
- ammonium hydroxide

1. Add drops of acetic acid (CH_3CO_2H) to DI water and mix.
2. Set pH by adding 10% ammonium hydroxide (NH_4OH). Mix the solution.
3. Test pH and conductivity by placing drops of the prepared solution onto the pH and conductivity sensors. Make sure that the conductivity sample well and flat pH glass sensors are covered with the solution.
4. If necessary, add 10% NH_4OH in 0.5ml increments or dropwise to raise the pH or dilute with DI water to reduce conductivity. Dilution example: To reduce the conductivity by half without a significant change in pH, dilute the final solution with DI water in 1:1 ratio.

To preserve the aqueous cleaning solutions, add a drop of Germaben II in each batch and store in sanitized, airtight containers inside a refrigerator. Discard the solutions when mold growth appears.

To clean a paint film, lightly moisten a hand-rolled cotton swab with aqueous cleaning solution and apply 3-4 passes. Less than 3 passes is required for paper support to prevent swelling of surface.

Refer to Technical Tip nos. 1 and 3 for detailed information on conditioning, cleaning, and storing the pH and conductivity sensors. The technical tips can be viewed and downloaded from the support section of our website www.horiba-laqua.com.

Results and Benefits

During sampling, the agarose pellets absorb the soluble components on the surface of paint films or paper supports by diffusion and capillary action. This causes the pH and conductivity of agarose pellets to shift closer to that of the paint films or paper supports. Although it is faster to perform the sampling with droplets of DI water, this method often results in aggressive localized swelling at the test site. The agarose pellets may be slower-acting, but they hold moisture in check and prevent swelling.

Aqueous cleaning solutions are prepared by first adding acetic acid (a weak acid) to DI water, then ammonium hydroxide (a weak base). The latter reacts with the former to produce salt, which sets the conductivity. Further addition of ammonium hydroxide raises the alkalinity and therefore the pH value of the solution.

Table 3: pH and Conductivity Readings from In the Garden by Paula Rego, July 12, 2012

Color	pH	Conductivity (µS/cm)
Control pellet	5.5	40
Deionized water droplet (on black)	6.3	1750
Black	5.6	1330
Dark green	6.2	780
Light green	6.2	130
Red	6.2	380
Orange	6.0	380
Blue	5.8	1120
Brown (A)	6.0	80
Brown (B)	6.0	90

Using aqueous cleaning solutions whose conductivity and pH most closely matched that of the colors of acrylic paint films and surface of paper support on which they were applied resulted in the least pigment transfer and swelling while maximizing cleaning efficiency. The solutions harmonize with the paint films or paper supports achieving near chemical equilibrium at the surface.

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Revision 1.0, 20 October 2016

Water Quality Check in Beer Brewing

The quality of brewing water affects the enzyme activity in mash, solubility of minerals, taste and quality of beer, and the condition of brewing equipment. To achieve the great taste of beer and ascertain the cleanliness of equipment after cleaning process, water quality check must be carried out in the various stages of brewing process with reliable and accurate instruments. Having the advantages of less maintenance design, low-volume sample requirement, and hassle-free operation, the HORIBA LAQUAtwin pocket meters and LAQUA dissolved oxygen (DO) handheld meters and electrodes are recommended for home and commercial beer brewers.

Introduction

Beer is one of the most widely consumed alcoholic drinks and the third most popular drink overall (after water and tea) in the world. It has become a part of the culture of many nations and often associated with social traditions such as festivals and games.[1]

Brewing is the process of making beer. The four main ingredients of beer are cereal grains (e.g., malted barley, wheat, maize, rice) as starch source, water, flavoring agents (e.g., hops, gruit, herbs, fruits), and yeast. Malted barley and hops are the most commonly used cereal grain and flavoring agent, respectively. In beer brewing, the starch source is mixed with water and converted into a sugary liquid called wort. The wort is subsequently converted into the alcoholic drink by fermentation using yeast.

As beer is mostly water, the composition of brewing water can affect the quality of beer. Brewing water should be clean and odorless. Water can come from two sources—surface water and groundwater. The former is low in dissolved minerals but higher in organic matter while the latter is generally higher in dissolved minerals and low in organic matter.[2] To determine the mineral composition of water, beer brewers can ask reports from local water companies, send sample water to laboratories, or perform the tests by themselves using proper equipment. The common test parameters are explained below. Based on the results, brewers can make necessary water adjustments to make a great beer.

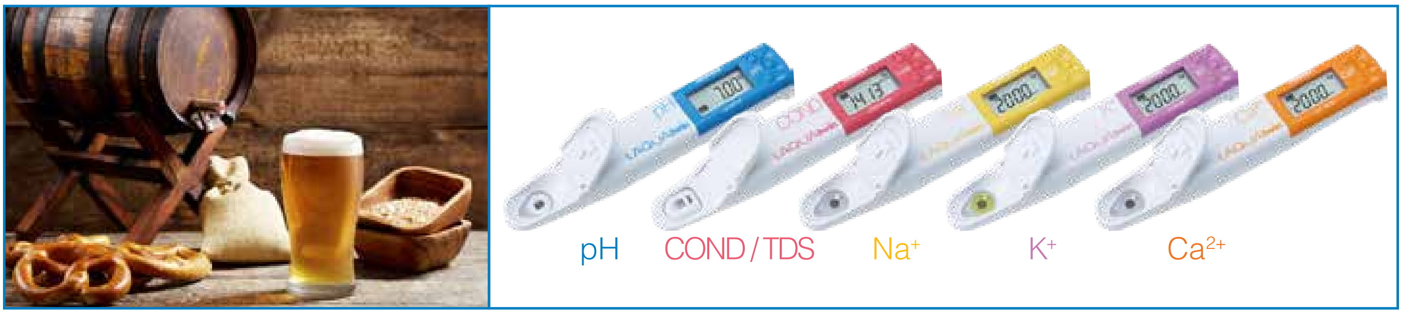
As water quality check in beer brewing process is a crucial step to achieve exceptional taste and quality of beer, the HORIBA LAQUAtwin pocket meters and LAQUA dissolved oxygen (DO) handheld meters and dissolved oxygen (DO) electrodes are recommended for beer brewers. Aside from their simple and easy operation, the LAQUAtwin pocket meters have unique flat sensors that can measure sample as low as 0.05 ml in just few seconds. The LAQUA DO handheld meters are packaged with DO electrodes, which have innovative replaceable DO tips and built-in temperature sensor, in carrying cases for routine measurements in the field.

Water Hardness

Water hardness is defined as the amount of dissolved calcium and magnesium in the water. Calcium is the principal ion that determines water hardness. It can overcome the buffering capacity of malt phosphates, lower the mash pH to acceptable range[3] and promote clarity, flavor, and stability in the finished beer.[2] The ideal calcium concentration in the brewing water is between 50 and 150 ppm.[3] Calcium sulfate ($CaSO_4$), also known as gypsum, or calcium chloride ($CaCl_2$) can be added to increase the amount of calcium ions in water. Magnesium also contributes to water hardness and therefore affects the mash pH, but to a lesser extent than the calcium.[2]

Alkalinity

Alkalinity is the capacity of water to resist changes in pH that would make the water more acidic. It is a measurement of the concentration of all alkaline substances dissolved in the water such as carbonates and bicarbonates which buffer pH in the water by neutralizing acids.



Calcium concentrations must be balanced with low carbonate-bicarbonate levels as they have countering effect on calcium. These ions should be kept to less than 50ppm. Bicarbonates, being strong alkaline buffers, may raise the pH of the mash to unacceptable levels, if available in large amounts.[3]

pH

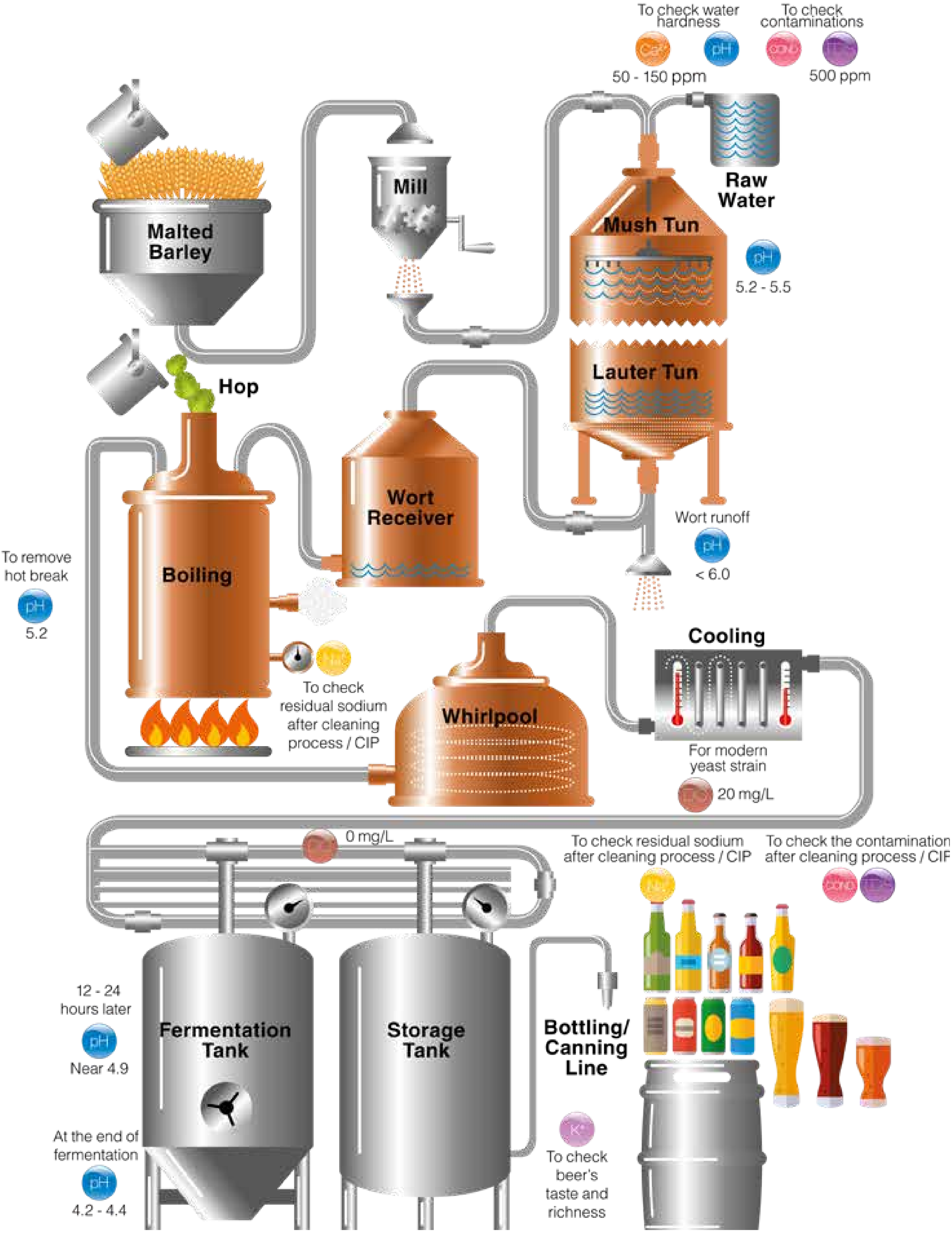
pH is important in various stages of beer brewing—mash, wort, and finished beer. Most municipal water sources are slightly alkaline. When water is combined with grains in a mash tun, the pH of the mixture, called mash, drops compared to the pH of water alone. The mineral composition (i.e., calcium, magnesium, carbonates, and bicarbonate) of the water and natural acidification process in mashing of malted grains drive the mash pH. The ideal mash pH range is 5.2 to 5.5 with preference to the lower end (5.2) for improved enzyme activity leading to optimal conversion of starches to liquid sugars called wort.[4] After mashing, the wort is drained and the grains are washed. This process is called sparging. As sparging progresses, the pH of wort being run off from the mash increases. The pH of the run off wort should be below 6 because higher pH will extract tannins, silicates, and other compounds from the grain leading to astringent-off flavors and cloudy, hazy beer.[3]

The collected wort is transferred to a kettle for boiling. During the boil, calcium phosphate is still precipitated (as long as calcium is still present) and the pH decreases, just like during mashing. A post-boil wort pH of 5.0 to 5.2 should be achieved. This pH range will help extract the best character from hops, maximize the amount of hop break formed, and keep color pick-up to a minimum. Another important function of boiling is coagulating the hot break. The optimal pH for break formation is 5.2. If big, fluffy bits of break material in wort are present in early boiling, it is a confirmation that pH is in the right range.[5] Hot break must be removed so that the hot wort can be clear.

Continued at the back

Stages of Beer Brewing	Optimal Values	HORIBA Instrument
1. **Wort Preparation**	**Brewing Water**	
A. Mashing Malted barley is mixed with hot water in a mash tun for 1 – 2 hours. The starches are converted to sugary liquid called wort.	Ca^{2+}= 50 – 150 ppm	LAQUAtwin Ca-11
	TDS = 500 ppm	LAQUAtwin EC33
	Mash	
	pH = 5.2 – 5.5	LAQUAtwin pH11/22/33
B. Sparging (Lautering) The sweet wort is drained off the grains. The grains are washed to gather as much of the fermentable liquid from the grains.	**Wort Run-off**	
	pH = < 6.0	LAQUAtwin pH11/22/33
2. Wort Boiling Wort is moved to a kettle, where it is boiled with hops and other ingredients that add flavor, aroma, and bitterness to the beer. This terminates enzymatic processes, precipitate proteins, isomerize hop resins, and concentrate and sterilize the wort.	**Post-boil Wort**	
	pH = 5.2	LAQUAtwin pH11/22/33
3. Wort Cooling The hopped wort settles to clarify in a vessel called a whirl-pool then drawn away from the compacted hop trub, and rapidly cooled via a heat exchanger to a temperature where yeast can be added.	**Cooled Wort**	
	DO = 6 - 8ppm, 16 ppm or higher depending on the strains of yeast and original gravity of wort; modern strains of yeast can require as high as 20ppm	DO110/120 meter and 9520-10D/9551-20D
4. Wort Fermentation The cooled wort goes into a fermentation tank and a type of yeast is selected and added. When the yeast is added to the wort, the fermenting process begins, where the sugars turn into alcohol, carbon dioxide and other components.	**Fermented Wort**	
	pH = < 4.4	LAQUAtwin pH11/22/33
5. Beer Storage Beer is free of oxygen and must be protected from oxygen exposure during transfer and packaging.	**Beer**	
	DO = < 50ppb (0.05ppm)	DO110/120 meter and 9520-10D/9551-20D
	K^+ = 300 – 500 ppm Na+ = 0-150 ppm	LAQUAtwin K-11 LAQUAtwin Na-11

How to utilize LAQUA meters in beer brewing process



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When yeast is added to the wort, the fermentation begins—sugar turns into alcohol and carbon dioxide. During fermentation, the pH continues to drop because yeast takes in ammonium ions (strongly basic) and excretes organic acids (includes lactic acid). The yeast strain chosen can affect the final beer pH—most lager beers = pH 4.2 – 4.6, some ales = pH 3.8, sour beers = around pH 3.0. An optimal pH of less than 4.4 favors faster beer maturation, better beer clarity, better biological stability and more refined beer taste.[5]

Sodium

Sodium is a desirable ion in beer for final product flavor complexity. The range is 0-150 ppm Na^+. Professional brewers use simple cleaning process or clean-in-place (CIP) techniques to make regular cleaning efficient and effective. Cleaning process / CIP involves circulating cleanser or sanitizer through a spray ball in enclosed equipment. Brewers will clean each time the wort or beer is transferred from a vessel. For example, kettle must be cleaned after the wort is boiled and sent off through the heat exchanger and into the fermentor. Cleansers with sodium hydroxide (commonly known as caustic soda) as active ingredient are by far the most widely used in breweries.[10] Any sodium residue in the equipment after cleaning process / CIP can be checked using an ion selective sensor and meter.

Total Dissolved Solids (TDS)

Brewing water from municipal water sources may contain total dissolved solids (TDS) such as minerals, salts, and organic matter. TDS is an indicator of water quality and, as discussed above, mineral composition of water affects mash pH in brewing process. The recommended TDS level in water is 500ppm.[6] The amount of TDS in water can be estimated using a TDS meter, which measures the conductivity of solution and converts it to TDS using a factor. Although TDS does not specify the exact mineral composition of water, it can be used in monitoring any changes in the water.

Electrical Conductivity (EC)

Electrical conductivity (EC), often simply referred to as conductivity, is a measure of the ability of an aqueous solution to carry an electric current. Pure water has no conductivity (reading is not zero but very low) because there are no dissolved ions in it. The more ions in solution, the higher the conductivity value. Conductivity measurement of water source in beer brewing gives an indication of the water purity and the baseline measurement before brewer can make any adjustments, like addition of minerals.

Dissolved Oxygen (DO)

After boiling in the kettle, the hopped wort is devoid of oxygen. It is cooled down rapidly to below 80 °F (27 °C) before oxygenation for better oxygen uptake. The amount of dissolved oxygen required depends on the yeast strain and the original gravity of the wort. Traditional ale and lager worts were usually not collected higher than 1045 (12°P) and required 6 to 8 ppm dissolved oxygen. With high gravity brewing original gravities have increased up to 1080 (20°P) and require dissolved wort oxygen levels of 16 ppm or higher.[7] Modern strains of yeast can require as high as 20ppm DO. After oxygenation, yeast is pitched into the wort. Yeast utilizes oxygen to become healthy and to reproduce before fermenting the wort to beer. Oxygen is necessary to produce unsaturated fatty acids and sterols for yeast's cell walls. A strong cell wall enhances the yeast' alcohol tolerance. Healthy yeast metabolizes wort into alcohol and carbon dioxide without giving off-flavors or off-odors.[8] Once fermentation is complete, the beer is free from oxygen and must be protected from oxygen exposure to prevent oxidation and staling. It is almost impossible not to introduce oxygen during transfers and packaging (bottling and canning), but the amount should be insufficient for healthy yeast to grow.[7] Brewers should be capable of achieving less than 50 ppb (0.05ppm) total in package oxygen.

Potassium

Malt contains between 4-6 g/kg of potassium, the major part of which is solubilized during mashing; in beer the concentration of potassium lies between 300 – 500 ppm (mg/L). Above 500 ppm, beer can be salty. Potassium has a purely saline effect. The potassium/calcium ratio affects yeasts flocculation.[9]

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Measuring Salt Content in Chili Sauce with LAQUAtwin Salt-11 Pocket Meter

Chili sauces may contain high amount of salts that increase chances of kidney and heart diseases. To measure the salt content in chili sauce, simply dilute a weighed sample with distilled or deionized water and then place some drops onto the sensor of LAQUAtwin Salt-11 pocket meter. The meter measures the salt content accurately and displays the result in either percentage (%) or parts per thousand (ppt) in just a few seconds.

Introduction

Chili sauce is a popular condiment that adds spice and flavour to food. It may be hot, sweet, or a combination thereof, and may have a thicker texture and viscosity compared to that of hot sauces. The ingredients of chili sauces vary, but typically include cooked chili peppers, vinegar, sugar, salt and sometimes red tomato. Some chili sauces available commercially are loaded with salt and other preservatives that can be damaging to your health.

Salt, chemically known as sodium chloride (NaCl), is a commonly used seasoning ingredient that serves as flavour enhancer and preservative in packaged or processed foods. It aids in balancing sweetness and suppressing bitterness. It also keeps the growth of pathogenic organisms at bay. Most bacteria, fungi, and other potentially pathogenic organisms cannot survive in a highly salty environment. Such environment is hypertonic, which will dehydrate any living cell causing it to die or temporarily inactivated.

The LAQUAtwin Salt-11 pocket meter offers fast, simple, and easy way of measuring salt content in packaged or processed foods such as chili sauces. This waterproof pocket meter measures the conductivity value of a sample and converts it to salinity value with selected seawater or sodium chloride (NaCl) calibration curve in the meter. The reading on the backlit LCD can be expressed as percentage (%) or parts per thousand (ppt). The replaceable sensor is designed with small sample well, which is embedded with two titanium metal electrodes coated with platinum black. This unique sensor can hold and measure micro-volume sample as little as 0.12ml.

Method

Meter set-up and calibration

Select the desired measurement unit and calibration curve combination in the meter settings - either % NaCl or ppt NaCl. Calibrate the meter according to manufacturer's instructions using 0.5% (5ppt) and 5% (50ppt) NaCl standards that come with the kit.

Sample preparation and measurement

1. Weigh a portion of the chili sauce and add distilled or deionized water.

   Example: 5 to 20 grams of chili sauce diluted to 100 ml or grams with DI water in a volumetric flask.

2. Mix the diluted sample thoroughly.
3. Using a dropper, place some drops of diluted sample onto the sensor.
4. Record the stable reading.

Chili sauce should be diluted with distilled or deionized water to liberate the salt. The reading of the diluted sample should fall within the calibrated measurement range of the meter. To obtain accurate results, a uniform temperature should be maintained for the standards and samples.

After measurement, clean the sensor with detergent and warm water. If there are still sample residues or stains after cleaning, place some drops of household bleach (≤5% sodium hypochlorite) onto the sensor and leave it for 5 to 30 minutes. Rinse the sensor with clean water and blot dry with soft tissue. For more information on maintenance, refer to Technical Tip 3: LAQUAtwin Conductivity Sensor Maintenance Procedures.

Results and benefits

Chili sauces may contain varying amounts of salt. Salt is soluble in water. It contains 40% sodium (Na), which is a mineral required by the body in small amount for maintaining blood pressure and fluid balance as well as transmitting nerve impulses. Besides salt,

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sodium is also found in monosodium glutamate (MSG), baking soda, and baking powder. Too much sodium can increase blood pressure and damage kidneys.

For packaged or processed foods, sodium is listed as milligrams (mg) per serving as well as per 100g on the nutrition information panel of the label, rather than salt. Table 1 shows the measurement results of chili sauce with LAQUAtwin Salt-11 pocket meter.

Table 1: Measurement Results of Chili Sauce with LAQUAtwin Salt-11 Pocket Meter

A	Sodium (mg / 100g) on Bottle Label	4520		
B	Chili Sauce Weight (g)	15.0581		
C	Volume (ml) or weight (g) After Dilution	100		
D	LAQUAtwin Salt-11 Pocket Meter Reading (% NaCl)	1.66	1.71	1.71
E	Calculated NaCl Salt (g / 100g)	11.02	11.36	11.36
F	Calculated Na (mg / 100g)	4335	4469	4469
G	Recovery (%)	96	99	99

To calculate the amount of sodium from salt (NaCl) reading obtained with LAQUAtwin Salt-11 pocket meter, use the equations in Table 2. Refer to the values in Table 1 to follow the sample calculations. Note that the ppt NaCl reading is not indicated in Table 1.

Table 2: Sodium Chloride (NaCl) and Sodium Calculations

Meter Reading	1.66% NaCl =1.66g NaCl / 100 ml or g dil. chili sauce	16.4ppt NaCl =16.4g NaCl / L or Kg dil. chili sauce
NaCl Salt (g / 100g)	**Meter reading (D) x Dilution Factor (C/B) x 100**	
	$\frac{1.66g\ NaCl}{100ml\ (g)} \times \frac{100ml\ (g)}{15.0581g} \times 100g$	$\frac{16.4g}{L\ (Kg)} \times \frac{0.1L\ (Kg)}{15.0581g} \times 100g$
Na (mg / 100g)	**NaCl salt per 100g (E) x $\frac{\text{Na molar mass}}{\text{NaCl molar mass}}$ x 1000**	
	$11.02g\ NaCl \times \frac{22.99\ Na}{58.44\ NaCl} \times \frac{1000mg}{g}$	$10.89g\ NaCl \times \frac{22.99\ Na}{58.44\ NaCl} \times \frac{1000mg}{g}$
Recovery (%)	**$\frac{\text{Calculated Sodium mg / 100g (F)}}{\text{Listed Sodium mg / 100g on Label (A)}}$ x 100**	
	$\frac{4335}{4520} \times 100$	$\frac{4284}{4520} \times 100$

According to the National Health Group Pharmacy in Singapore, adults should limit the amount of salt to one teaspoon per day, which is about 5g of salt or 2g of sodium. To ensure that you are not taking more than that amount, always check the amount of sodium per serving on the nutrition information panel of your chili sauce and other packaged or processed food. If that information is not available, simply perform a quick salt test with LAQUAtwin Salt-11 pocket meter.

References And Suggested Readings
1. Chili Sauce. Wikipedia. https://en.wikipedia.org/wiki/Chili_sauce
2. National Healthcare Group Pharmacy. All About Salt. https://www.pharmacy.nhg.com.sg/All_About_Salt/

Measuring Salt Content in Chili Sauce with LAQUAtwin Salt-22 Pocket Meter

Chili sauces may contain high amount of salts that increase chances of kidney and heart diseases. To measure the salt content in chili sauce, simply dilute a weighed sample with distilled or deionized water and then place some drops onto the sensor of LAQUAtwin Salt-22 pocket meter. The meter measures the salt content accurately and displays the result in percentage (%) unit in just a few seconds.

Introduction

Chili sauce is a popular condiment that adds spice and flavour to food. It may be hot, sweet, or a combination thereof, and may have a thicker texture and viscosity compared to that of hot sauces. The ingredients of chili sauces vary, but typically include cooked chili peppers, vinegar, sugar, salt and sometimes red tomato. Some chili sauces available commercially are loaded with salt and other preservatives that can be damaging to your health.

Salt, chemically known as sodium chloride (NaCl), is a commonly used seasoning ingredient that serves as flavour enhancer and preservative in packaged or processed foods. It aids in balancing sweetness and suppressing bitterness. It also keeps the growth of pathogenic organisms at bay. Most bacteria, fungi, and other potentially pathogenic organisms cannot survive in a highly salty environment. Such environment is hypertonic, which will dehydrate any living cell causing it to die or temporarily inactivated.

The LAQUAtwin Salt-22 pocket meter offers fast, simple, and easy way of measuring salt content in packaged or processed foods such as chili sauces. This waterproof pocket meter with backlit LCD measures the sodium concentration of a microvolume sample and converts it to salt or sodium chloride concentration in percentage (%) unit. The replaceable sensor has a sample well embedded with flat sodium ion selective sensor. This unique sensor can hold sample as little as 0.3ml or 0.05ml when used with sampling sheet.

Method

Meter Set-up and Calibration

Calibrate the meter according to manufacturer's instructions using 0.5% and 5.0% NaCl standards that come with the kit.

Sample Preparation and Measurement

1. Weigh a portion of the chili sauce and add distilled or deionized water.

   Example: 5 to 20 grams of chili sauce diluted to 100 ml or grams with DI water in a volumetric flask.
2. Mix the diluted sample thoroughly.
3. Using a dropper, place some drops of diluted sample onto the sensor.
4. Record the stable reading.

Chili sauce should be diluted with distilled or deionized water to liberate the salt. The reading of the diluted sample should fall within the calibrated measurement range of the meter. To obtain accurate results, a uniform temperature should be maintained for the standards and samples.

After measurement, clean the sensor with detergent and warm water. If there are still sample residues or stains after cleaning, place some drops of household bleach (≤5% sodium hypochlorite) onto the sensor and leave it for 5 to 30 minutes. Rinse the sensor with clean water and blot dry with soft tissue. For more information on maintenance, refer to Technical Tip 2: LAQUAtwin Ion Sensor Maintenance Procedures.

Results and Benefits

Chili sauces may contain varying amounts of salt. Salt is soluble in water. It contains 40% sodium (Na), which is a mineral required by the body in small amount for maintaining blood pressure and fluid balance as well as transmitting nerve impulses. Besides salt, sodium is also found in monosodium glutamate (MSG), baking soda, and baking powder. Too much sodium can increase blood pressure and damage kidneys.

For packaged or processed foods, sodium is listed as milligrams (mg) per serving as

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well as per 100g on the nutrition information panel of the label, rather than salt. Table 1 shows the measurement results of chili sauce with LAQUAtwin Salt-22 pocket meter.

Table 1: Measurement Results of Chili Sauce with LAQUAtwin Salt-22 Pocket Meter

A	Sodium (mg / 100g) on Bottle Label	4520
B	Chili Sauce Weight (g)	10.0618
C	Volume (ml) or weight (g) After Dilution	100
D	LAQUAtwin Salt-22 Pocket Meter Reading (% NaCl)	1.1
E	Calculated NaCl Salt (g / 100g)	10.93
F	Calculated Na (mg / 100g)	4300
G	Recovery (%)	95

To calculate the amount of sodium from salt (NaCl) reading obtained with LAQUAtwin Salt-22 pocket meter, use the equations in Table 2. Refer to the values in Table 1 to follow the sample calculations.

Table 2: Sodium Chloride (NaCl) and Sodium Calculations

Meter Reading	1.1% NaCl =1.1g NaCl / 100 ml or g dil. chili sauce
NaCl Salt (g / 100g)	Meter reading (D) x Dilution Factor (C/B) x 100
	$\frac{\text{1.1g NaCl}}{\text{100ml (g)}} \times \frac{\text{100ml (g)}}{\text{10.0618g}} \times \text{100g}$
Na (mg / 100g)	$\text{NaCl salt per 100g (E)} \times \frac{\text{Na molar mass}}{\text{NaCl molar mass}} \times 1000$
	$\text{10.93g NaCl} \times \frac{\text{22.99 Na}}{\text{58.44 NaCl}} \times \frac{\text{1000mg}}{\text{g}}$
Recovery (%)	$\frac{\text{Calculated Sodium mg / 100g (F)}}{\text{Listed Sodium mg / 100g on Label (A)}} \times 100$
	$\frac{4300}{4520} \times 100$

According to the National Health Group Pharmacy in Singapore, adults should limit the amount of salt to one teaspoon per day, which is about 5g of salt or 2g of sodium. To ensure that you are not taking more than that amount, always check the amount of sodium per serving on the nutrition information panel of your chili sauce and other packaged or processed food. If that information is not available, simply perform a quick salt test with LAQUAtwin Salt-22 pocket meter.

References and Suggested Readings

1. Chili Sauce. Wikipedia. https://en.wikipedia.org/wiki/Chili_sauce
2. National Healthcare Group Pharmacy. All About Salt. https://www.pharmacy.nhg.com.sg/All_About_Salt/

Measuring Sodium Content in Chili Sauce with LAQUAtwin Na-11 Pocket Meter

Chili sauces may contain high amount of sodium from dissolved salts. To measure the sodium content in chili sauce, simply dilute a weighed sample with distilled or deionized water and then place some drops onto the sensor of LAQUAtwin Na-11 pocket meter. The meter measures the sodium content accurately and displays the result in either parts per million (ppm) or mg/L in just a few seconds.

Introduction

Salt, chemically known as sodium chloride (NaCl), is a commonly used seasoning ingredient that serves as flavour enhancer and preservative in packaged or processed foods. It aids in balancing sweetness and suppressing bitterness. It also keeps the growth of pathogenic organisms at bay. Most bacteria, fungi, and other potentially pathogenic organisms cannot survive in a highly salty environment. Such environment is hypertonic, which will dehydrate any living cell causing it to die or temporarily inactivated.

Chili sauce is a popular condiment that adds spice and flavour to food. It may be hot, sweet, or a combination thereof, and may have a thicker texture and viscosity compared to that of hot sauces. The ingredients of chili sauces vary, but typically include cooked chili peppers, vinegar, sugar, salt and sometimes red tomato.

Chili sauces may contain varying amounts of salt. Salt is soluble in water. It contains 40% sodium (Na), which is a mineral required by the body in small amount for maintaining blood pressure and fluid balance as well as transmitting nerve impulses. Besides salt, sodium is also found in monosodium glutamate (MSG), baking soda, and baking powder. Too much sodium can increase blood pressure and damage kidneys.

The LAQUAtwin Na-11 pocket meter offers fast, simple, and easy way of measuring sodium content in packaged or processed foods such as chili sauces. This waterproof pocket meter measures the sodium concentration in micro volume sample ~ 0.3ml when directly placed onto the sensor or 0.05ml with sampling sheet. The replaceable sensor is designed with small sample well, which is embedded with flat sodium ion selective sensor. The reading on the backlit LCD can be expressed as mg/L or parts per million (ppm).

Method

Meter Set-up and Calibration

Calibrate the meter according to manufacturer's instructions using 150ppm and 2000ppm sodium standards that come with the kit.

Sample Preparation and Measurement

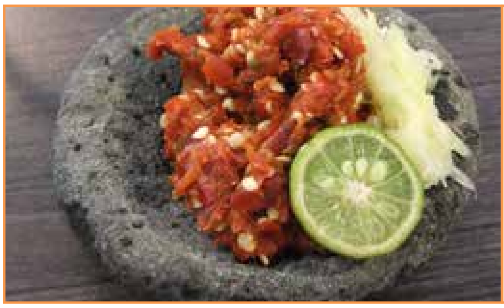
1. Weigh a portion of the chili sauce and add distilled or deionized water.

   Example: 2 to 10 grams of chili sauce diluted to 100 ml or grams with DI water in a volumetric flask.

2. Mix the diluted sample thoroughly.
3. Using a dropper, place some drops of diluted sample onto the sensor.
4. Record the stable reading.

Chili sauce should be diluted with distilled or deionized water to liberate the salt. The reading of the diluted sample should fall within the calibrated measurement range of the meter. To obtain accurate results, a uniform temperature should be maintained for the standards and samples.

After measurement, clean the sensor with detergent and warm water. If there are still sample residues or stains after cleaning, place some drops of household bleach (≤5% sodium hypochlorite) onto the sensor and leave it for 5 to 30 minutes. Rinse the sensor with clean water and blot dry with soft tissue. For more information on maintenance, refer to Technical Tip 2: LAQUAtwin Ion Sensor Maintenance Procedures.



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Results and Benefits

For packaged or processed foods, sodium is listed as milligrams (mg) per serving as well as per 100g on the nutrition information panel of the label, rather than salt. Table 1 shows the measurement results of chili sauce with LAQUAtwin Na-11 pocket meter.

Table 1: Measurement Results of Chili Sauce with LAQUAtwin Na-11 Pocket Meter

A	Sodium (mg / 100g) on Bottle Label	4520
B	Chili Sauce Weight (g)	2.3185
C	Volume (ml) or weight (g) After Dilution	100
D	LAQUAtwin Na-11 Pocket Meter Reading (ppm)	1000
E	Calculated Na (mg / 100g)	4313
F	Calculated NaCl Salt (g / 100g)	10.96
G	Recovery (%)	95

To calculate the amount of salt from sodium reading obtained with LAQUAtwin Na-11 pocket meter, use the equations in Table 2. Refer to the values in Table 1 to follow the sample calculations.

Table 2: Sodium and Sodium Chloride Conversions

Meter Reading	1000ppm Na =1000 mg Na / L or Kg dil. chili sauce
Na (mg / 100g)	Meter reading (D) x Dilution Factor (C/B) x 100
	$\frac{1000 \text{ mg Na}}{\text{L (Kg)}} \times \frac{0.1\text{L (Kg)}}{2.3185\text{g}} \times 100\text{g}$
NaCl Salt (g / 100g)	$\text{Na per 100g (E)} \times \frac{\text{NaCl molar mass}}{\text{Na molar mass}} \times \frac{1}{1000}$
	$4313\text{mg Na} \times \frac{58.44 \text{ NaCl}}{22.99 \text{ Na}} \times \frac{\text{g}}{1000\text{mg}}$
Recovery (%)	$\frac{\text{Calculated Sodium mg / 100g (E)}}{\text{Listed Sodium mg / 100g on Label (A)}} \times 100$
	$\frac{4313}{4520} \times 100$

According to the National Health Group Pharmacy in Singapore, adults should limit the amount of salt to one teaspoon per day, which is about 5g of salt or 2g of sodium. To ensure that you are not taking more than that amount, always check the amount of sodium per serving on the nutrition information panel of your chili sauce and other packaged or processed food. If that information is not available, simply perform a quick sodium test with LAQUAtwin Na-11 pocket meter.

References and Suggested Readings

1. Chili Sauce. Wikipedia. https://en.wikipedia.org/wiki/Chili_sauce
2. National Healthcare Group Pharmacy. All About Salt. https://www.pharmacy.nhg.com.sg/All_About_Salt/

pH Measurement in the Acidification of Fermented Sausages

Lowering pH or increasing acidity of meat has become main hurdle against pathogenic bacteria in sausage making. pH is used in the course of fermentation process in order to produce microbiologically stable product that has a pH value of 5.3 or less.

Introduction

The process of fermenting and drying is believed to be one of the oldest techniques for preserving meat. This results in a characteristic flavoured sausage with a lowered pH and a reduced water activity that makes the final sausage stable with long shelf life, even if not being subjected to heat treatment.

Fermented sausages are a class of chopped or ground meat products that, as a result of microbial fermentation of a sugar have reached a pH of 5.3 or lower and have undergone a drying/aging process to remove 15-25% moisture. They are classified according to moisture content—dry (e.g., Pepperoni, Salami) or semi-dry (e.g., Summer sausage, Thuringer, Cervelat, Landjaegar).

After mixing the ingredients and stuffing into casings, sausages are placed in an environment with controlled temperature and humidity. At this fermentation stage, the pH of the sausages decreases due to lactic acid bacteria that produce lactic acid from metabolizing sugar. Lactic acid bacteria such as *Lactobacillus* or *Pediococcus* are either naturally present or added as starter cultures. Aside from bacteria, chemical acidulants such as glucono-delta-lactone and citric acid can also be added to rapidly increase acidity and create an extra margin for safety. The pH drop causes the proteins to give up water, resulting in a drying effect that creates an environment unfavorable to spoilage organisms. Drying continues after the fermentation stage and more moisture is removed from the sausage.

Fermented sausages should attain a pH of 5.3 or lower within the proper time frame in order to control the growth of pathogenic bacteria such as *E. coli 0157:H* and *Staphylococcus aureus*. During the fermentation of sausages to a pH 5.3, it is necessary to limit the time during which the sausage is exposed to temperatures exceeding 15.6°C, otherwise the product will spoil, even though the recommended pH was attained. This time frame is temperature dependent and these are the criteria (tables shown are guidelines in developing fermentation process):

Time in C degree-hours above 15.6°C	Maximum Chamber Temperature
Less than 665	Less than 33°C
<555	33-37°C
<500	Greater than 37°C

Degrees are measured as the excess over 15.6° C, the critical temperature at which staphylococcal growth effectively begins. Degree-hours = temperature in excess of 15.6°C (deg) x time (hours)

The pH of every batch of sausages should be periodically checked and recorded during fermentation to ensure that the pH reaches 5.3 or lower within the required period. The LAQUAtwin pH meter can be used by home sausage-makers or meat processing plants for monitoring the pH of their sausages.

Constant Temperature Fermentation

Degree (C)-hours limit for the corresponding temperature	Chamber Temperature	Maximum hours to pH 5.3
	°C	
665	24	78.9
665	26	63.8
665	28	53.6
665	30	46.2
665	32	40.5
555	33	31.8
555	34	30.1
555	35	28.6

This table provides maximum hours that a product may be fermented at a given constant fermentation temperature to obtain pH 5.3. Example: At 26°C constant temperature, a sausage must reach pH 5.3 within 63.8 hours or less. Those hours can also be calculated for any temperature.

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> **Fermented sausages such as salamis have been associated with food-poisoning outbreaks globally due to pathogenic microorganisms.**

Method

Test the meter's accuracy regularly and if necessary, calibrate the LAQUAtwin pH meter using 4.01 and 7.00 pH buffers according to manufacturer's instructions.

Sample Measurement

This method is based on the Australia New Zealand Food Standards Code - Standard 1.6.2.

1. Mince a representative portion of the sausage and place that portion in a stoppered bottle with twice its weight of water then shake.
2. Place a portion of the liquid into the sensor. Record the pH and temperature once stabilized.
3. Clean the sensor with soap and warm water to remove oily residues and/or protein cleaning solution to remove proteins. Rinse the sensor with water and blot dry with soft tissue.

To obtain accurate results, a uniform temperature should be maintained for the standard buffer solutions and samples. The test should be made at a temperature between 20-30°C, the optimum is 25°C.

Results and Benefits

Fermented sausages such as salamis have been associated with food-poisoning outbreaks globally due to pathogenic microorganisms. In light of this, it is of utmost importance to be in strict compliance with the regulatory guidelines for fermented sausages. In the USA, the Food Safety and Inspection Service requires that the shelf-stable dry sausages be nitrite cured, fermented, smoked, reached a final pH of 5 or less and have a moisture/protein ratio of 1.9:1 or less. The two main factors contributing to the safety and stability of these products are low pH and reduced water activity. The product must reach pH 5.3 or below (or other validated pH) within a specified period to control the growth of pathogenic microorganisms including Staphylococcus aureus and pathogenic E. coli.

Average Characteristics of Australian UCFM processes and products*

Characteristic	Salami (range of variation)	Mettwurst (range of variation)
Composition (lean % : fat %)	80.4 : 19.6 (70:30 - 90:10)	83.25 : 16.75 (70:30 - 96:4)
NaCl (%)	2.45 (2.0 - 3.3)	2.02 (1.3 - 2.8)
Nitrite (ppm)	284 (145- 490)	211 (35 - 490)
Final pH	4.72 (5.0 - 4.4)	4.66 (4.8 - 4.4)
Fermentation time (hrs)	49 (24 - 72)	42 (18 - 72)
Fermentation temp. (°C)	23.3 (18 - 28)	28.6 (17 - 40)
Ripening time (days)	14.8 (1-30)	5.3 (0 – 28)
Ripening temp. (°C)	14.1 (4 - 32)	18 (0 - 40)

*Derived from data supplied by ANZFA reflecting current Australian uncooked comminuted fermented meat product formulations
(Source: Ross, T., and Shadbolt, C.T., Predicting Escherichia coli inactivation in uncooked comminuted fermented meat products. University of Tasmania. Meat and Livestock Australia.)

References and Suggested Reading

1. Marianski, Adam and Marianski, Stanley. The Art of Making Fermented Sausages. 2nd ed. USA: Book Magic, 2009.
2. New Zealand Food Safety Authority.Guidelines for the Production of Uncooked Comminuted Fermented Meat (UCFM) Products. July 2009
3. Good Manufacturing Processes for Fermented Dry & Semi-Dry Sausage Products. The American Institute Foundation. October 1997

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Food & Beverage
Application Notes

pH of Brine For Canned Food Testing

For brine of canned acid foods, the equilibrium pH value must be 4.6 or below to inhibit the growth of Clostridium botulinum, the most heat resistant of the food pathogen microorganisms.

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Introduction

The anaerobic bacterium *Clostridium botulinum* produced in improperly canned foods has caused illness and death. The vacuum seal on cans provides an oxygen-free environment that will allow *C. botulinum* spores to grow and produce deadly toxin, if the canning process is not carried out properly. Fortunately, the *C. botulinum* spores will not grow in high-acid foods (pH ≤ 4.6). For low-acid foods (pH > 4.6), these spores, that are resistant to boiling water temperature, must be killed during the canning process.

The appropriate pH in the cans is obtained by the use of brines with known acid concentrations or tablets of known acid compositions that are added to cans of specified volumes. The contents of the cans must be then conveniently stirred to ensure that the pH is below 4.6 in the center of all food particles. Acids used in canning to lower the pH to 4.6 are usually citric, lactic and malic, but also glucono-delta-lactone.

The LAQUAtwin pH meter can be used by food processors or home canners to measure the pH of brine in canned foods. There are three (3) LAQUAtwin pH meter models available, namely pH 11, 22, and 33. These light, pocket-sized meters allow two to five calibration points using either NIST or USA pH buffers. The pH 33 meter has built-in temperature sensor that measures and displays temperature and automatic temperature compensation feature (ATC) that performs automatic calibration to the exact pH of the buffer at the measured temperature. Refer to the specifications of each meter model for more information.

Method

Calibrate the LAQUAtwin pH meter using pH 4.01 and 7.00 (or 6.86) buffers according to manufacturer's instructions.

Sample Measurement

Using the pipette that comes with the meter, take an aliquot of the brine sample and place some drops into the sensor. Record the pH and temperature once stabilized. After testing each brine sample, rinse the sensor with water and blot dry with soft tissue.

To obtain accurate results, a uniform temperature should be maintained for the standard buffer solutions and brine samples. The test should be made at a temperature between 20-30°C, the optimum is 25°C.

Results and Benefits

Food acidity is important in preventing botulism, a foodborne illness that comes from eating contaminated food with toxins produced by *C. botulinum*. This fact is used in canning acid foods. Aside from following tested recipes and proper canning methods to ensure that C. botulinum is killed and does not grow in canned food, performing accurate pH measurement using a reliable instrument is also necessary to ensure that the correct pH value of 4.6 or below is attained for food safety and regulatory compliance. The final equilibrium pH (the pH of a food product after the food acid is distributed equally throughout the product) must be checked, controlled and documented after the product has completed the thermal processing step.

Table 1: Some pH Values of Common Foods

Food	pH
Vinegar	2.5
Lemon Juice	2.6
Jelly	3.1
Ketchup	3.6
Mayonnaise	3.7
Canned peaches	3.9
Canned Tomatoes	4.0
Canned Green Beans	5.0
Canned Hominy	6.8

(Source: John E. Rushing, Ph.D., Formulating Dressings, Sauces, and Marinades. Food Safety)

Table 2: Acidity and Canning Requirements

Acid (pH)	Type	Botulism Potential	Canning Method
≤ 4.6	Acid Food	No	Hot fill* (~190°F) or Boiling Water Canner (~212°F)
> 4.6	Low Acid Food	Yes	Pressure required (~250°F)

*Hot fill processing is only recommended for licensed food processors. Home canners should use the boiling water canning process. (Source: Numer, Brian. Food Acidity and Safety, FN/Food Safety/2008-01)

References

1. Sun, Da-Wen. Thermal Food Processing New Technologies and Quality Issues. 2nd ed. USA: CRC Press, 2012.
2. Numer, Brian. Food Acidity and Safety. FN/Food Safety/2008-01. Utah University. August 2008.
3. Pickle Bill Factsheet. Dairy and Food Inspection Division. Minnesota Department of Agriculture

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pH Measurement to Determine Freshness of Meat Products

Fresh meat must have a pH value in the range of 5.5 to 6.2 before selling to consumers. LAQUAtwin pH meter provides a simple and cost effective way to check the freshness of meat in the local markets.

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LAQUAtwin pH Meters Product Page

Introduction

Fresh meat must have a pH value in the range of 5.5 to 6.2.[1] During temporary storage, especially when it is not properly preserved, the fresh meat will turn rancid and have a pH value below 5.3.

The LAQUAtwin pocket pH Meter is used as quality control check to ensure freshness of the meat, before selling to consumers. This is an easy, quick check method used to abide to the Vietnamese Standards in ensuring that customers are purchasing fresh meat that can be safely consumed.

Method

A small sample of meat is sliced off and minced. This is to ensure total sampling of the inner and outer part of the meat. Place the minced meat on the flat sensor of the LAQUAtwin pocket pH Meter and measure. To repeat sampling, wash with diluted soap water and pat dry with a paper tissue. Place new meat sample on the senor and repeat testing process.

Results and Benefits

As mentioned in the article by VNExpress on 1st March 2014, the Laqua Twin pH meter provides a simple and cost effective way to check the freshness of meat in the local markets. This test procedure is implemented by the Hanoi Departments of Health, Agriculture, Industries and Commerce to establish quality control of food safety by using a quick inspection tool in Vietnam wholesale markets.

The LAQUAtwin pocket pH meter is small and compact; convenient to carry around the marketplace for easy on-site testing. Its easy-to-use interface is simple for anyone to use the LAQUATwin pocket pH Meter. Preliminary results show stable and accurate readings were obtained during a trial run of LAQUATwin pocket pH Meter in Hanoi meat market.

Typical pH values for meat and meat products:[2]

Product	pH value (range)
Meat mixes in jelly + vinegar added	4.5 to 5.2
Raw fermented sausage	4.8 to 6.0
Beef	5.4 to 6.0
Pork	5.5 to 6.2
Canned meats	5.8 to 6.2
Curing brines	6.2 to 6.4
Blood sausages	6.5 to 6.8
Muscle tissues, immediately after slaughter	7.0 to 7.2
Blood	7.3 to 7.6

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[1] Vietnam's National Standard TCVN 7046 2002

[2] Meat Processing Technology For Small- To Medium-Scale Producers, FAO Document Repository

pH Measurement to Determine Acidification of Sushi Rice

The rice used for sushi must be acidified with acetic acid (vinegar) to pH less than 4.6 to inhibit the growth of pathogenic bacteria. To measure pH, simply place a sample of rice mixture onto the flat sensor of LAQUAtwin pH meter.

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LAQUAtwin pH Meters Product Page

Introduction

Rice used for sushi must have a pH of less than 4.6. At pH levels below 4.6, most pathogenic bacteria do not grow or produce toxins[1]. Thus, the rice must be acidified using acetic acid (vinegar) to be classified as non-hazardous. The LAQUAtwin pocket pH Meter is used as quality control check to ensure that the rice is adequately acidified, before selling to consumers. This is an easy, quick check method used to abide to the ANZ Standards[2] in ensuring that customers are safely consuming sushi.

Method

Acetic acid (vinegar) should be mixed into the rice according to the following table.

Ingredients	Recipe 1	Recipe 2	Recipe 3
Short Grain Rice	900 g	900 g	900 g
Water	1100 ml	1320 ml	1250 ml
Rice Vinegar	135 ml	99 ml	128 ml
Sugar	57 g	94 g	44 g
Salt	9 g	25 g	8 g

A small sample of the rice mixture is placed on the flat sensor of the LAQUAtwin pocket pH Meter and measured. If the measured value is above pH 4.6, add more acetic acid to the rice mixture and stir well. Place new rice sample on the senor and repeat testing process. After tests, wash the sensor with diluted soap water and pat dry with a paper tissue.

Results and Benefits

The use of accurate pH testing in controlling the quality of sushi rice prevents the growth of pathogenic bacteria and toxins.

The LAQUAtwin pocket pH meter is small and compact; convenient to carry around in your pocket and is ideal for on-site testing. Its easy-to-use interface makes the LAQUATwin pocket pH Meter an indispensable tool for food testing. 💧

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[1] Hocking, A.D; 2003. Foodborne Microorganisms of Public Health Significance, AIFST, Waterloo
[2] Food Safety Guideline for Preparation and Display of Sushi, June 2007, NSW/FA/F1005/0706

pH Measurement of Pickled Fruits and Vegetables

Pickling is a process of preserving fruits and vegetables in brine, oil, water or vinegar. The Australia New Zealand Food Standard Code 2.3.1 requires the preserved fruits and vegetables to have a pH not greater than 4.6 to prevent botulism.

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pH Meters
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Introduction

Vegetables in oil have caused botulism outbreaks in United States. Botulism is caused by the anaerobic, spore-forming bacterium *Clostridium botulinum*. This resulted to the development of Title 21 of the Code of Federal Regulation (21 CFR 114), a regulation for acidified foods. Australian authorities adopted similar precautions to 21 CFR 114 and included a requirement in the Australia New Zealand Food Standard Code 2.3.1. This code states that “fruits and vegetables in brine, oil, vinegar or water, other than commercially canned fruit and vegetables, must have a pH not greater than 4.6”.

The LAQUAtwin pH meter have three (3) models, namely pH 11, 22 and 33, which can be used to measure pH of pickled fruits and vegetables. These pocket-sized meters allow two to five calibration points using either NIST or USA pH buffers. The pH 33 meter has built-in temperature sensor that measures and displays temperature and automatic temperature compensation feature (ATC) that performs automatic calibration to the exact pH of the buffer at the measured temperature. Refer to the specifications of the meters for more information.

Method

Calibrate the LAQUAtwin pH meter using pH 4.01 and 7.00 (or 6.86) buffers according to manufacturer’s instructions.

Sample Preparation And Measurement

1. Drain the liquid of pickled fruits and vegetables.
2. Blend the fruits and vegetables in a blender to a paste consistency. For some samples, it may be necessary to add a small amount of distilled water (less than 20mL DI in 100g sample) to facilitate blending. This will not alter the pH of most products as distilled water contains no hydrogen ions.
3. Place a portion of the paste into the sensor.
4. Record the pH and temperature once stabilized.
5. After each sample, rinse the sensor with water and blot dry with soft tissue.
6. Determine two pH values on the blended sample. These readings should agree with one another to indicate that the sample is homogeneous.

Results and Benefits

Food acidity is important in preventing botulism, a foodborne illness that comes from eating contaminated food with toxins produced by *C. botulinum*. This fact is used in preparing pickled fruits and vegetables. Aside from following tested recipes in acidification and proper packaging of products, performing accurate pH measurement using a reliable instrument is also necessary to check if pH 4.6 or below is attained for food safety and regulatory compliance.

References

1. NSW Food Authority. Shelf stable acid preserved foods. NSW/FA/FI035/0811
2. Title 21 of the Code of Federal Regulation (21 CFR 114)

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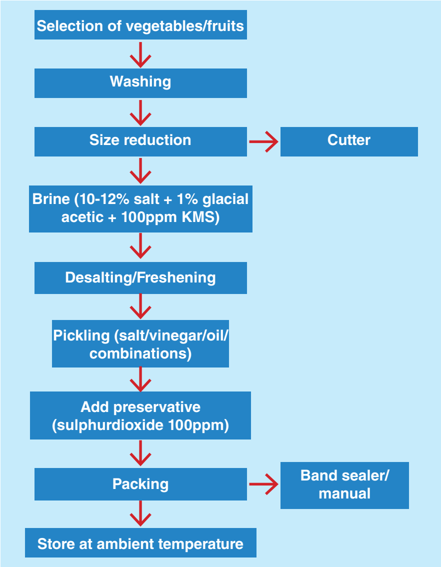


Figure 1: Flowchart of Pickling Process
(Source: Lesson 9. Processed Products from Fruits and Vegetables, Crop Process Engineering)

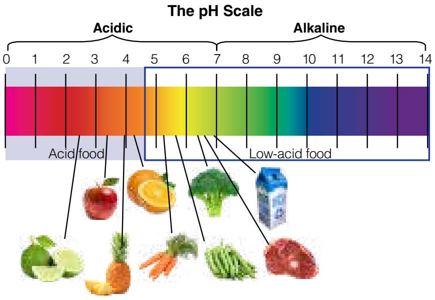
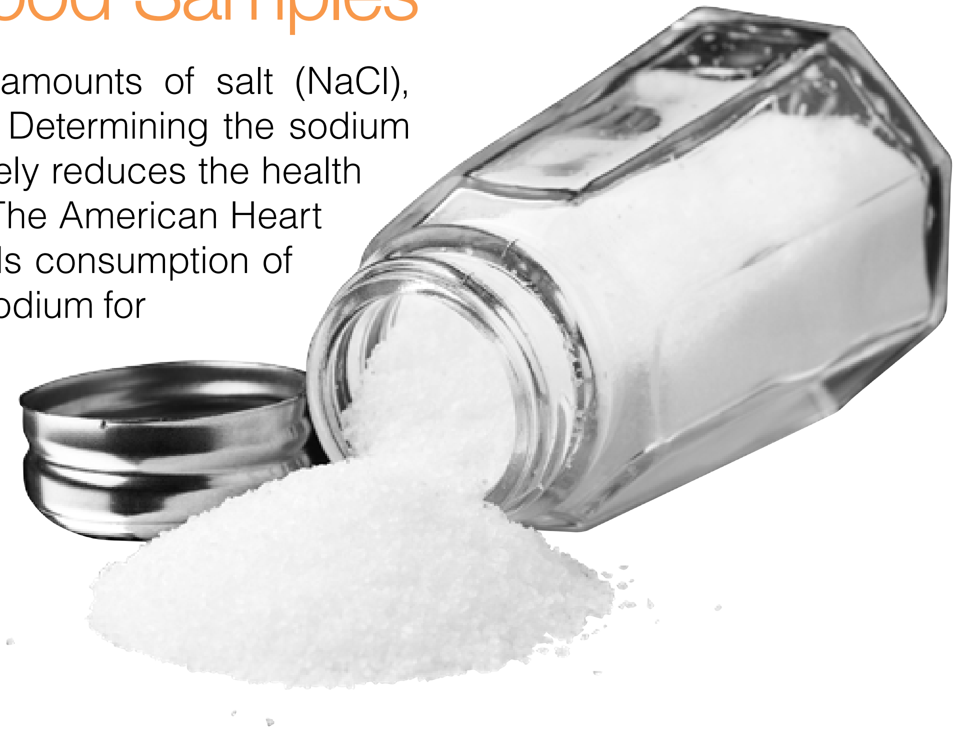


Figure 2: The pH Scale
(Source: Science Basics for Food and Safety and Quality, Virginia Cooperative Extension)

Determination of Sodium Content in Food Samples

Foods contain varying amounts of salt (NaCl), which has 40% sodium. Determining the sodium content in foods accurately reduces the health risks associated with it. The American Heart Association[1] recommends consumption of less than 1500 mg/day sodium for most American adults, which is the level with the greatest effect on blood pressure.



Introduction

Most foods have sodium from dissolved salts, either naturally present or added in cooking or processing. Table salt known as sodium chloride (NaCl) is the most common source of sodium. It is made up of 40% sodium and 60% chloride and often used in processed and packaged foods as flavour enhancer or preservative. Other sources of sodium added in foods are monosodium glutamate (MSG), sodium nitrite, sodium saccharin, baking soda (sodium bicarbonate), and sodium benzoate.

Table 1: Range of Sodium Content for Selected Foods

Food Group	Serving Size	Range (mg)
Breads, all types	1 oz	95-210
Frozen pizza, plain, cheese	4 oz	450-1200
Salad dressing, regular fat, all types	2 tbsp	110-505
Salsa	2 tbsp	150-240
Soup (tomato), reconstituted	8 oz	700-1260
Tomato juice	8 oz	340-1040
Potato chips	1 oz	120-180
Tortilla chips	1 oz	105-160
Pretzels	1 oz	290-560
1 oz = 28.4g		

(Source: Dietary Guidelines for Americans- http://health.gov/dietaryguidelines/dga2005/document/html/chapter8.htm)

The sodium content of food has implications on our health. Sodium is an essential mineral required in small amount by the body to control blood pressure and help the nerves and muscles to function properly. However, high sodium intake can cause health problems such as high blood pressure and cardiovascular diseases, which include heart, stroke, and blood vessel disease. Thus, knowing the sodium content in food and controlling the intake are of utmost important to keep diseases at bay.

To determine the sodium content in food samples, LAQUAtwin B-722 Sodium Ion meter offers rapid, simple, and easy measurement. This pocket meter has flat sodium sensor, which measures the sodium concentration in micro-volume samples, and result compensation setting (i.e., multiplication/known factor), which can be used to account sample preparation (e.g., dilution, blank reading) in results. Results can be expressed as parts per million (ppm) or mg/L.

Method

Meter Set-Up and Calibration

Make sure that the meter is set to two (2) calibration points prior to calibration. Calibrate the meter according to manufacturer's instructions using 150ppm and 2000ppm sodium ion standards.

Sample Preparation and Measurement

Liquid samples such as soups, sauces, brines, beverages, etc., can be placed directly onto the sensor. Dilute the sample with distilled or deionized water, if the results exceeded the meter's calibration or measurement range (e.g., 5ml sample dilute to 100ml using DI water).

Solid samples such as chips, cheese, ham etc., must be prepared to liberate the sodium. Mince or crush the sample in a blender. Weigh the crushed sample accurately, then add distilled or deionized water (e.g., 5 grams of sample in 100ml DI water). Mix the sample thoroughly. Place some drops of prepared sample onto

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> **The sodium content of food has implications on our health. Sodium is an essential mineral required in small amount by the body to control blood pressure and help the nerves and muscles to function properly.**

the sensor and record the reading. To obtain accurate results, a uniform temperature should be maintained for the standard solutions and samples.

After measurement, clean the sensor with detergent and water (warm, if measured sample is oily). If the sensor is stained with sample residues, place a few drops of bleach onto the sensor and leave for 5 to 30 mins. Rinse the sensor with water and blot dry with soft tissue. Condition the sensor by soaking it with 2000ppm sodium standard for 10 minutes to 1 hour prior to next use.

For high accuracy measurement, prepare ionic strength adjuster (ISA) solution containing 4M NH_4Cl and 4M NH_4OH. Add equal volume of ISA to all samples and standards (i.e., 2ml ISA in 100ml samples or standards)[2].

Results and Benefits

Foods contain varying amounts of salt. For processed or packaged foods, sodium is listed as milligrams (mg) per serving on the nutrition information panel of the food packaging rather than salt. To compute the sodium and salt (NaCl) contents in food samples from the results, use the formulas in the table above.

Table 2: Sodium and Salt Contents Computation

Content Per Serving	Liquid	Solid
Sodium (mg)	Sodium (mg/L or ppm) x sample volume (L)	Sodium (mg/L or ppm) x DI water volume (L) x original sample weight (g) / analyzed sample weight (g)
NaCl (mg)	Sodium (mg) x 2.54	Sodium (mg) x 2.54
Example	Sample: 150mL Tomato Juice 1) Drops of tomato sauce give 1500 ppm reading. 2) 5ml juice diluted to 100ml gives 75 ppm (x 20 to account dilution). For 1 and 2, the sodium content is 225 mg while the salt content is 571.5 mg.	Sample: 28.4g Potato Chips Crush chips and weigh 5g. Add the 5g in 100ml DI water and mix thoroughly. Drops of diluted chips give 250 ppm reading. The sodium content is 142 mg while the salt content is 360.68 mg.

The American Heart Association[1] recommends consumption of less than 1,500 mg per day sodium for most American adults, which is the level with the greatest effect on blood pressure. This level does not apply to people who lose large amounts of sodium in sweat, such as competitive athletes, workers exposed to extreme heat stress, or to those directed otherwise by their healthcare provider.

To achieve the recommended level, check the nutrition information panel on food packaging when shopping and purchase the product which has the lowest sodium content after comparing different brands. Alternatively, test your food samples to determine the sodium content. 💧

Figure 1: Nutrition Facts on the label of Tomato Juice (Source: Sodium Content, Medline Plus https://www.nlm.nih.gov/medlineplus/ency/imagepages/19703.htm)

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REV 1.0, 6 DECEMBER 2015

Sodium Value Check for Canned Food

There is a growing concern on canned foods with large sodium content as excessive intake of sodium can cause high blood pressure and hypertension. To check the sodium content in canned food, dilute a sample with DI water in 1:5 ratio, then place the resulting solution onto the LAQUAtwin sodium ion meter.

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Introduction

Sodium is a mineral needed for normal body function, but an excessive intake of it can cause high blood pressure and hypertension. The 2010 Dietary Guidelines for Americans recommends that individuals consume less than 2300 mg of sodium per day.

A growing concern is the large sodium content especially in canned foods. Many foods are misleading in their sodium content and it is important that people know about the amounts of sodium they are ingesting.

To determine the sodium content of canned foods, the Horiba LAQUAtwin Na+ meter can be used. This is an easy and quick method used to consider the sodium content of canned products.

Method

1. The canned product must be liquefied (if solid) by blending.
2. 1 g of the sample can be taken and added to 4 g of water.
3. The mixture should be shaken for one minute. A pipette can be used to extract a small sample of the blended mixture.
4. This is placed on the sensor of the LAQUAtwin Na^+ meter and the sodium content is measured after one minute.
5. To repeat sampling, wash the sensor with tap water and pat dry with a paper tissue.

Results and Benefits

The use of the Horiba LAQUAtwin Na^+ meter to measure the sodium content of canned food products will improve consumers' knowledge of their sodium intake. This will thus help to combat the increasing issues of high blood pressure and hypertension.

The LAQUAtwin pH meter is small and compact; convenient to carry around the marketplace for easy on-site testing. Its easy-to-use interface is simple for anyone to use the LAQUAtwin hand held pH meter.

Sample	Sodium concentration on the Label	Sodium Concentration after 5 Times Dilution (A÷5)[*1]	Measurement Result by LAQUAtwin	Error of Each Measurement Data to Label Value[*2]
Minestrone	5390 mg/kg	1078 mg/L	1000 mg/L	within ± 10 %
Clam Chowder	6530 mg/kg	1306 mg/L	1300 mg/L	within ± 10 %
Corn Soup	6330 mg/kg	1266 mg/L	1200 mg/L	within ± 10 %

[*1] Sodium concentration was calculated on the assumption that the specific gravity of sample is 1.
[*2] The error may become larger for extremely viscous or oily samples.

How to Measure Sodium Ion in Canned Soup with LAQUAtwin (5 times dilution measurement)

1. Scale 1g of sample

2. Add 4g of water, so that it weighs 5g in total

3. Shake the sample container for 1 min.

4. Drop the supernatant until it fully covers the electrode

5. Read the value after 1 min.

Measurement of Calcium in Milk and Milk Beverages

Determining the calcium content of milk and milk beverages helps consumers accurately gauge their calcium intake. Unlike atomic absorption spectroscopy (AAS) and inductively coupled plasma atomic emission spectroscopy (ICP), the LAQUAtwin calcium ion meter offers a simpler method of measuring calcium ion-ionizing proteinbound calcium in sample using acid before analysis.

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Product Page

Introduction

It is often necessary to determine the calcium content of milk and milk beverages. This may be done by atomic absorption spectroscopy (AA) or inductively coupled plasma atomic emission spectroscopy (ICP). Alternatively, by ionizing protein-bound calcium using an acidizing pretreatment, the LAQUAtwin Ca^{2+} can be used to measure the total amount of calcium easily.

The LAQUAtwin Ca^{2+} meter is used as check to determine the Calcium content of milk products before selling to consumers. This is an easy, quick method to check the amount of calcium in lactic products.

Method

Pretreatment procedure (for milk)

Acidify the milk with hydrochloric acid (HCl) to a pH of between 4.3 and 4.6 (which can be determined by use of the LAQUAtwin pocket pH meter). Wait for the solution to precipitate and use the liquid part of the sample for the test. A small sample of the solution is placed on the sensor of the LAQUAtwin Ca^{2+} and measured. To repeat sampling, wash with diluted soap water and pat dry with a paper tissue.

Pretreatment procedure (for milk beverages such as lactic drinks)

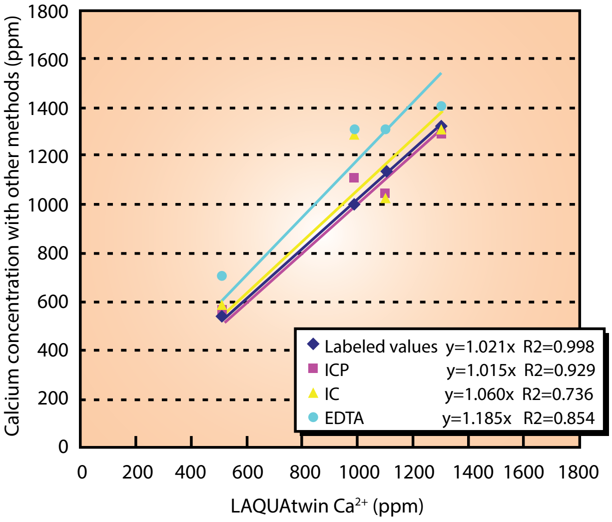
Acidify the lactic drink with hydrochloric acid (HCl) and use the LAQUAtwin pH meter to confirm it has a pH of about 2. Then, dilute this sample and add tris-hydroxy-aminomethane so that the solution has a pH value between 4.3 and 4.6. Wait for the solution to precipitate and use the liquid to sample. A small sample of the solution is placed on the sensor of the LAQUAtwin Ca^{2+} and measured. To repeat sampling, wash with diluted soap water and pat dry with a paper tissue.

Results and Benefits

The use of accurate Calcium ion testing in controlling the quality and calcium content of lactic products ensures that consumers are accurately able to gauge their calcium intake. This is especially beneficial for those who are lactose intolerant.

The LAQUAtwin Ca^{2+} pocket meter is small and compact; convenient to carry around the marketplace for easy on-site testing. Its easy-to-use interface is simple for anyone to use the LAQUATwin Ca^{2+} pocket meter.

[1] Correlation of Calcium concentration between LAQUAtwin Ca^{2+} and other methods



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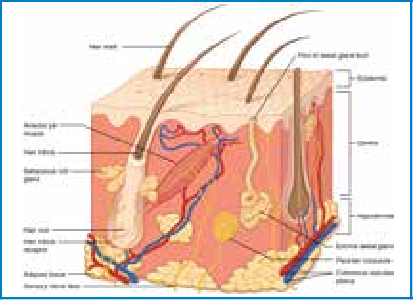
[1] Internal study by HORIBA labs, 2013

Measurement of Skin Surface pH

Human skin is covered with an acid mantle making it slightly acidic – pH 4.8 to 6.0. The apparent pH value of skin can be measured by applying 1 or 2 drops of DI water or physiological saline and placing a 6261-10C flat glass pH electrode or 0040-10D ISFET pH electrode on the moistened surface. The results may vary for test sites within an individual and between individuals.



Introduction

The skin is the outer covering of the body which serves primarily as protection against pathogens and excessive water loss. The other functions of skin include insulation, temperature regulation, sensation, synthesis of vitamin D, and the protection of vitamin B folates. The skin is composed of three primary layers: the epidermis (outermost), the dermis, and the hypodermis (innermost). The epidermis consists of five layers and the outermost layer is the stratum corneum. On top of the stratum corneum is a very fine, slightly acidic film called acid mantle that acts as barrier to bacteria, viruses, and other potential contaminants that might penetrate the skin.[1] The normal values of pH in intact skin range from 4.8 to 6.0 due to presence of the acid mantle, while the interstitial fluid is characterized by neutral values.[2]

The skin hydrogen potential (pH) is a measure of the hydrogen ion concentration $[H^+]$ in the watery solution present on the surface. This solution is obtained by adding water to the skin surface, which is a hydrophobic layer comprising of lipids. Some of the lipids (the free fatty acid) are amphiphilic. These amphiphilic free fatty acids release their H^+ ions into the added water. The pH is therefore the measurement of their dissociation within the water applied on the skin surface.[3] Since the skin is not an aqueous solution, the measured skin surface pH values are referred to as apparent pH values due to the extraction of water-soluble components of the stratum corneum into the liquid interface between the skin and the pH measuring system.[4]

The skin surface pH can provide an indication of the skin condition and health. In the past, measurement of skin surface pH has been used to assess the barrier properties of the stratum corneum and also to evaluate the relationship between changes in superficial skin microflora and the development of skin irritation. Researchers have noted that a relationship exists between the acidity of the skin surface and its antimicrobial activity. Currently, skin pH measurements are used in assessing the effects of various materials such as acid or alkaline products and environmental factors on the skin surface and in assessing the state of acute or chronic cutaneous diseases.[2]

Flat pH electrodes, also called flat bottom pH electrodes, flat tip pH electrodes, and flat surface pH electrodes, were developed for measuring pH of surface skin. The use of flat pH electrode connected to a pH meter provides not only excellent contact with the skin but also measurement accuracy within ± 0.1 pH. This measurement is non-invasive and produces only small electric current causing no skin damage. Both the sensing membrane and reference junction of a flat pH electrode are constructed on the flat surface tip of the electrode body. This tip configuration is perfect for measuring pH of single drop or small volume of liquid samples as well as moist surfaces of soft solid or semi-solid samples such as meat, paper, skin, cloth, cheese, leaves, leather, bread dough, and culture media.

HORIBA offers two types of flat pH electrodes which are based on two different electrode technologies, the 6261-10C combination flat glass pH electrode and 0040-10D ion sensitive field effect transistor (ISFET) pH electrode. The pH sensitive part of the former is a glass membrane based on pH glass electrode technology while that of the latter is a miniature semiconductor-based sensor based on pH transistor technology. The 6261-10C is a refillable combination pH electrode with glass-body that is resistant to chemical attack and sleeve junction that prevents clogging because of its relatively high flowrate compared to conventional ceramic junction. The 0040-10D is designed with ISFET chip and non-glass body, which make it rugged, unbreakable, low maintenance, and waterproof. The advantages of 0040-10D over 6261-10C are as follows:

Features of 0040-10D ISFET pH electrode:

- The sensor is replaceable, easy to clean with soft toothbrush, and can be stored dry.
- The robust epoxy body is ideal for applications and environments where glass material is unacceptable.
- It is integrated with temperature sensor for automatic temperature compensation (ATC) and accurate pH reading.
- It has improved electrostatic protection circuit for reduction of static electricity effect.
- It gives fast response and reduces acidic or alkaline errors in extreme pH conditions.
- It shuts off automatically when not in use.

Method

Meter Set-up and Calibration

Since pH is temperature-dependent, use a pH meter with ATC capability. If 6261-10C pH electrode is used, measure the temperature of pH buffers using a calibrated thermometer and enter the value into the pH meter. This will allow the pH meter to compensate the temperature effect in the calibration.

1. Prepare the pH electrode according to the instruction manual.
2. Set the pH buffer group (e.g. USA or NIST) and desired resolution (e.g. 0.1 pH) in the pH meter and connect the pH electrode.
3. Select at least two pH buffers (usually pH 4.01 and 7.00 buffers) that bracket the expected skin pH. Pour small amount of fresh pH buffers in beakers for calibration.
4. Rinse the tip of pH electrode with distilled or deionized water and blot dry with soft tissue.
5. Calibrate the pH electrode / meter system with pH buffers according to the manufacturer's instructions.

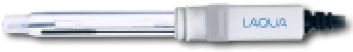
After calibration, slope should be within 95 – 105%. If slope is not within this range, change the pH buffers and clean, drain / refill (only applicable for 6261-10C), and condition the pH electrode according to the instruction manual.

Sample Preparation And Measurement

This method is based on the European Group on Efficacy Measurement of Cosmetics and Other Topical Products (EEMCO) guidance for the in vivo assessment of skin surface pH.[4]

During 24 hours before the measurement, sweating and washing the test site should be avoided. Practical considerations are as follows:

- Keep the room temperature under 23°C (e.g. 20 – 22°C) and the relative humidity between 40 and 60% to to minimize sweat production.
- Let the volunteers acclimatized to the measuring environment for at least 20 mins before measurements are performed.

Model	 **6261-10C**	 **0040-10D**
Description	Combination Flat glass pH Electrode	Ion Sensitive Field Effect Transistor (ISFET) pH Electrode
pH Range	0 – 12	0 – 14
Temperature Range (°C)	0 – 50	0 – 60
Reference Junction	Sleeve	Porous sintered polyethylene
Reference Electrode	Ag/AgCl	Ag/AgCl
Temperature Sensor	—	Built-in
Replacement Sensor	—	0141
Material	Glass	Epoxy
Dimensions (mm)	150 x 12	190 x 10
Cable length	1m	1m
Connector(s)	BNC	BNC & phono jack
Fill Solution	3.33M KCl	—
Power	—	CR2032 x 2
Part No.	3014081807	3200367925
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- Avoid cleaning, even with pure water, as it can greatly affect pH measurements.
- Allow minimum period of time to elapse between the personal hygiene procedures of the volunteers and the measurements. For tap water, a period of 2 - 3 hours should be enough. After the use of synthetic cleansers and alkaline soaps, periods of 5 and 10 - 24 hours are recommended, respectively.
- Measurements should be made 12 hours after application of creams.[2]
- Remove cosmetic residues and excessive sebum on the skin by dry wiping.
- Refer to the instruction manual for the proper preparation, maintenance, cleaning, and storage of the pH electrode.
- To obtain accurate results, calibration and measurement should be carried out at the same temperature.

To measure pH on skin surface, perform the following:

1. Moisten the skin surface or pH electrode[3] by applying one or two drops of distilled / deionized water or physiological saline.
    - For comparative measurements, the volume of water used should be standardized (e.g. 20 μl) as the result of pH measurements could be affected by a surplus of water on the electrode.
2. Place the flat pH electrode on the moist skin surface with a slight pressure to measure pH. Make sure that the tip touches the skin surface and no gap between them.
    - Avoid excessive pressure on the electrode because this could influence the extraction of material from epidermis' stratum corneum and may exclude water between the skin and the pH electrode membrane.
3. Record the pH and temperature displayed on the meter once stable.
4. After measurement, rinse the tip of pH electrode with distilled or deionized water and blot dry with soft tissue.

The pH values of surface skin may vary for each test site within an individual and between one individual to another as a result of a number of factors. As such, report results of skin surface pH measurements as difference or percent change in pH values (rather than absolute values) using a measure of central tendency and variability (i.e., arithmetic mean and standard deviation).[5]

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23 October 2017, Rev. 0

Measuring Sodium and Potassium Concentrations in Athlete's Sweat

Sweat testing carried out by regional patch sweat collection, syringe sweat extraction, and LAQUAtwin analysis is the simplest and most practical method to assess electrolyte losses of athletes in the field for electrolyte replacement recommendations. During exercise or training, athlete's sweat is collected with absorbent patches applied on skin sites and subsequently extracted with a syringe for rapid determination of sodium (Na$^+$) and potassium (K$^+$) concentrations with LAQUAtwin Na-11 and K-11 pocket meters, respectively. Baker et al. (2014) compared the results of this field method with those obtained from laboratory-based centrifuge-HPLC and found that they were significantly correlated.

Introduction

Sweating allows the body to regulate its temperature. It causes a decrease in temperature through evaporative cooling at the skin surface. When individuals are in hot weather or their muscles heat up due to physical activity, more sweat is produced in order to cool down. Sweat is mostly water with small amounts of electrolytes, which include sodium (Na$^+$), potassium (K$^+$), calcium (Ca^{2+}), and magnesium (Mg^{2+}). As sweating increases, electrolyte composition in the body decreases. The concentrations of electrolyte loss can vary among individuals.

Measuring the electrolyte losses from athletes' sweat could assist health professionals in planning personalized water and electrolyte replacement strategies. This would prevent water/electrolyte imbalances and heat-related whole-body muscle cramps in sports that could impair athletes' performance. While Na$^+$ loss is primarily measured since it is the electrolyte lost in the greatest quantities and has the most significant impact on body fluid balance, K$^+$ loss measurement can also provide valuable information. Both sweat sodium concentration [Na$^+$] and potassium concentration [K$^+$] are needed to predict changes in serum [Na$^+$] from mass balance equations. Furthermore, sweat [K$^+$] can serve as quality control check of sweat sample. A sweat sample with very high [K$^+$] can indicate quality issues such as sample evaporation, contamination, or leaching of electrolytes from skin that would not have been detected from measuring sweat [Na$^+$] alone.

To perform sweat testing in the field, sweat can be easily sampled with absorbent patches placed on clean skin of anatomical sites after the athlete established steady-state sweating during exercise or training. The sweat sample is then extracted from each absorbent patch with syringe for immediate analysis with LAQUAtwin Na-11 and K-11 pocket meters.

The LAQUAtwin Na-11 and K-11 waterproof pocket meters measure sodium concentration [Na$^+$] and potassium concentration [K$^+$], respectively, in microvolume samples and display results in just a few seconds. The sensors are replaceable and each has sample well embedded with flat ion selective electrode paired with a reference electrode. With this unique design, the sensors are capable of measuring samples as little as 0.3ml with direct application or 0.05ml with sampling sheet. The reading in the backlit digital LCD can be expressed as ppm, mg/L, or mmol/L unit.

Method

Meter set-up and calibration

Calibrate the LAQUAtwin Na-11 and K-11 pocket meters according to manufacturer's instructions using their respective 150 and 2000ppm standard solutions.

Sample collection and measurement

Sweat tests with athletes should be conducted during exercise or training and in conditions representative of their sport.

1. After the onset of exercise or training (~10 mins), clean the following athlete's anatomical skin sites with alcohol wipe or deionized / distilled water rinse and dry with sterile gauze or towel: right anterior mid thigh, right posterior mid forearm, left posterior mid forearm, upper chest, right scapula, left scapula, and forehead.
2. Attach one sterile patch at each site.
3. Remove each patch with sterile tweezers after absorbing sufficient sample but before complete saturation.
4. Place each patch inside the barrel of a 5-ml syringe. Depress the plunger to compress the patch and expel sweat directly onto the sensors of pocket meters or vial for later analysis.
5. Record the stable readings.

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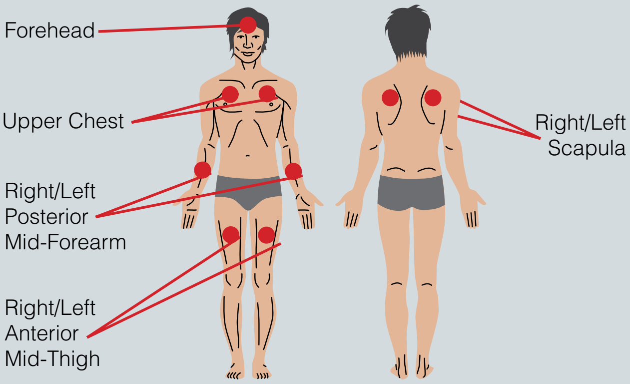
To obtain accurate results, a uniform temperature should be maintained for the standard solutions and samples. If sweat sample volume is not enough to cover the flat sensor, a sampling sheet can be used to disperse the sample on the sensor surface. After measurement, rinse the sensor, tweezer, and syringe with distilled or deionized water and blot dry with soft tissue. For more information on maintenance, refer to **Technical Tip 2: LAQUAtwin Ion Sensor Maintenance Procedures**.



Results And Benefits

To maintain water and electrolyte balance during prolonged exercise or training, it is recommended to drink water and/or sports drink to replace the water and Na$^+$ loss from profuse sweating. Thus, having a rapid, low-cost method and user-friendly, portable instrument to measure athlete's sweat in the field could assist health professionals in tracking changes in sweat [Na$^+$] and planning water and electrolyte replacement strategies.

Baker et al. (2014) conducted a study comparing a field versus reference laboratory method for extracting (syringe vs. centrifuge) and analysing sweat [Na$^+$] and [K$^+$] (LAQUAtwin vs. HPLC) collected with regional absorbent patches during exercise in a hot-humid environment. They found that the sweat [Na$^+$] and [K$^+$] obtained with the syringe-LAQUAtwin field method were significantly correlated to those of centrifuge-HPLC laboratory method (See Table 1 for the results). The LAQUAtwin Na-11 and K-11 pocket meters (superseded the B-722 and B-731 models used in the study) have been proven practical and useful tools in delivering rapid, cost-effective, and highly reliable measurements of athletes' sweat [Na$^+$] and [K$^+$], respectively, in field studies.

Table 1: Validity of field technique using syringe extraction of sweat and LAQUAtwin analysis: SYRINGE LAQUAtwin vs. CENTRIFUGE HPLC for sweat [Na$^+$] and [K$^+$].

	Sweat [Na$^+$]	Sweat [K$^+$]
Mean Difference ± SD (mEq/L)	3.97 ± 10.87*	0.50 ± 0.48*
95% CI of mean difference (mEq/L)	2.49-5.45	0.42-0.59
ICC	0.93*	0.84*
SEE (mEq/L)	8.68	0.44
TEM (mEq/L)	7.68	0.34
CV (%)	12.54	8.48

n = 210 for sweat [Na$^+$] and 116 for sweat [K$^+$]. CV, coefficient of variation; CI, confidence interval; HPLC, ion chromatography using the Dionex ICS-3000; HORIBA, HORIBA B-722 for sweat [Na$^+$] and HORIBA B-731 for sweat [K$^+$]; ICC, interclass correlation coefficient (based on two-way mixed ANOVA, absolute agreement, average measures); SD, standard deviation; SEE, standard error of the estimate; TEM, typical error of measurement; *$P < 0.001$.

Source: Baker et al. (2014). Validity and reliability of a field technique for sweat Na$^+$ and K$^+$ analysis during exercise in a hot-humid environment.

Sweat [Na$^+$] determined from anatomical sites can be used to predict whole-body sweat [Na$^+$] with regression equations. Sweat [Na$^+$] can vary considerably among individuals and typically ranges from approximately 10 to 90 mmol/L. Unlike [Na$^+$], sweat [K$^+$] is considerably lower and less variable despite changes in sweating rate. For this reason, sweat [K$^+$] can serve as quality control check in sweat electrolyte testing. If the sweat [K$^+$] is > 10 mmol/L, the potential issues are sample evaporation, contamination, or leaching of electrolytes from skin. Sweat samples that do not fall within these normal ranges: [Na$^+$] =10 – 90 mmol/L, [K$^+$] = 2 – 10 mmol/L should be flagged. Initial sweat may have high concentrations due to minerals trapped in sweat pore. To avoid this, clean skin surface and collect sample after 10 minutes of training or exercise or when steady-state sweating is achieved.

To convert ppm or mg/L reading to mEq/L or mmol/L, divide the reading by the molar mass of the ion (Na$^+$ = 22.989, K$^+$ = 39.098). Alternatively, refer to **Technical Tip 7: Procedure for Setting mmol/L Unit in LAQUAtwin Ion Pocket Meters** to set the meter to display the reading in mmol/L unit. Callibration in mmol/L unit can also be performed on the LAQUAtwin ion pocket meters.

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Measurement of Sodium in Athletes' Sweat

Determining the sodium concentration in sweat and replacing that with proper electrolyte intake prevent fluid and electrolyte imbalances. Sweat can be easily extracted from sterile patches applied on skin and tested with LAQUAtwin sodium ion meter. According to Gatorade Sports Science Institute, the sodium results obtained with HORIBA falls within 15.4 mEq/L 95% of the time.

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Introduction

It is useful to determine the amount of sodium present in sweat as replacing sodium (Na^+) lost from sweating plays an important role in preventing fluid and electrolyte imbalances. By finding the amount of sodium lost, one may estimate the amount of electrolyte that should be replaced.

Sweat can usually be tested for sodium content by a ion chromatography techniques in analytical laboratories. But most athletes do not have ready access to such facilities. The Horiba ion tester can be used instead of the traditional ion chromatography in order to determine the amount of sodium in sweat

The LAQUAtwin Na^+ meter is used as simple test to determine the Sodium ion content of sweat in order to replace the electrolytes after intense activity. This is an easy, quick method used to check the amount of sodium present in sweat.

Method

When the subject has begun to sweat, the target sites must be cleaned with deionized water and dried. Then, sterile patches can be applied directly onto the right anterior mid-thigh, right posterior mid forearm, left posterior mid forearm, upper chest, right scapula, left scapula, and forehead. The subjects should then continue with their strenuous activity and the patches removed just before they are saturated with sweat.

Sweat is then extracted from the patches. A small sample of the sweat solution extracted is placed on the sensor of the LAQUAtwin Na^+ and measured. To repeat sampling, wash the sensor with tap water and pat dry with a paper tissue.

Results and Benefits

By using accurate Sodium ion testing for sweat in athletes, we can determine the electrolyte imbalance and thus athletes can better address this by optimising their electrolyte intake during activity.

Though ion chromatography is the gold laboratory standard, the results derived by Horiba's ion analysis alternate method are not only simpler to acquire, but also accurate.

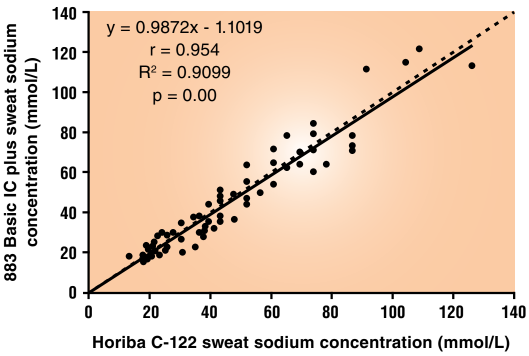
According to a study by Gatorade Sports Science Institute, 'On the basis of typical error of the measurement results, sweat [Na^+] and [K^+] obtained with HORIBA falls within `15.4 mEq/L and `0.68 mEq/L, respectively 95% of the time'.

The LAQUAtwin Na^+ pocket meter is small and compact; convenient to carry around the marketplace for easy on-site testing. Its easy-to-use interface is simple for anyone to use the LAQUATwin Na^+ pocket meter.

Reference:

Lindsay B. Baker, Corey T. Ungaro, Kelly A. Barnes, Ryan P. Nuccio, Adam J. Reimel, and John R. Stofan "Validity and reliability of a field technique for sweat Na^+ and K^+ analysis during exercise in a hot-humid environment" Physiological Reports Vol. 2 Issue 5 (2014)

Eric D. B. Goulet, Tommy Dion, and Étienne Myette-Côté "Validity and reliability of the Horiba C-1 compact sodium analyzer in sweat sample of athletes" European Journal of Applied Physiology (2012)



Inter-analyzer correlation plot for the Horiba C-122 versus 883 Basic IC plus analyzer. The *dashed line* represents the line of identity

pH of Cement for Floor Installation Testing

Fresh concrete is usually very alkaline, above pH 11. When the alkalinity in a concrete subfloor is high, it can stop the floor covering adhesive from bonding properly to the concrete. Australian Standard 1884 for resilient flooring installation states the the pH level of the concrete surface should be between 9 and 10 before the flooring can be installed.

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LAQUAtwin pH Meters Product Page

Introduction

When flooring tiles are installed, it is very important that the subfloor level has a certain pH level. When the alkalinity in a concrete subfloor is high, it can stop the floor covering adhesive from bonding properly to the concrete. This is a problem that has only recently been discovered and the new Australian Standard for resilient flooring installation (AS 1884-2012) now says that a pH test must be carried out on a concrete subfloor as part of the pre-installation assessment.

Fresh concrete is usually very alkaline, above pH 11. AS 1884 states ‘the pH level of the concrete surface should be between 9 and 10’ before the flooring can be installed.[1]

In order to determine the pH level, and hence consider whether floor installation can be commenced, the Horiba LAQUAtwin pH meter can be used.

The Horiba LAQUAtwin pH meter is used to determine the pH of the cement to prepare for floor installations. This is an easy and quick method used to ensure that the cement is at the optimum pH.

Method

Sand a small section of the concrete surface with 200 grit sandpaper and remove dust.

Put several drops of distilled or ‘de-ionised’ water onto the prepared surface.

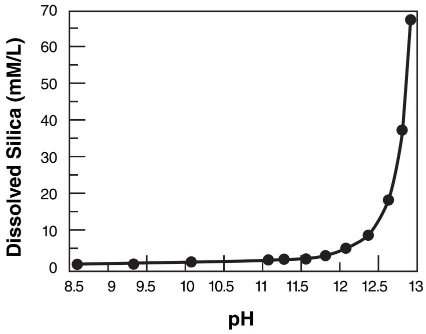
Leave the drops for 60 seconds and then extract the water droplets using a pipette.

The solution is placed on the sensor of the LAQUAtwin pH meter and measured. To repeat sampling, wash the sensor with tap water and pat dry with a paper tissue.

Results and Benefits

The use of the Horiba LAQUAtwin pH meter to ensure a pH of between 9 and 10 in concrete will allow the floor-covering adhesive to bond properly to the concrete. The use of the Horiba pH Meter as opposed to using pH test strips enables the determination of accurate and reliable results.

The LAQUAtwin pH meter is small and compact; convenient to carry around in your pocket for easy on-site testing. Its easy-to-use interface is simple for anyone to use the LAQUAtwin hand held pH meter.



Effect of pH on Dissolution of Amorphous Silica (Tang and Su-fen, 1980)[2]

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[1] Australain Standard AS 1884-2012 Standard report

[2] Alkali-Silica Reaction, United States Department of Transportation - Federal Highway Administration Publication Number FHWA-RD-03-047 July 2003

Residual Sodium Check During Clean-in-Place Process

Caustic soda or sodium hydroxide (NaOH) is the chemical commonly used in alkaline cleaning solution for clean-in-place (CIP) in process plants. Measuring the sodium ion concentration on the water rinse or swab can indicate whether residual chemical has been removed properly from the process equipment.

Introduction

Clean-in-place (CIP) is a method of cleaning the interior surfaces of pipes, vessels, process equipment, filters and associated fittings without disassembly. The CIP system is run by digital computer called programmable logic controllers (PLCs) to control the flow, temperature, and time for the chemical solutions, which could be acidic, alkaline or sometimes both, to achieve maximum cleaning. The chemical solutions are circulated through a circuit of tanks and/or lines to eliminate contaminants or product residues and are rinsed out with water. Depending on the CIP system, chemical solutions may flow back to a reservoir so that they can be re-used or drained immediately after they have been used.

After CIP, the equipment should be visibly clean and free from chemical residues. The final water rinse must ensure that chemical residues are removed properly. Chemical residues from cleaning solutions can be monitored by specific or non-specific analytical method. Specific methods that detect the individual ingredients of cleaning solutions are ion selective electrode (ISE), high performance liquid chromatography (HPLC), thin layer chromatography (TLC), flame photometry, and ultraviolet spectroscopy. Non-specific methodsthat detect the presence of blend of ingredients are pH, conductivity, and total organic carbon (TOC). Specific methods are usually preferable by regulatory agencies, but they may accept non-specific methods with adequate rationales for their use.

As CIP offers fast, repeatable, and effective cleaning without chemical exposure risk to people, it is utilized in industries that require high levels of hygiene such as dairy, beverage, processed foods, pharmaceutical, and cosmetics. CIP is typically employed for cleaning bioreactors, fermenters, mix vessels and other equipment in manufacturing facilities and many CIP systems use alkaline cleaning solutions containing 0.5 to 2% (by weight) caustic soda or sodium hydroxide (NaOH) to remove fats and proteins.

The LAQUAtwin B-722 sodium ion meter can be used to measure and monitor residual sodium ion (Na^+) concentration during CIP in process plants. The meter analyses as little as 0.3 ml sample and delivers result in just few seconds. This fast, easy, and accurate measurement complements the cleaning efficiency of CIP.

Method

Calibrate the LAQUAtwin B-722 sodium ion meter according to manufacturer's instructions using the 150ppm and 2000ppm sodium ion standards included in the kit.

Sample Measurement

Rinse water sampling and wipe sampling are two sampling methods for measuring cleaning chemical residues. Combination of these is desirable.

Rinse water sampling involves taking a sample of an equilibrated water rinse (usually water for injection or pure water) that has been recirculated over all surfaces. To measure, place drops of rinse water sample onto the

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LAQUAtwin B-722 Product Page

> **As CIP offers fast, repeatable, and effective cleaning without chemical exposure risk to people, it is utilized in industries that require high levels of hygiene such as dairy, beverage, processed foods, pharmaceutical, and cosmetics.**

sodium ion sensor using a pipette. Alternatively, open the sensor guard and soak the sensor into a beaker containing rinse water.

Swab or wipe sampling is done directly on equipment surfaces. This is performed in order to assure that the residues are being adequately detected and not simply sitting on the surface and not being dissolved into the equilibrated rinse water. Before wiping begins, moisten the sampling sheet included in the meter kit with water for injection or pure water and allow the equipment to dry after the cleaning procedure. To measure, wipe the surface with a moistened sampling sheet then place it onto the sensor. A blank preparation is required for this sampling method.

Refer to Technical Tip 2: LAQUAtwin Ion Sensor Maintenance Procedures for detailed information on conditioning, cleaning, and storing the sodium ion sensor. The technical tip can be downloaded from the support section of our website www.horiba-laqua.com.

Table 1: LAQUAtwin B-722 Sodium Ion Meter Measurement Results

Solution	Na^+ Concentration (ppm)	Result (ppm)	Recovery	Error
0.01% (100ppm) NaOH	57.5	54	94%	< 10%
0.001% (10ppm) NaOH	5.75	4*	NA	NA
Pure Water (Blank)	0	0-1*	NA	NA

*Values are outside the meter measurement range of 23 to 23,000ppm and are shown for reference only.

Results and Benefits

Cleaning validation is a critical part of current good manufacturing practice to ensure that production materials that come in contact with equipment surfaces are not contaminated. The pre-rinse, alkali circulation, and other steps must take place in correct order. Checks on the identity, purity and strength of cleaning chemicals and on quality of water used for rinsing are needed. Also, the validation protocol must include testing for the residual cleaning chemical to ensure that cleaning chemical used is properly removed. The analysis must be quantitative and the acceptance criteria are determined according to regulatory guidelines and company policy. The table above shows the measurement results of LAQUAtwin B-722 sodium ion meter.

References And Suggested Readings

1. Batt, C.A., Modern Systems of Plant Cleaning. Encyclopedia of Food Microbiology, pp 194-199.
2. Chan, C.C., Lam, H., Zhang X., Practical Approaches to Method Validation and Essential Instrument Qualification.

Revision 1.0, 7 September 2016

Determination of pH as Quality Control Test in Culture Media

pH affects the physical appearance of culture media and their ability to grow microorganisms. Most bacteria grow in pH 6.5 - 7.0 while animal cells thrive in pH 7.2 – 7.4. Measure the pH value of culture media sample in final form at room temperature with a 6261-10C flat glass pH electrode or 0040-10D ISFET pH electrode and pH meter to ensure the quality of each batch.

Introduction

In laboratories, microorganisms such as bacteria, yeast, fungi, animal cells, and plant cells are cultivated in favourable growth environments known as culture media or growth media for various microbiological tests. Culture media contain nutrients, growth promoting factors, energy sources, buffer salts, minerals, metals, and sometimes solidifying or gelling agents (agar) to support the growth and survival of microorganisms. They can be prepared in-house by mixing individual components or purchased commercially as complete dehydrated media and may form as liquid (broth), semi-solid, or solid (agar plate, slant, or deep tube) depending on the solidifying or gelling agent content. Different types of culture media are designed for different types of microorganisms and applications.

Apart from complete nutritional composition, right and stable pH is another important requirement for optimum microbial growth in culture media. The pH of a culture medium should be suitable to the microorganisms that will be grown. Most bacteria grow in pH 6.5 - 7.0 while most animal cells thrive in pH 7.2 – 7.4. As certain microorganisms like bacteria tend to release acidic products that can interfere with their growth, buffers are added in culture media to stabilize the pH. Media manufacturers adjust the pH values of dehydrated media so that the final pH values of the finished culture media conform to the specifications on the product labels when cooled to 25°C.

Prior to use, each batch of culture media must undergo quality control tests. The most important chemical test is pH measurement as pH influences the performance of culture media. If the pH of the finished culture medium is outside the recommended range, not only the growth of the microorganisms that the culture medium is intended to grow is inhibited, but also physical changes such as precipitation of components or soft gelling of agar may occur. Routine pH checks in liquid, semi-solid, or solid culture media can be simply carried out with pH meter and pH electrode after proper calibration with pH buffers.

Flat pH electrodes, also called flat bottom pH electrodes, flat tip pH electrodes, and flat surface pH electrodes, are commonly used in measuring pH of culture media, especially for agar plates. Both the sensing membrane and reference junction of the flat pH electrode are constructed on the flat surface tip of the electrode body. This tip configuration is perfect for measuring pH of single drop or small volume of liquid samples as well as moist surfaces of soft solid or semi-solid samples such as meat, paper, skin, cloth, cheese, leaves, leather, bread dough, and culture media.

HORIBA offers two types of flat pH electrodes which are based on two different electrode technologies, the 6261-10C combination flat glass pH electrode and 0040-10D ion sensitive field effect transistor (ISFET) pH electrode. The pH sensitive part of the former is a glass membrane based on pH glass electrode technology while that of the latter is a miniature semiconductor-based sensor using pH transistor technology. The 6261-10C is a refillable combination pH electrode with glass body that is resistant to chemical attack and sleeve junction that prevents clogging because of its relatively high flowrate compared to conventional ceramic junction. The 0040-10D is designed with ISFET chip and non-glass body, which make it rugged, unbreakable, low maintenance, and waterproof. The advantages of 0040-10D over 6261-10C are as follows:

Features of 0040-10D ISFET pH electrode:

- The sensor is replaceable, easy to clean with soft toothbrush, and can be stored dry.
- The robust epoxy body is ideal for applications and environments where glass material is unacceptable.

- It is integrated with temperature sensor for automatic temperature compensation (ATC) and accurate pH reading.
- It has improved electrostatic protection circuit for reduction of static electricity effect.
- It gives fast response and reduces acidic or alkaline errors in extreme pH conditions.
- It shuts off automatically when not in use.

Model	 **6261-10C**	 **0040-10D**
Description	Combination Flat glass pH Electrode	Ion Sensitive Field Effect Transistor (ISFET) pH Electrode
pH Range	0 – 12	0 – 14
Temperature Range (°C)	0 – 50	0 – 60
Reference Junction	Sleeve	Porous sintered polyethylene
Reference Electrode	Ag/AgCl	Ag/AgCl
Temperature Sensor	—	Built-in
Replacement Sensor	—	0141
Material	Glass	Epoxy
Dimensions (mm)	150 x 12	190 x 10
Cable length	1m	1m
Connector(s)	BNC	BNC & phono jack
Fill Solution	3.33M KCl	—
Power	—	CR2032 x 2
Part No.	3014081807	3200367925
Scan the QR code for more information		

Method

Meter Set-Up And Calibration

Since pH is temperature-dependent, use a pH meter with ATC capability. If 6261-10C pH electrode is used, measure the temperature of pH buffers using a calibrated thermometer and enter the value into the pH meter. This will allow the pH meter to compensate the temperature effect in the calibration.

1. Prepare the pH electrode according to the instruction manual.
2. Set the pH buffer group (e.g. USA or NIST) and resolution (e.g. 0.01 pH) in the pH meter and connect the pH electrode.
3. Select at least two pH buffers (usually, pH 4.01, 7.00, and 10.01 USA buffers are used) that bracket the expected pH value of the culture medium. Pour small amount of fresh pH buffers in beakers for calibration.
4. Rinse the tip of pH electrode with distilled or deionized water and blot dry with soft tissue.
5. Calibrate the pH electrode / meter system with pH buffers according to manufacturer's instructions.

After calibration, each slope should be within 95 – 105%. If slope is not within this range, change the pH buffers and clean, drain / refill (only applicable for 6261-10C), and condition the pH electrode according to instruction manual.

Sample Preparation And Measurement

Measure the pH of culture media at room temperature (20 – 25°C) unless otherwise specified by the media manufacturer. To obtain accurate results, pH buffers and samples should be at the same temperature.

Laboratory-prepared media should be checked for pH and adjusted with 1M NaOH or 1M HCl (if necessary) before dispensing for sterilization. Verify pH after sterilization as changes in pH may occur. In contrast, commercially available dehydrated media usually require no pH adjustment if properly prepared, so a single sample of sterilized finished culture media can be checked for pH. For agar-based culture media, take the pH of the solidified sample.

1. Place the tip of the flat pH electrode on the surface of the culture medium sample to measure the pH. Make sure that the tip touches the culture medium and no gap between them.
2. Record the pH and temperature displayed on the meter once stable.
3. Refer to literature for the desired pH range of the culture medium. For commercially purchased dehydrated media, refer to the product label to check whether the pH is within the stated range. If not, follow the media manufacturer's recommendations.
4. Before measuring another sample, rinse the tip of pH electrode with distilled or deionized water and blot dry with soft tissue.
5. Discard samples after testing.

Always store the pH electrode clean. To remove protein residues from pH electrode, use HORIBA 250 cleaning solution and warm water. For more information on cleaning and maintenance, refer to the electrode instruction manual.

References And Suggested Readings

1. Baird, R., Denyer, S. & Hodges, N. Handbook of Microbiological Quality Control in Pharmaceuticals and Medical Devices, p. 27.
2. Control of Microbiological Culture Media by Nordic Committee on Food Analysis. Retrieved from http://www.nmkl.org/dokumenter/prosedyrer/sk/PROC10_no.pdf on 25 September 2016.

6 October 2017, Rev. 0

General
Application Notes

Determination of pH in Non-Aqueous Solutions

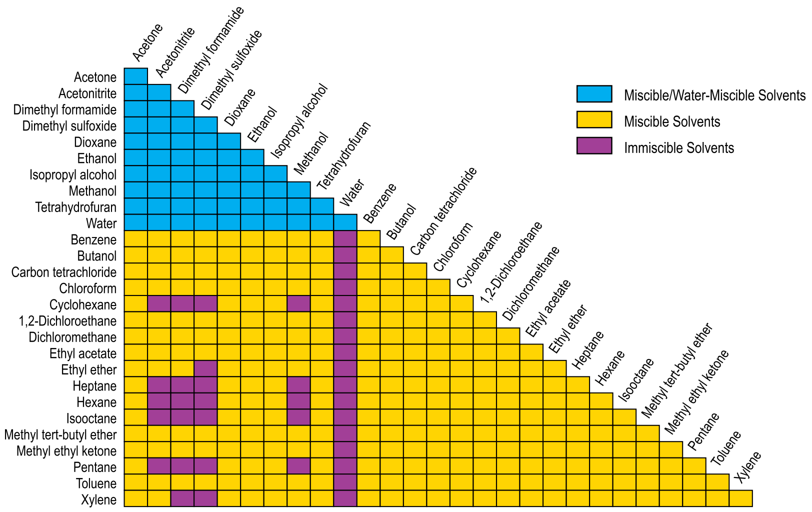
A simple extraction procedure using water is recommended for measuring the pH of non-aqueous solutions containing water-immiscible solvents. Water is added and mixed thoroughly with the sample. After reaching equilibrium, the solvent phase is separated and the pH of the water phase is then measured.

Introduction

Liquids can serve as solvents to dissolve solutes (i.e., solid, liquid or gaseous) to form solutions. The most common solvent is water. Solvents other than water are called non-aqueous solvents. Some examples of non-aqueous solvents are hexane, alcohol, oil, etc. These are often mixed with water or some other non-aqueous solvents to form mixed solvents appropriate for certain applications in chemical research or industrial processes. Non-aqueous solvents that tend to mix with water to form homogeneous mixture are called water-miscible (e.g., methanol, acetone) while those which separate or form a layer when mixed with water are water-immiscible (e.g., oil, hexane, toluene).

pH measurement in non-aqueous and mixed solutions poses a number of issues such as dissociation of the solvent, different pH scale, and liquid junction potential to name a few. The typical problems encountered during measurement with pH electrodes are slow response time, unstable readings, and erroneous results. According to Frant[2], the electrode should have an adequate outward flow from the junction and the junction design should permit easy cleaning for optimum performance. These two key features prevent memory effects at the junction and minimize liquid junction potential.

The Sleeve ToupH 9481-10C electrode (PN 3200611631) is our recommended product for pH measurement in non-aqueous and mixed solutions. It is a refillable, double-junction, glass-body, combination pH electrode. The cable length is 1m and the connector is BNC, compatible with any pH meter that has BNC input. The movable glass sleeve allows easy cleaning of the liquid junction and prevents clogging. The applications include testing of non-aqueous solvents, viscous solutions, and samples containing non-aqueous solvent (e.g., cosmetics, paints, etc). If a combination pH electrode with built-in temperature sensor is desired, the Sleeve ToupH 9681S-10D electrode (PN 3200585463) meets this requirement. This electrode is compatible with HORIBA pH meters only.



Solvent Miscibility and Solubility

🟦 Miscible/Water-Miscible Solvents
🟨 Miscible Solvents
🟪 Immiscible Solvents

	Acetone	Acetonitrite	Dimethyl formamide	Dimethyl sulfoxide	Dioxane	Ethanol	Isopropyl alcohol	Methanol	Tetrahydrofuran	Water	Benzene	Butanol	Carbon tetrachloride	Chloroform	Cyclohexane	1,2-Dichloroethane	Dichloromethane	Ethyl acetate	Ethyl ether	Heptane	Hexane	Isooctane	Methyl tert-butyl ether	Methyl ethyl ketone	Pentane	Toluene	Xylene
Acetone	🟦																										
Acetonitrite	🟦	🟦																									
Dimethyl formamide	🟦	🟦	🟦																								
Dimethyl sulfoxide	🟦	🟦	🟦	🟦																							
Dioxane	🟦	🟦	🟦	🟦	🟦																						
Ethanol	🟦	🟦	🟦	🟦	🟦	🟦																					
Isopropyl alcohol	🟦	🟦	🟦	🟦	🟦	🟦	🟦																				
Methanol	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦																			
Tetrahydrofuran	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦																		
Water	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦																	
Benzene	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟪	🟨																
Butanol	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟪	🟨	🟨															
Carbon tetrachloride	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟪	🟨	🟨	🟨														
Chloroform	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟪	🟨	🟨	🟨	🟨													
Cyclohexane	🟨	🟪	🟪	🟪	🟨	🟨	🟨	🟪	🟨	🟪	🟨	🟨	🟨	🟨	🟨												
1,2-Dichloroethane	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨											
Dichloromethane	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨	🟨										
Ethyl acetate	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨									
Ethyl ether	🟨	🟨	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨								
Heptane	🟨	🟪	🟪	🟪	🟨	🟨	🟨	🟪	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨							
Hexane	🟨	🟪	🟪	🟪	🟨	🟨	🟨	🟪	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨						
Isooctane	🟨	🟪	🟪	🟪	🟨	🟨	🟨	🟪	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨					
Methyl tert-butyl ether	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨				
Methyl ethyl ketone	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨			
Pentane	🟨	🟪	🟪	🟪	🟨	🟨	🟨	🟪	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨		
Toluene	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	
Xylene	🟨	🟨	🟪	🟪	🟨	🟨	🟨	🟨	🟨	🟪	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨

Figure 1: **Solvent Miscibility and Solubility**
(Source: Restek http://www.restek.com/techtips/Solvent-Miscibility-and-Solubility)

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LAQUA Sleeve
ToupH Electrode
9681S-10D
Product Page

Method

Calibrate the meter and electrode system according to manufacturer's instructions with at least two pH buffers that bracket the expected sample pH.

Sample Preparation And Measurement

The method described below is based on US EPA Method 9045D.

1. Add 20ml of water to 20g sample in a beaker or container. Cover and stir for 5 minutes.
2. Let the solution stand for 15 minutes or centrifuge it to allow the sample and water to separate.
3. Measure the pH of water phase. Record the pH value and the temperature.

To obtain accurate results, standard buffer solutions and samples should be measured at the same temperature. If the electrode is coated with oily material from a sample, clean it with detergent and warm water.

Results And Benefits

As non-aqueous solvents have very low conductivity and can dehydrate the glass membrane, it is difficult to use glass electrodes in measuring pH directly. There must be some electrical conductivity through the solution and glass membrane must be hydrated to function well.

For water-immiscible non-aqueous solvents and non-aqueous solutions with water-immiscible solvents, this measurement can be accomplished by adding water as described in the method above. Pure water with very low buffering capacity and no dissolved salts should be mixed thoroughly with the solvent. Once the two phases are in equilibrium with each other, the activity of any dissolved species should be the same in both phases. After separating the solvent phase, the pH of water phase is then measured.

For water-miscible non-aqueous solvents and mixed aqueous/water-miscible non-aqueous solutions (e.g., water and methanol), a reproducible measurement process can be achieved if the solvent background is known and constant. To do this, it is important to describe the choice of pH electrode, calibration standards, sample preparation, and electrode conditioning.

1. pH electrode

A glass-body electrode resists chemical attack. A flowing reference should be used to eliminate or minimize liquid junction problem. An aqueous filling solution may be used, but most often develops a large or unstable junction potential. This can be reduced by changing the filling solution so that it is compatible with the sample (e.g., methanol saturated with KCl, 90% glacial acetic acid plus 10% saturated aqueous LiCl).

2. Calibration Standards

Ideally, the calibration standards should have the same background as the sample. A constant solvent background may be used in testing the measuring system. A "check" standard made with dry buffer and same solvent background can be measured after calibrating the electrode/meter system in aqueous pH buffers. Its reproducibility is a good test although the reading will be different from the aqueous values. In pH measurement of non-aqueous and mixed solutions, only relative readings can be obtained.

3. Sample Preparation

The ionic strength of non-aqueous solvents can be increased by adding a neutral electrolyte such as a quarternary ammonium salt.

4. Electrode Conditioning

When measuring pure solvents or samples with less than 20% water, the contact time of the electrode to the sample should be kept to a minimum as solvents may dehydrate the glass membrane. Between measurements and after use, it should be soaked in buffer or KCl solution to hydrate the glass membrane. Dried electrodes can be drifty and sluggish.

References And Suggested Readings

1. US Environmental Protection Agency Method 9045D Soil and Waste pH, Revision 4 November 2004
2. Frant, Martin. How to Measure pH in Mixed and Non-Aqueous Solutions. American Chemical Society. 1995
3. C. Westcott. pH Measurements. Academic Press Inc. New York, USA. 1978

REV 1.0, 9 September 2015

Nitrate Measurement in Hybrid Sudangrass and Pearl Millet Hays

Determining the nitrate concentrations of sudangrass and pearl millet before feeding them to livestock prevents nitrate toxicity. Plant sap testing with LAQUAtwin B-743 nitrate ion meter offers fast and accurate nitrate in-field analysis. Generally, the maximum nitrate concentrations considered safe for all cattle are 820 ppm and 700 ppm for sudangrass sap and pearl millet sap, respectively.

Introduction

Hybrid Sudangrass and pearl millet have high potential for accumulating nitrate. Pearl millet has been noted to accumulate significantly higher quantities of nitrate than does sudangrass. These high nitrate plants, either standing in the field or fed as hay, can cause abortion in pregnant cattle or death if consumed in great quantities. Factors that contribute to nitrate accumulation in plants are excessive use of nitrogen fertilizers and stressful environmental conditions that restrict plant growth such as drought, reduced sunlight, low growing temperatures and acidic or phosphorus-deficient soil.

The LAQUAtwin B-743 nitrate ion meter provides the easiest way to measure nitrate concentration in fresh plant sap. The sensor requires only few drops of sap, which can be quickly extracted using a garlic press. The meter analyses the sap in just few seconds and displays reading expressed as either nitrate (NO_3^-) or nitrate-nitrogen (NO_3-N) ppm. Nitrate results can be obtained immediately in the field with much less effort and relatively low cost. These advantages are useful for farmers and ranchers who are managing livestock and forage crops.

Method

Calibrate the LAQUAtwin B-743 nitrate ion meter according to manufacturer's instructions using the 150ppm and 2000ppm nitrate ion standards included in the kit. Make sure that the unit of measurement set in the meter is nitrate (NO_3^-) ppm.

Sample Collection and Measurement

1. Select five plants randomly from each sample and cut them with a pruner at a similar height to that of harvest.
2. Cut the plant samples into 6-inch long pieces. Then, cut again to shorter 1/3-inch pieces.
3. Mix the pieces thoroughly into a small pile.
4. Transfer a portion of the 1/3-inch pieces consisting of leaves and stems to a garlic press.
5. Squeeze the garlic press and collect the sap into a container.
6. Place drops of sap onto the nitrate ion sensor using a dropper. See Notes.
7. Record the nitrate reading once it is stable.
8. Rinse the sensor with deionized or distilled water and blot dry before testing another sample.
9. Re-check the reading of a standard after testing 10 samples.

Notes:

a. If very small amount of sap is extracted from the plant sample (i.e., sap volume is not enough to cover the flat sensor), use sampling sheet in calibration as well as in sample measurement. To do this, place a sampling sheet onto the sensor and then place drops of standard solution or sap to saturate the sampling sheet.
b. Another way to saturate the sampling sheet with sap is to place it over the holes of garlic press before loading plant sample and squeezing the press. Transfer the sap-saturated sampling sheet onto the sensor using a tweezer.
c. Allot one sampling sheet for each standard solution type and sap sample and discard all used sheets after testing.

Refer to Technical Tip 2: LAQUAtwin Ion Sensor Maintenance Procedures

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LAQUAtwin B-743
Product Page

> **Nitrate results can be obtained immediately in the field with much less effort and relatively low cost.**

for detailed information on conditioning, cleaning, and storing the nitrate ion sensor. The technical tip can be viewed and downloaded from the support section of our website www.horiba-laqua.com.

Results and Benefits

To interpret the LAQUAtwin B-743 nitrate ion meter results with sudangrass and pearl millet plants, refer to the established guidelines in Table 1.

The sap nitrate results measured with LAQUAtwin B-743 nitrate ion meter are highly correlated with those dry-weight based nitrate results obtained from conventional laboratory procedures. As shown on Figures 1 and 2, the correlation coefficients for hybrid sudangrass and pearl millet are 0.88 and 0.89, respectively. To convert the sap nitrate concentration to dry-weight based concentration, use the following equations:

Hybrid Sudangrass:
Nitrate(Dry Weight) = 3.64 x Nitrate(Sap)
Pearl millet:
Nitrate(Dry Weight) = 4.4 x Nitrate(Sap)

Table 1: Guidelines for Interpreting Nitrate Analysis Results with Plant Sap and Dry Hay

Sudangrass Sap (ppm)	Pearl millet Sap (ppm)	Dry Hay (ppm)	Interpretation
0 - 820	0 - 700	0 – 3000	Generally safe for all cattle
820 - 1380	700 - 1140	3000 – 5000	Generally safe for non-pregnant beef cattle. Low risk of reduced breeding performance and early term abortions. Total ration for dairy cattle should be less than 2500 ppm.
1380 - 2750	1140 – 2270	5000 – 10000	Some risk for all cattle. May cause mid to late term abortions and weak newborn calves. May decrease growth and milk production.
> 2750	> 2270	> 10000	Potentially toxic for all cattle. Can cause abortions, acute toxicity symptoms, and death.

Source: Zhang, H., 1999. Quick Nitrate Test for Hybrid Sudangrass and Pearlmillet Hays.

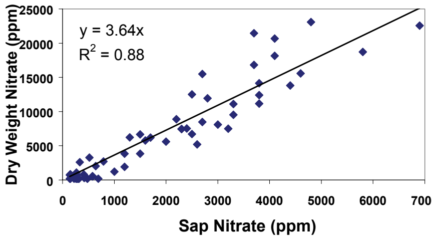

Figure 1: Correlation between sorghum-sudangrass sap nitrate measured with LAQUAtwin B-743 nitrate ion meter and sorghum-sudangrass dry-weight based nitrate obtained from laboratory.

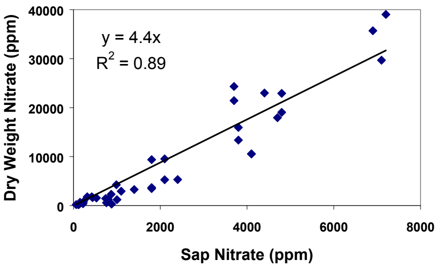

Figure 2: Correlation between pearl millet sap nitrate measured with LAQUAtwin B-743 nitrate ion meter and pearl millet dry-weight based nitrate obtained from laboratory.

References and Suggested Readings

1. Zhang, H., 1999. Quick Nitrate Test for Hybrid Sudangrass and Pearlmillet Hays. Oklahoma Cooperative Extension Service [online]. Available from: http://www.specmeters.com/assets/1/7/nitrate_sorghum3.pdf [Accessed on 18 October 2016].
2. Selk, G., Step, DL., Strickland, G., Zhang, H., 1999. Nitrate Toxicity in Livestock. Oklahoma Cooperative Extension Service [online]. Available from: http://extension.oregonstate.edu/douglas/sites/default/files/documents/lf/faqf/pss2903.pdf [Accessed on 18 October 2016].

Revision 1.0, 18 October 2016

Water Quality Assessment of Inukami River in Japan

Six sites in Inukami River were selected and measured with LAQUA WQ-330 handheld meter and sensors for pH, conductivity, dissolved oxygen, and temperature to determine the water quality. Waters in spring area, which originate from underground, were found with lower pH, DO, conductivity, and temperature compared to waters from mainstream and downstream.

Introduction

The Inukami River in Shiga Prefecture, Japan is 27.1-km long and flows from the Suzuka Mountains to Lake Biwa. It is known not only for its clean water, but also for its underground flow and numerous springs in its riverbed. In order to preserve the Inukami River water, it is essential to determine the water quality and understand the effect of its ecosystem and surrounding areas.

Method

Six sites in Inukami River were selected for pH, conductivity (EC), dissolved oxygen (DO) and temperature measurements (See Figure 1). These four water quality parameters have important interactions between each of them. For example, conductivity measurement is typically conducted in checking the cleanliness of water. Conductivity increases as temperature and dissolved charged ions (e.g. Na^+, Cl^-, NO_3^-) from inorganic substances (e.g., minerals, salts) in water increases. pH is also affected by temperature and minerals dissolved in water. Unlike conductivity, dissolved oxygen concentration decreases as water salinity and temperature increases.

The new LAQUA WQ-330 triple-channel multi-parameter handheld meter was used to simultaneously measure the pH, conductivity, dissolved oxygen, and temperature of Inukami River. Prior to river water measurements, the 300PH-2 / 300-P-C pH sensor, 300-C-2 / 300-4C-C 4-cell conductivity sensor, and 300-D-2 optical DO sensor connected to the meter were calibrated with NIST pH buffers (pH 4.01, 6.86, and 9.18), 84µS/cm conductivity standard, and ambient air, respectively.

Results

Measurement in the Mainstream

As shown in Table 1, the water at confluence point of Inukami River and Ota River ② has higher temperature, pH, conductivity, and dissolved oxygen compared to the waters before ① and after ③ the confluence point. As the tributary Ota River is situated along residential area, it is believed that human activities in the area may have contributed to the slightly elevated water temperature and conductivity obtained at the confluence point. Dissolved inorganic substances (e.g., minerals, salts) coming from sewage may pollute water. The conductivity value of underground flow before the confluence point is affected by geological conditions.

Dissolved oxygen (DO) is free oxygen present in water from atmosphere and photosynthetic production by aquatic plants and algae. There is more dissolved oxygen in cold, flowing water with many rocks or obstacles, and moderate amount of aquatic plants and algae but generally less at the bottom of river. Although the water at confluence point ② is warmer than ① and ③, higher DO was observed which could be due to the merging water flows, aquatic plants, algae, and rocks in the area.

Measurement in the Spring Area

Spring water ⑤ is pumped out from underground and utilized as drinking water in the residential area. The water was found having lower temperature, pH, conductivity, and dissolved oxygen than mainstream water. The riverbed

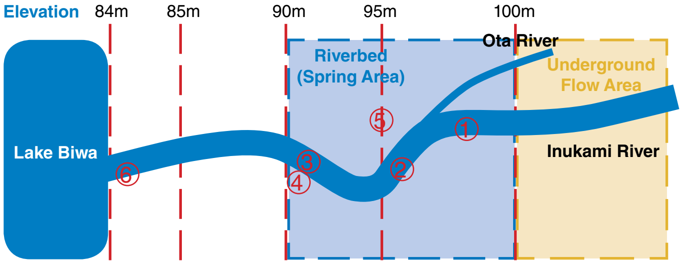

Figure 1: **Six sites in Inukami River were selected for water quality determination**

Table 1: **Results of Inukami River Water Quality Determination**

Inukami River Water		Temp (°C)	pH	EC (µS/cm)	DO (%)
①	Before confluence	21.9	8.56	188	120
②	Confluence point	26.4	8.99	248	143
③	After confluence	19.9	8.11	206	125
④	Riverbed	15.7	7.63	203	88
⑤	Spring	15.4	7.72	171	99
⑥	Estuary	27.1	9.21	218	152

water ④ was found having close results to the spring water ⑤. Due to numerous springs in the riverbed, it is believed that the measured riverbed water ④ originated from the springs.

The temperature of water in river is normally affected by the ambient temperature and changes with the seasons. On the other hand, spring water temperature is almost stable since it is not affected by the ambient temperature. Groundwater tends to maintain a relatively long-term average temperature of its aquifer so flow from a spring may be cooler than a summer day but remain unfrozen in the winter.[1] This explains the temperature of spring water ⑤ being lower than mainstream water. In stagnant area of a river, sunlight may raise the temperature. This makes the temperature of riverbed water ④ slightly higher than spring water ⑤.

Many springs have naturally low oxygen due to the length of time the water has been underground where no photosynthesis can occur. After leaving the spring vent, gas exchange with atmosphere and photosynthesis from aquatic plants and algae increases the oxygen level as the water flows down the spring run.[2] The DO results in spring and riverbed waters were lower than mainstream and estuary waters.

The pH of groundwater is affected by the rocks and chemicals beneath the ground, as well as the quality of the water being recharged or percolating down into the aquifer from the surface. In some places, limestone in aquifer is made mostly of calcium carbonate ($CaCO_3$). Acidic water will react with the carbonate in the limestone, dissolving the limestone, and neutralizing the acid to a pH around 7.[3] This could be the reason for the pH values obtained in ④ and ⑤.

Measurement in the Downstream

Water in estuary ⑥ gently flows around while getting good exposure to sunlight. The measured water pH, DO, and temperature in estuary were the highest results obtained. An area with good exposure to sunlight and water is a conducive environment for aquatic plants to grow. Plants take up carbon dioxide for photosynthesis and release oxygen. This could be the reason for high DO.

The aquatic plants growing in the water also play a role in affecting the pH. During the day, plants photosynthesize producing both oxygen and bicarbonate ions which shift the pH upward. At night, those same plants respire and release carbon dioxide which lowers the pH.[3] This could be the reason for high pH in mainstream and estuary waters at the time of measurement.

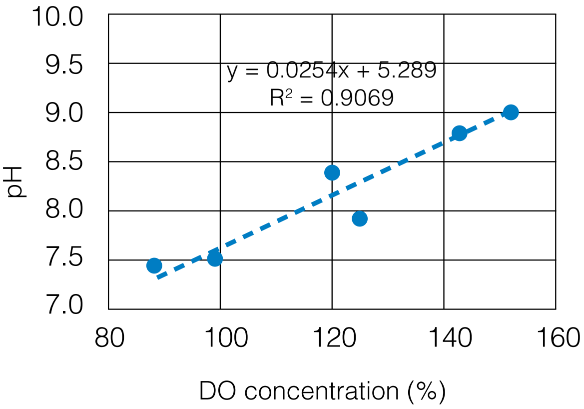

Figure 2: pH vs DO measured at Inukami River

Conclusion

Simultaneous pH, conductivity, DO, and temperature measurements provided data that help us understand the Inukami river condition and its water quality. In addition, the measurement results for the different sites selected were as expected considering the factors such as locations, surroundings, and aquatic plants in the Inukami river and also proven that LAQUA WQ-330 is suitable for river water measurements.

References and Suggested Readings

1. Spring (hydrology) - https://en.wikipedia.org/wiki/Spring_(hydrology)
2. Dissolved Oxygen - http://www.srwmd.state.fl.us/422/Dissolved-Oxygen
3. pH - http://www.srwmd.state.fl.us/423/pH

12 November 2019, Rev. 0

Measuring Salinity of Water

Measuring the salinity or the dissolved salt content of water is important as aquatic organisms, livestock, and crops thrive at different salinity levels. Freshwater has a salinity value of less than 0.5 ppt while seawater has an average salinity of 35 ppt.

Introduction

Salinity is the measure of the amount of dissolved salts in water. It is usually expressed in parts per thousand (ppt) or percentage (%). Freshwater from rivers has a salinity value of 0.5ppt or less. Within the estuary, salinity levels are referred to as oligohaline (0.5-5.0 ppt), mesohaline (5.0-18.0 ppt), or polyhaline (18.0-30.0 ppt). Near the connection with the open sea, estuarine waters may be euhaline, where salinity levels are the same as the ocean at more than 30.0 ppt.[1]

Salinity varies from place to place in the oceans, but the relative proportions of the most major dissolved constituents remain virtually constant. Even though there are smaller quantities of other ions in seawater (e.g., K^+, Mg^{2+}, SO_4^{2-}), sodium (Na^+) and chloride (Cl^-) ions represent about 91% of all the seawater ions. Freshwater has much lower levels of salt ions.[2]

Salinity is often derived from electrical conductivity (EC) measurement. EC is measured by passing an electric current between two metal plates or electrodes in the water sample and measuring how readily current flows between the plates. The use of EC measurements to estimate the ionic content of seawater led to the development of Practical Salinity Scale 1978 (PSS-78).[3]

The PSS-78 has been considered by the Joint Panel on Oceanographic Tables and Standards and recommended by all oceanographic organizations as the scale in which to report future salinity data. The practical salinity of a sample of seawater is defined in terms of the ratio of the electrical conductivity of the seawater sample at the temperature of 15°C and the pressure of 1 standard atmosphere, to that of a potassium chloride (KCl) solution containing a mass of 32.4356 g KCl in a mass of 1 kg of solution at the same temperature and pressure. A ratio equal to 1 corresponds to a practical salinity 35 (standard seawater).[4] As the definition is a ratio, practical salinity is expressed as dimensionless number.

The LAQUAtwin Salt 11 pocket meter measures the conductivity value of a sample then converts it to salinity value based on the salinity standard curve selected. The sensor has two titanium metals coated with platinum black that resist corrosion and temperature sensor for accurate measurement. The meter is programmed with two standard calibration curves—seawater and sodium chloride (NaCl). The former

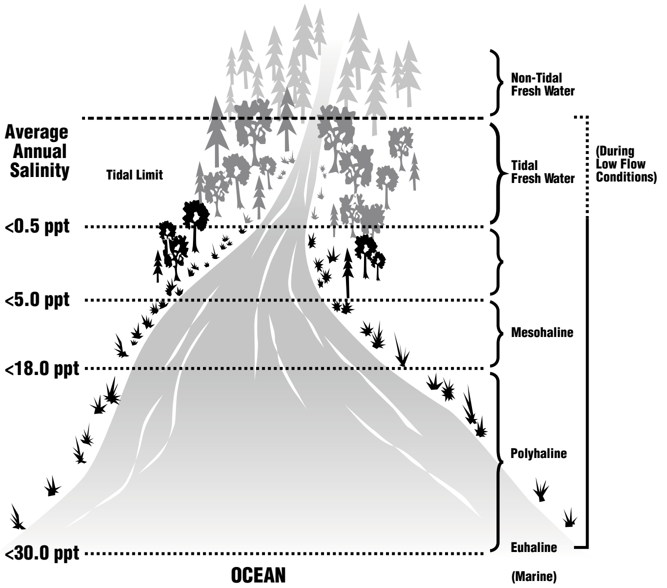

Figure 1: Estuarine salinity slowly increases as one moves away from freshwater sources and toward the ocean.
Source: Chapter 14 Salinity. Voluntary Estuary Monitoring Manual.

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LAQUAtwin
Salt-11
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> **As temperature affects pH, it is important to use a pH electrode integrated with temperature sensor (3-in-1) for accurate pH measurement.**

follows the PSS-78 equation while the latter follows the equation in Figure 2.

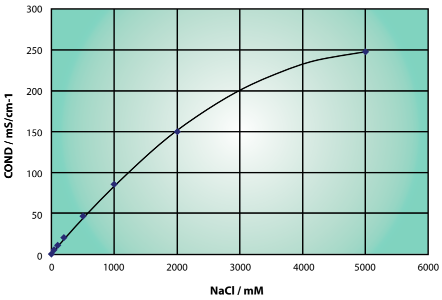

Figure 2: NaCl Curve

Method

Calibrate the LAQUAtwin Salt 11 pocket meter according to manufacturer's instructions using the 0.5% (5ppt) and 5.0% (50ppt) NaCl standard solutions included in the kit.

Prior to calibration, make sure to select the standard calibration curve (either NaCl or Seawater) and the unit (either ppt or %) depending on your application and reporting unit requirement. If both seawater curve and ppt unit are selected, calibrate the meter with 5ppt NaCl standard. It is best to use 5ppt and 50ppt seawater standards, if available. Note that if ppt is set as the measurement unit, the meter will display only the salinity reading without the unit (dimensionless).

Sample Collection and Measurement

Place drops of water onto the sensor using the pipette included in the kit. Make sure that sample well is completely filled-up with sample and that there are no bubbles formed. Record the salinity reading once it is stable.

Before testing another sample, rinse the sensor with DI (distilled or deionized) water or with the next sample to be tested and dab a soft tissue to remove remaining water trapped inside the sample well.

Refer to Technical Tip 3 for detailed information on conditioning, cleaning, and storing the salt sensor. The technical tip can be viewed and downloaded from the support section of our website www.horiba-laqua.com.

Results and Benefits

Salinity is an important measurement in seawater or in estuaries where freshwater from rivers or streams mixes with salty ocean water since aquatic organisms have varying abilities to survive and thrive at different salinity levels. Saltwater organisms survive in salinity levels up to 40 ppt, yet many freshwater organisms cannot live in salinity levels above 1 ppt.[2]

Salinity affects the dissolved oxygen levels in water. The solubility of oxygen in water decreases as salinity increases. The solubility of oxygen in seawater is about 20% less than it is in fresh water at the same temperature.[5]

The table below shows the salinity values of different types of water and their uses.

Table 1: Water Salinity

Salinity Status	Salinity (%)	Salinity (ppt)	Use
Fresh	< 0.05	< 0.5	Drinking and all irrigation
Marginal	0.05 – 0.1	0.5 – 1	Most irrigation, adverse effects on ecosystems become apparent
Brackish	0.1 – 0.2	1 – 2	Irrigation certain crops only; useful for most stock
Saline	0.2 – 1.0	2 – 10	Useful for most livestock
Highly Saline	1.0 – 3.5	10 – 35	Very saline groundwater, limited use for certain livestock
Brine	> 3.5	> 35	Seawater; some mining and industrial uses exist

Source: Department of Water. Government of Western Australia.

References and Suggested Readings

1. Chapter 14 of the Volunteer Estuary Monitoring Manual, A Methods Manual, Second Edition, EPA-842-B-06-003. https://www.epa.gov/sites/production/files/2015-09/documents/2009_03_13_estuaries_monitor_chap14.pdf
2. Chloride and Salinity. http://www.ruf.rice.edu/~cbensa/Salinity/
3. Salinity. Wikipedia. https://en.wikipedia.org/wiki/Salinity
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6. Understanding Salinity. Department of Water. Government of Western Australia. http://wadow.clients.squiz.net/water-topics/water-quality/managing-water-quality/understanding-salinity

Revision 1.0, 28 October 2016

Determination of Potassium in Sea Water

Seawater has high ionic strength. To eliminate matrix effect in measuring potassium (K^+) concentration, standard solutions made with the same background as the seawater sample are recommended for calibration. The result of measurement using the LAQUAtwin Potassium Ion meter is within ±10% of typical seawater concentration.

Introduction

Seawater is a complex solution of different ions with different charges. Matrix effect can be eliminated or reduced by either standard addition method or standard calibration solutions made with the same background matrix as the sample. The former technique is challenging in onsite testing.

It has been known that the composition of sea water throughout the mass of the oceans is relatively constant, and that, whatever the degree of concentration or dilution, the ratios between the concentrations of the major components vary, if at all, between narrow limits. Potassium (K) is one of the major components in seawater. The concentration is 380mg/L K^+ in typical seawater.

The pocket-sized LAQUAtwin Potassium Ion meter can be used directly in seawater to measure the potassium (K^+) concentration. This compact meter provides quick result with just a few drops of sample, a suitable alternative for laboratory methods such as gravimetric and atomic absorption spectrometry.

Method

Calibration

Calibrate the LAQUAtwin Potassium Ion meter according to manufacturer's instructions using two HORIBA's standard solutions that bracket the concentration of potassium in seawater samples.

For more accurate measurement, standard solutions with the same background matrix as the sample are recommended for calibration. These solutions can be prepared as follows:

Option 1: One-point calibration with 1000ppm Potassium Standard with 2.5% NaCl. Mix 2000 ppm potassium standard solution (Y031H) and 5% NaCl solution (514-50) in 1:1 ratio. The resulting solution is 1000 ppm potassium standard with 2.5% NaCl.

Prior to calibration, set the low calibration value of the meter from 150ppm (default value) to 1000ppm. Refer to the Low Calibration Value Setting of the meter's instruction manual.

Option 2: Potassium Standards with synthetic ocean water background.

Prepare synthetic ocean water without potassium according to ASTM D1141 to closely match the background of seawater sample. Add known amount of potassium chloride (KCl) salt to the prepared synthetic ocean water.

Example: If 2-point calibration is to be performed, prepare two standards with concentrations that are ten-fold apart (e.g., 200ppm and 2000ppm; set the low calibration value of the meter to 200ppm). To prepare standards, follow the below table or perform serial dilution (e.g., First, prepare 200ml of 2000ppm (see below table). Take 10ml from this and

Potassium Standard (K+ ppm)	Weight of KCl (mg) per 100ml Synthetic Ocean Water
150	28.6
200	38.2
1000	190.8
2000	381.6

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> **The result of potassium determination in seawater using LAQUAtwin Potassium Ion meter and HORIBA's standard solutions is within ±10% of typical seawater concentration.**

dilute to 100ml using synthetic ocean water. The resulting solution is 200ppm standard.)

Sample Measurement

Samples should be measured at the same temperature as the standard solutions used in calibration. Using the pipette that comes with the LAQUAtwin Potassium Ion meter, place a few drops of seawater sample into the sensor. Alternatively, open the slide cap of the sensor and scoop sample directly from source or container. Record the reading once stable. Rinse the sensor with DI water and blot dry with soft tissue.

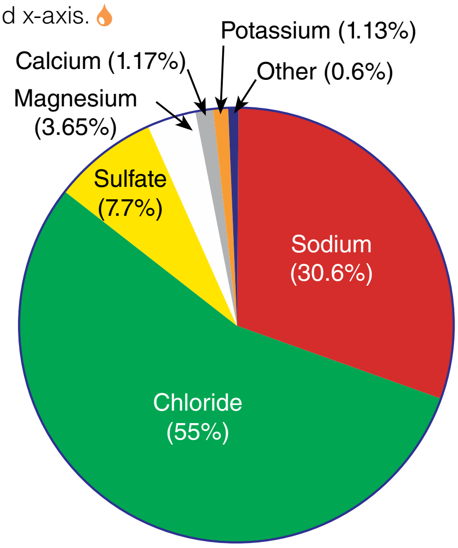
If the sensor response becomes sluggish, rinse the sensor with DI water and then leave a few drops of 150ppm potassium standard for a few hours. If this failed to restore the sensor response, replace the sensor.

Results And Benefits

The result of potassium determination in seawater using LAQUAtwin Potassium Ion meter and HORIBA's standard solutions is within ±10% of typical seawater concentration. For more accurate measurement, sodium chloride (NaCl) can be used to adjust the ionic strength of a standard solution. It is the major salt component in seawater. Alternatively, prepare standard solutions that closely match the background matrix of sample. This can be accomplished by using synthetic ocean water.

Supplementary Information

- Ionic strength – the quantity used to characterize the aqueous solutions that contain different concentrations of ions.
- Matrix effect – the matrix, which refers to the components of the sample other than the analyte of interest, can have a considerable effect on the way the analysis is conducted and the quality of the results obtained
- Standard addition method – Measure the sample mV then add a known amounts of the standard. Record the mV values after each addition. Plot mV values (y-axis) against concentration (x-axis). Set the sample mV at 0 concentration. Extrapolate the line connecting the measured mV values to 0 mV. Read the sample concentration at the intersection of the line and x-axis.



Salts In Seawater

(Source: Ocean Health - http://oceanplasma.org/documents/chemistry.html)

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2. ASTM D1141-98 (2013) Standard Practice for the Preparation of Substitute Ocean Water. www.astm.org
3. Richard E. Zeebe and Dieter Wolf-Gladrow. CO2 in Seawater: Equilibrium, Kinetics, Isotopes. First Edition. The Netherlands: Elsevier Science B.V., 2001
4. D.A. Webb, Ph.D. The Sodium and Potassium Content of Seawater. Department of Zoology. Cambridge University. 15 November 1938

REV 0, 2 SEPTEMBER 2015

Water & Wastewater
Application Notes

Measurement of Calcium in Drinking Water

Determining the calcium content of drinking water helps consumers accurately gauge their calcium intake. Unlike atomic absorption spectroscopy (AAS) and inductively coupled plasma atomic emission spectroscopy (ICP), the LAQUAtwin calcium ion meter offers a simpler method of measuring calcium ion - ionizing bound calcium in water using acid before analysis.

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LAQUAtwin Ca-11 Product Page

Introduction

It is helpful to determine the amount of calcium contained in water, since this will enable one to ascertain whether the water is hard, or if the water (if drinking water) has minerals. This can be determined using atomic absorption spectroscopy (AA) or inductively coupled plasma atomic emission spectroscopy (ICP). However, a much simpler way is by ionizing acid-bound calcium using acidizing pretreatment. The LAQUAtwin Ca^{2+} can be used to measure the total amount of calcium.

The LAQUAtwin Ca^{2+} meter is used as check to determine the Calcium content of water products before selling to consumers. This is an easy, quick method used to check the amount of calcium present in water.

Method

Pretreatment procedure

1. Place 5 mL of sample solution in a 100 ml beaker.
2. Add 10 to 40 µL of 5M hydrochloric acid to the sample solution and confirm that it has a pH of around 2 Return the sample solution to the beaker.
3. Add 15 to 20 mL of tris-hydroxy-aminomethane buffer solution with a pH of 6.95 to the solution created in step 2 (thereby diluting it by a factor of 4 to 5) and confirm its pH has changed to around 6 using LAQUAtwin pH.

A small sample of this solution is placed on the sensor of the LAQUAtwin Ca^{2+} and measured. To repeat sampling, wash with tap water and pat dry with a paper tissue.

Results and Benefits

The use of accurate Calcium ion testing in controlling the quality and calcium content of water products ensures that consumers are accurately able to gauge their calcium intake. It also enables one to determine whether or not scaling will occur with boiling of their water.

The LAQUAtwin Ca^{2+} pocket meter is small and compact; convenient to carry around for on-site testing. Its easy-to-use interface is simple for anyone to use the LAQUATwin Ca^{2+} pocket meter.

[1]For each type of sample, the following table shows the labeled value, together with the values measured by various methods. Figure 1 shows the correlation between LAQUAtwin Ca^{2+} data and that from ion chromotography for pretreated and non pretreated samples. Figure 2 shows the correlation between LAQUAtwin Ca^{2+} data and that from other methods for a pretreated sample. Calcium rich mineral water contains calcium sulfate and calcium carbonate, and these were ionized by pretreatment. The data for total Ca amount obtained by LAQUAtwin Ca^{2+} shows better correlation with other methods when the sample has been pretreated.

Fig. 1 Correlation of Calcium concentration between LAQUAtwinCa^{2+} and IC method

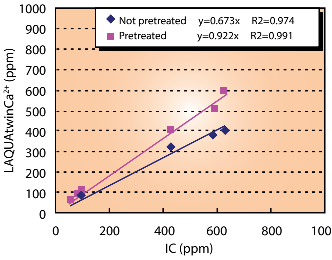
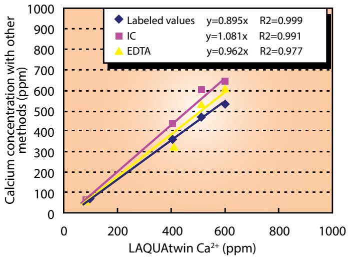


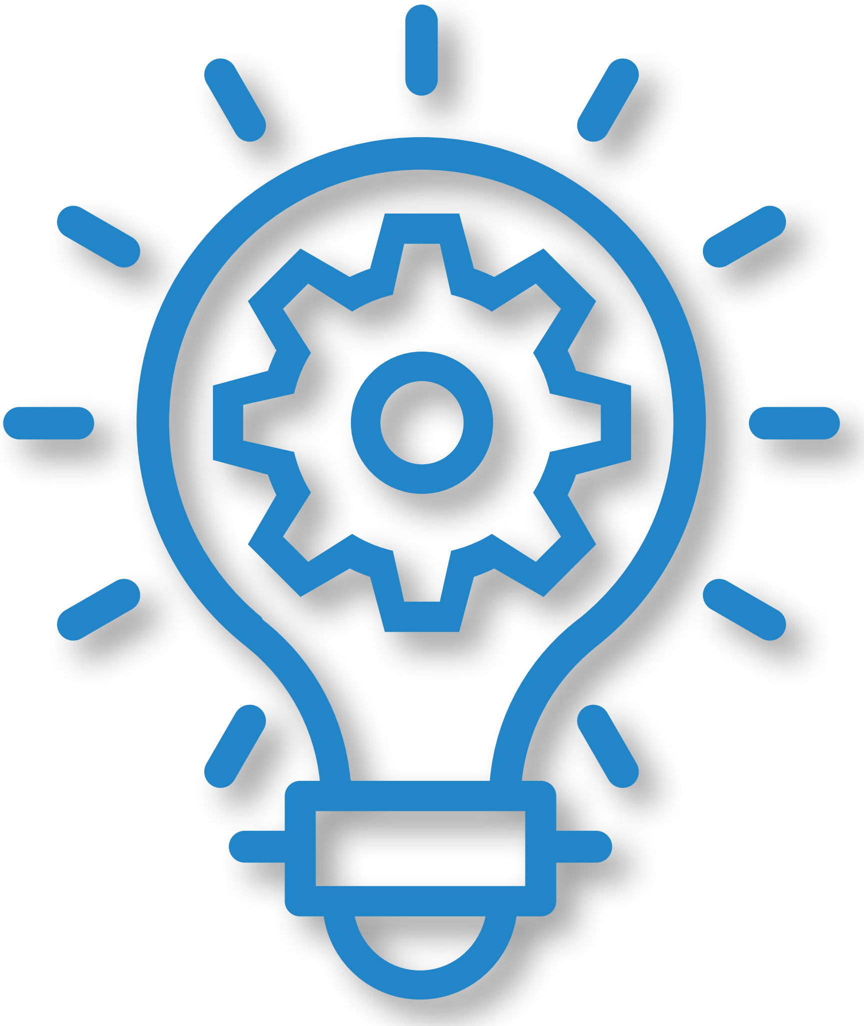
Fig. 1 Correlation of Calcium concentration between LAQUAtwinCa^{2+} and other methods



[1] Internal study by HORIBA labs, 2013

Notes

LAQUA
Technical Tips



A number of application notes based on citation articles written by independent researchers and scientists and technical tips covering product usage, maintenance, and troubleshooting are available for download from our website to help our customers become experts in their measurements.

pH Electrode Care and Maintenance Procedures

Your pH electrode will eventually reach the end of its useful life as its performance naturally degrades over time. To maximize the performance of your pH electrode and extend its life span, proper care and regular maintenance are equally required.

- Part no. 3014028653 Cleaning Solution 220 - contains 10% thiourea and 1% hydrochloric acid (HCl) for removing inorganic residues on glass membrane and junction

- Part no. 3999960031 500-7 pH 7.00 buffer

- Mild detergent

- Part no. 3200366771 Cleaning Solution 250 - contains less than 0.5% enzyme protease, less than 0.1% sodium azide, and other ingredients (See SDS) for removing protein residues on glass membrane and junction

- Part no. 3999960029 500-4 pH 4.00 buffer

- Soft lint-free tissue

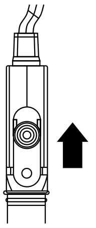
- Part no. 3999960023 525-3 3.33M KCl pH electrode filling solution (for liquid-filled electrodes)

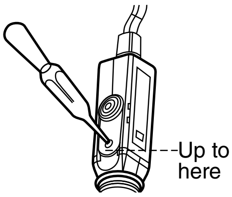
- Clean water (e.g., tap, distilled or deionized water) in a squirt bottle

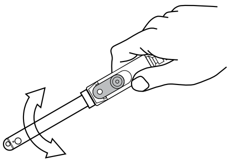
Refer to the safety data sheet (SDS) of the chemical solution to be used in cleaning and wear the appropriate personal protective equipment for safe handling. Download the SDSs of HORIBA solutions at www.horiba-laqua.com.

Refilling

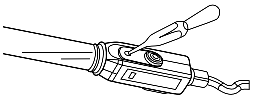
The pH electrode may be filled with either an ionic liquid solution (refillable or liquid-filled pH electrode) or ionic gel solution (sealed or gel-filled pH electrode). Gel-filled pH electrodes do not require routine refilling and typically require less maintenance than liquid-filled electrodes. Liquid-filled pH electrodes are constructed with refilling port, which is securely covered with a slider. The refilling port allows you to fill or empty the reference chamber.







- To top up or re-fill the reference chamber of liquid-filled pH electrode, push the slider upward to uncover the refilling port and insert a dropper containing fresh 3.33M potassium chloride (KCl) solution. The filling solution should reach the bottom of the refilling port.
- The filling solution level must be maintained just below the refilling port and higher than the pH buffer or sample level during calibration and measurement. This creates a positive head pressure forcing the filling solution to leak into pH buffer or sample through the junction and preventing the reverse.
- Bubbles may form and get trapped within the solution of the sensing tip or reference chamber during transportation. This can affect the operation of your pH electrode. To dislodge the bubbles, gently shake the electrode body.
- If the filling solution inside the reference chamber gets contaminated with sample or microbial growth or the reading is drifting, change the filling solution. Tilt the pH electrode, uncover the refilling port, and draw out the old solution using a dropper before refilling it with fresh 3.33M KCl solution.



Conditioning

Nowadays, combination and 3-in-1 pH electrodes are commonly available. Both types of pH electrodes consist of glass electrode and reference electrode built in one body, but the latter is integrated with temperature sensor for detecting the temperature of the solution being measured.

The glass electrode has a silver-based electrical wire suspended in a neutral solution with KCl contained inside a special glass. The surface of the glass bulb or membrane at the tip of the electrode must be hydrated to function properly. This can be accomplished by immersing the glass membrane in an aqueous solution, where a hydrated layer that is responsible for the pH response of the glass, is developed.

Another component of the pH electrode that must remain hydrated is the junction of the reference electrode. The junction is made of porous material such as ceramic or sintered polyethylene, which allows filling solution of the electrode to leak into the solution being measured. Keeping the reference junction hydrated will prevent precipitation of KCl from the filling solution which may clog it and cause erratic or slow electrode response.

- All pH electrodes come with white protective cap. A sponge wet with pure water is positioned at the bottom of the cap to keep the glass membrane and junction moist. If you find KCl salts formed on the junction or refilling port of your pH electrode, simply rinse off using clean water. This KCl creep from the filling solution is normal.

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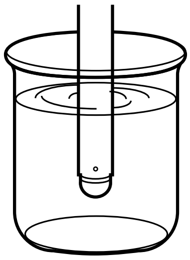
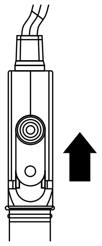
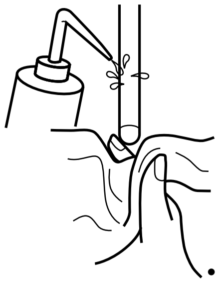
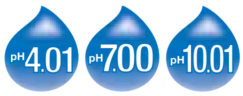


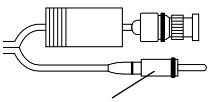
- A dry pH electrode will give inaccurate reading in pH measurement. Condition a dry pH electrode by soaking the glass membrane and junction in pH 7.00, 4.01 buffer, or tap water for at least 1 hour to regenerate the hydrated layer. Note: High salt solutions such as 3.33M KCl and the like are not recommended for conditioning our pH electrodes. After conditioning, rinse the pH electrode with clean water and proceed with calibration.
- Never touch the glass membrane with fingers as oil or dirt may coat the glass and interfere with measurement.

Calibration and Measurement

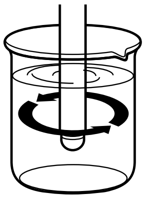








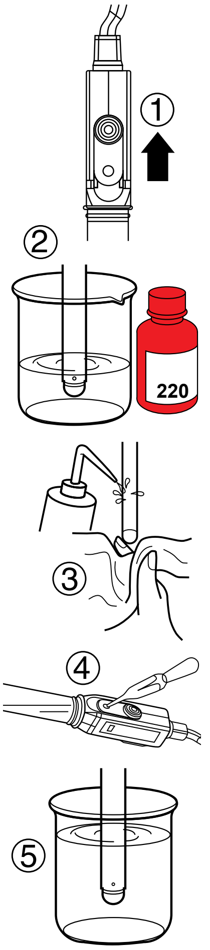
Temperature connector



- If a liquid-filled pH electrode is in use, the refilling port must be uncovered and the filling solution level must be higher than the pH buffer or sample level. These conditions will ensure smooth outward flow of filling solution through the junction during calibration and measurement.
- Before and after measurement, rinse the pH electrode with clean water and/or with a portion of the next solution to be measured and blot with soft lint-free tissue to remove excess water or solution. Rinsing between measurements prevents contamination by carry-over on the electrodes. Avoid wiping or rubbing as this can scratch the glass membrane, remove the hydrated layer, and cause static charge, resulting in inaccurate pH readings.
- Calibrate frequently using at least two fresh pH buffers that bracket the expected sample pH value. Make sure that the glass membrane and junction of pH electrode are both immersed in pH buffer or sample.
- To compensate for temperate effect on pH, use either 3-in-1 pH electrode or combination pH electrode and temperature probe. If temperature probe is not available, check the solution temperature using a calibrated thermometer and input the reading into the meter.
- Stir pH buffers and sample at same rate. Stirring provides representative pH value of a solution and faster electrode response. If stirring is not possible due to measurement noise, limited sample volume or other reasons, it may be abandoned in both calibration and measurement.
- There is a wide selection of pH electrodes and each model is designed to suit specific applications. Choose the best pH electrode suitable for your sample.

Cleaning

A clean, hydrated glass membrane and free-flowing junction are necessary in performing an accurate measurement of pH. The choice of cleaning solution should effectively remove all contaminants based on sample tested without damaging your pH electrode.

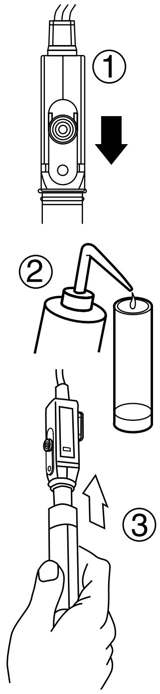


1. If the pH electrode is liquid-filled, uncover the refilling port.
2. Clean the tip of your pH electrode using the appropriate cleaning solution. Make sure that the glass membrane and junction are both immersed in cleaning solution.
    - General samples – Soak the pH electrode in diluted detergent solution for 5 to 10 minutes, while moderately stirring the solution. A strong cleaning solution is needed for clogged junction, stains, and electrodes exhibiting slow response. Soak the pH electrode in cleaning solution 220 or 0.1M HCl for at least 1 hour.
    - Oily samples – Soak the pH electrode in warm, diluted detergent solution for 5 to 10 minutes, while moderately stirring the solution. Alternatively, rinse the pH electrode with methanol or ethanol. Note: Alcohol is only applicable for glass-body electrodes. Never use organic solvents such as alcohol, acetone etc. to clean any plastic-body electrode as they may damage the body and shorten the life span. Use of organic solvents will void the electrode warranty.
    - Protein-containing samples – soak the pH electrode in cleaning solution 250 for at least 1 hour.
3. Rinse the pH electrode with clean water.
4. If the pH electrode is liquid-filled, draw out the old filling solution from the reference chamber and refill it with fresh 3.33M KCl (See Refilling).
5. Condition the pH electrode (See Conditioning).

If calibration with fresh pH buffers failed repeatedly and cleaning failed to restore the performance, replace the pH electrode with a new one.

Storage

pH electrodes must be clean before they are stored for any length of time.



1. If the pH electrode is liquid-filled, cover the refilling port with the slider to prevent evaporation of filling solution.
2. Wash the protective cap with clean water to wet the sponge and remove KCl salts.
3. Insert the pH electrode into the protective cap with wet sponge. The water will not dissipate easily as the cap fit snugly on the electrode body. This environment is enough to keep the glass membrane and junction moist. It is not necessary to fill the cap with clean water and soak the pH electrode tip.

Short-term storage:

Between measurements, the pH electrode can be soaked in pH 7.00 buffer or clean water (e.g., tap, distilled or deionized).

Conductivity Cell Care and Maintenance Procedures

Conductivity cells, also called conductivity electrodes or probes, are constructed with metal electrodes placed at a fixed distance in either glass or plastic body and surrounded by an outer tube. The distance between the electrodes divided by their surface area is known as cell constant. HORIBA offers two-electrode conductivity cells with cell constants expressed in cm^{-1} and m^{-1} units.

The cell constant and performance of a conductivity cell may degrade over time due to fouling of electrodes or peeling of their platinum black coating. To maximize the performance of a conductivity cell and extend its life span, proper care and regular maintenance are equally required.

Materials Needed

☐ 1M Hydrochloric acid (HCl)

☐ Clean water (e.g., tap, distilled or deionized water) in a squirt bottle or beaker

☐ Mild detergent

☐ Soft lint-free tissue

Refer to the safety data sheet (SDS) of any chemical solution that will be used in cleaning and wear the appropriate personal protective equipment (PPE) for safe handling.

Selection

1. Cell Type

HORIBA has two types of conductivity cells—submersible and flow-through. The differences between the two conductivity cells are outlined in the table below.

	
Submersible Cells	**Flow-through Cells**
● Designed for measuring sample in a beaker or cup ● Require large volume of sample ● Sample is exposed to air	● Designed for measuring flowing sample in a closed liquid system ● Require small volume of sample ● Sample is protected from air

2. Cell Constant

Each type of conductivity cell has four models with 0.1 cm^{-1} (10 m^{-1}), 1.0 cm^{-1} (100 m^{-1}) and 10 cm^{-1} (1000 m^{-1}) cell constants. When selecting a conductivity cell, check the expected conductivity of the sample and then look at the cell constants of conductivity cells. Choose a conductivity cell that covers the expected sample conductivity. The higher the conductivity value of sample, the higher the cell constant required. A conductivity cell with 1.0 cm^{-1} (100 m^{-1}) cell constant is the most commonly used because it measures low to high conductivity.

Conductivity	Cell Constant	Measurement Range
Low	0.1 cm^{-1} (10 m^{-1})	0.1 μS/cm – 10 mS/cm (10 μS/m – 1 S/m)
Normal	1.0 cm^{-1} (100 m^{-1})	1 μS/cm – 100 mS/cm (0.1 mS/m – 10 S/m)
High	10 cm^{-1} (1000 m^{-1})	10 μS/cm – 1 S/cm (1 mS/m – 100 S/m)

- Typically, a low conductivity solution is measured with a flow-through cell having a 0.1 cm^{-1} (10 m^{-1}) cell constant to prevent absorption of carbon dioxide (CO_2) from air, which can affect the conductivity value.

- A high conductivity solution is measured with a submersible cell having a 10 cm^{-1} (1000 m^{-1}) cell constant in a beaker.

3. Body Materials

To avoid compromising the appearance and performance of a conductivity cell, check the chemical components of the sample. The

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Conductivity Electrodes

chemical components of the sample must be compatible to the wetted materials of the conductivity cell body. All HORIBA conductivity cells are glass-body, except 9382-10D.

Glass-body Cells	**Plastic-body Cells**
• Intended for laboratory use • Measures aqueous samples and mixed aqueous / organic samples • Electrodes are platinum metals coated with platinum black	• Intended for laboratory and field use • Measures aqueous samples • Electrodes are titanium metals coated with platinum black

- Glass-body conductivity cells are chemical-resistant. They can be used in aqueous samples as well as in samples containing organic solvents.
- Plastic-body conductivity cells are durable and rugged, making them ideal for field measurements.
- Conductivity cells with platinum electrodes are the best choice for chemically reactive solutions whereas those with titanium electrodes are suitable for low reactive aqueous solutions.

4. Temperature Sensor

Conductivity is highly temperature-dependent. A conductivity cell with built-in temperature sensor allows simultaneous measurement of conductivity and temperature. All HORIBA conductivity cells have built-in temperature sensor, except 3573-10C and 3574-10C.

- The temperature sensor detects the temperature of the solution being measured.
- The conductivity meter accepts the temperature reading to automatically correct or normalize the conductivity reading.

Conditioning

The electrodes of conductivity cells are coated with a layer of platinum black. The platinum black creates a higher effective surface area for the electrodes and eliminates polarization error. If the platinum black is dry, dirty, or peeled off, it will adversely affect the conductivity measurement.

- Prior to use, soak the conductivity cell in clean water (e.g., tap, distilled, or deionized water) for at least 1 hour, if the platinum black is dry. Make sure that the water level is right on the mark indicated in the cell body or it fully covers the electrodes.
- Note that the 9382-10D plastic conductivity cell is soaked in pure water when shipped to prevent the platinum black from drying.

Calibration and Measurement

- Prior to calibration, select the desired measurement unit and enter the cell constant (indicated on the cap of the conductivity cell) into the meter settings.
- Before and after measurement of each solution (standard or sample), rinse the conductivity cell with clean water and/or with a portion of the next solution to be measured. If water is used in rinsing, wipe the conductivity cell with a tissue to remove excess water. Rinsing between measurements prevents cross contamination.
- When immersing the conductivity cell in a solution, make sure that the solution level is right on the mark indicated in the conductivity cell body. If there is no marking indicated in the body, make sure that the metal electrodes are completely immersed in a solution.
- Calibrate at least once a day using a fresh standard solution that has a conductivity value as close as possible to the expected sample value. After calibration with a standard solution, the meter will display a calibrated cell constant. The calibrated cell constant should be within ±10% of the nominal cell constant. The conductivity standard solution should give a reading of expected value ± 5%.
- HORIBA meters allow calibration within ±30% of the nominal cell constant.
- To detect temperature and compensate its effect on conductivity, use a conductivity cell with built-in temperature sensor. If the conductivity cell has no built-in temperature sensor, check the solution temperature using a calibrated thermometer and enter that temperature into the meter.
- Stir conductivity standards and sample at same rate. Stirring provides representative conductivity value of a solution. If stirring is not possible due to limited sample volume or other reasons, it may be abandoned in both calibration and measurement.
- Dislodge any bubbles formed inside the conductivity cell.

Cleaning

A clean conductivity cell is necessary in performing an accurate conductivity measurement. The choice of cleaning solution should effectively remove all contaminants based on sample tested without damaging the conductivity cell.

Clean the part of conductivity cell in contact with sample using the appropriate solution and then rinse it thoroughly with clean water. Abrasive objects should never be used in cleaning. A piece of cotton soaked in a cleaning solution can be used with caution.

- General samples – Simply wash the conductivity cell with clean water. If there are sample residues clinging to the conductivity cell, immerse the conductivity cell in diluted detergent solution for 5 to 10 minutes while moderately stirring the solution.
- Oily samples – Immerse the conductivity cell in warm, diluted detergent solution for 5 to 10 minutes while moderately stirring the solution. Alternatively, wash or wipe the conductivity cell with acetone or ethanol.

  Note: Never soak the plastic-body conductivity cell in organic solvents such as alcohol, acetone etc. because these solutions may damage it. Also, this action will void the warranty.
- Lime or hydroxide-containing samples – Soak the conductivity cell in 1M HCl for 30 minutes. Alternatively, soak the conductivity cell in detergent solution containing 5% household bleach for 30 minutes.

Storage

Conductivity cells should be clean before they are stored for any length of time.

- Short-term: Between measurements and overnight, store the conductivity cell in clean water. Before inserting the conductivity cell into the protective cap, place sufficient amount of clean water to cover the metal electrodes. Those conductivity cells without protective cap (i.e., 3551-10D & 3553-10D) can be soaked in a beaker containing clean water.
- Long-term: Store the conductivity cell dry. Make sure to perform conditioning before use (See Conditioning).
- Avoid storing the conductivity cell in places with direct sunlight or high temperature and humidity.

29 June 2017, Rev. 0

Dissolved Oxygen Electrode Care and Maintenance Procedures

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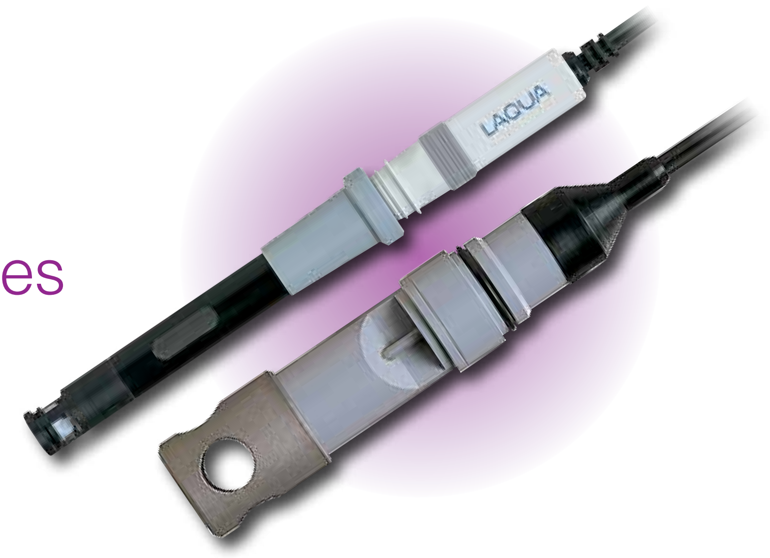


Electrochemical dissolved oxygen (DO) electrodes are composed of anode and cathode, which are submerged in electrolyte solution and enclosed in a cap fitted with hydrophobic, gas permeable membrane. They are also integrated with temperature sensors to measure the temperature of standards and samples and allow the DO meter to compensate the temperature effect on the measured DO values. There are two types of electrochemical DO electrodes: polarographic and galvanic. The advantages of galvanic DO electrodes over polarographic DO electrodes are that they don't require outside voltage source and warm-up time to operate and their electrolyte can be used indefinitely.

Electrochemical DO electrodes available in the market have replaceable electrolyte and either loose membranes or membrane cap assemblies (caps pre-fitted with membranes). The usual maintenance involves periodic changing of the membrane or membrane cap assembly, refilling the electrolyte, and cleaning the anode and cathode. To reduce downtime, the replaceable parts should be readily available and users should know how to perform maintenance.

With the advantages of galvanic DO electrodes and improvement of user experience in mind, HORIBA introduced galvanic DO electrodes equipped with replaceable innovative DO tips for hassle-free plug-and-use operation and built-in temperature sensors for temperature compensation on measured DO values. The DO tips require no maintenance, making them beneficial for both expert and novice users and ideal for continuous measurements in the laboratory or field. Simply, plug the DO tip into the electrode body to perform calibration and measurement and unplug it when the DO electrode will be stored for a long period.

Materials Needed

- Clean water (e.g., distilled, deionized, or tap water)
- Sodium sulfite (Na_2SO_3) or Nitrogen gas
- Cobalt (II) salt (e.g., $CoCl_2 \bullet 6H_2O$)
- Soft cotton gauze or tissue
- Pocket barometer

Selection

There are two DO electrode models available, the 9520-10D with 7541 DO tip and 9551-20D (1m cable) / 100D (10m cable) with 5401 DO tip, which are intended for laboratory and field applications, respectively. Electrode bodies are made of durable plastic. The DO tips have lead anode and silver cathode submerged in KOH electrolyte solution and isolated from sample by a gas permeable membrane.

Aside from DO tips, the DO electrodes are also supplied with accessories. The 9551-20D comes with stirrer (and its casing) and an adapter to fit the electrode body into standard biological oxygen demand (BOD) bottles. A magnetic stir plate should be used with the DO electrode for the stirrer to function. The 9551-20D / 100D comes with stainless steel protective guard that shields the DO tip from getting damage and attached cable hook that helps secure the electrode's connection to the meter and prevents the cable from breaking.

DO Electrode Model	9520-10D	9551-20D	9551-100D
Application	For laboratory use	For field use	
DO Range	0 – 19.99 mg/L	0 – 19.99 mg/L	
Temperature Range	0 – 45 °C	0 – 40 °C	
Dimensions	184 x 15 mm (1m cable)	165 x 32 mm (2m cable)	165 x 32 mm (10m cable)
Replacement DO tip	7541	5401	

Preparation

Each DO electrode comes with one DO tip. The DO tip is packaged with a drying agent in a sealed aluminum foil bag when shipped. It must be plug into the electrode body before using the DO electrode. Refer to the electrode manual for the procedure.

Calibration

One or two calibration points can be performed on the DO meter / electrode system before measuring samples. For most applications, air calibration is sufficient. Calibration should be checked daily and after relevant changes of ambient conditions (i.e. temperature or pressure). If DO is a critical parameter or sample has low DO value, it is recommended to perform a second calibration point or a check using a zero DO solution.

Set the atmospheric pressure (also called air pressure) in the DO meter before calibrating in either saturation ratio (%) mode, also known as percent saturation mode, or DO (mg/L) mode. If measurement will be carried out at sea level, no need to adjust the default setting 101.3 kPa (equal to 1 atm = 760 mmHg). If measurement is at high altitude, measure the atmospheric pressure with a pocket barometer or check it from your local weather service and enter the value into the DO meter. The atmospheric pressure decreases as altitude increases. Refer to the meter manual for the atmospheric pressure setting and calibration procedures in saturation ratio (%) mode and DO (mg/L) mode.

- **Air Calibration**

  This is performed in clean air. There should no water droplets on the membrane or temperature sensor. Evaporation of moisture on the membrane and temperature sensor of DO electrode may influence the readings during calibration.

  After air calibration in saturation ratio (%) mode, the meter will show 105%. This is equivalent to 100% saturation in water. HORIBA determined 5% as the difference between the electrode currents in air and in water based on experimental results. In DO (mg/L) mode, the meter will show the actual DO concentration at the measured temperature and set atmospheric pressure. This value divided by the theoretical DO concentration gives the percent saturation.

- **Zero Calibration**

  This is performed in a pure nitrogen atmosphere or in an oxygen-free solution. A zero DO solution can be prepared by dissolving 1 g or more of sodium sulfite (Na_2SO_3), an oxygen scavenger, with 1 L of distilled or deionized (DI) water in a container. This solution should be freshly prepared and the volume should be enough to cover the membrane and temperature sensor. If available, 1 mg of cobalt salt (e.g., $CoCl_2 \bullet 6H_2O$) can be added in the solution to act as catalyst and indicator. Immediately after preparation, close the container with a cap or film to prevent it from absorbing oxygen and use the solution after an adequate reaction time.

  After calibration in saturation ratio (%) mode, the meter will show 0%. In DO (mg/L) mode, the zero DO solution should read less than 0.2 mg/L DO. Rinse the DO electrode thoroughly to avoid contaminating samples.

- **Slope**

  After one or two calibration points, the meter will display a slope (%). The slope should be within the range 50 - 200%. If the slope is less than 50% or more than 200%, replace the DO tip.

Sample Measurement

When measuring samples, take note of the following:

- Measure directly in the water body on site. If not possible, measure discrete sample immediately after sampling.
- The factors that affect DO in samples are temperature, atmospheric pressure, and salinity. DO meters detect the temperature from DO electrodes so make sure that the temperature sensor is submerged in the sample. Adjust the atmospheric pressure and enter the salinity values of samples into the meter, if necessary.
- Stir the sample by using stirrer or moving the electrode to prevent loss of signal due to consumption of oxygen by the DO electrode.
- Avoid formation of any air bubbles in the samples.
- Between measurements, rinse the DO electrode with clean water and blot dry with soft tissue.

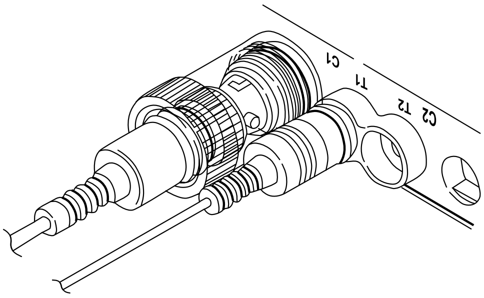
Cleaning

If the membrane is dirty, wipe it gently with soft cotton gauze or tissue then rinse with clean water. Be careful not to scratch the membrane.

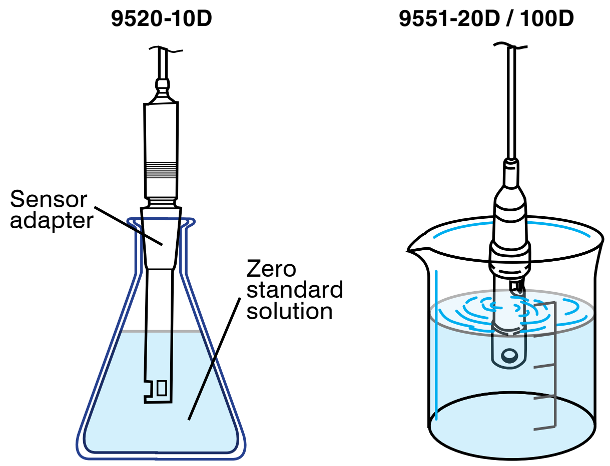
Storage

DO electrodes should be clean before they are stored for any length of time.

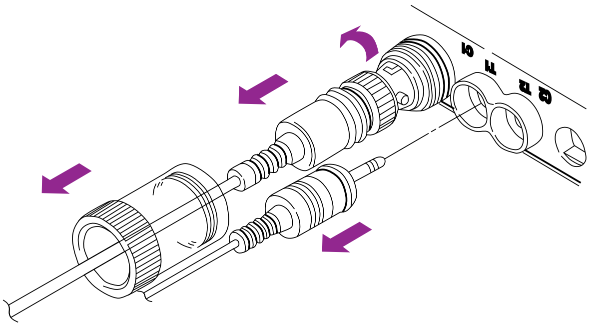
- **Short-term**
  1. Leave the DO electrode connected to the meter.



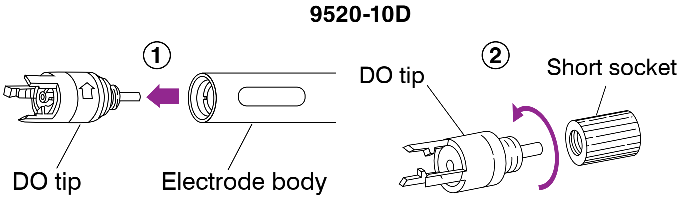
  2. Immerse the DO tip of 9520-10D in zero DO solution (5% Na_2SO_3 solution = 50g Na_2SO_3 in 1L DI water) and the DO tip of 9551-20D / 100D in clean water (e.g., distilled, deionized, or tap water) to prevent the membrane from drying out.

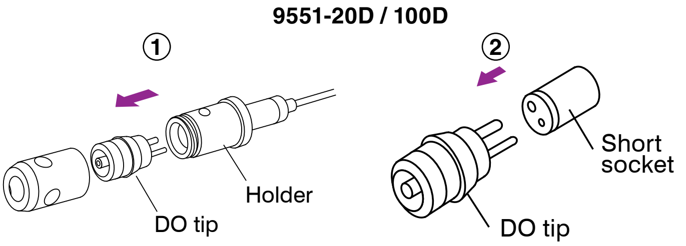


- **Long-term**
  1. Disconnect the DO electrode from the meter.

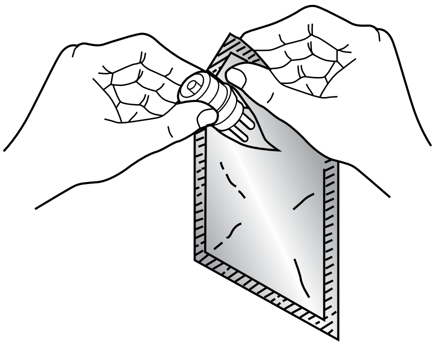


  2. Detach the DO tip from the electrode and plug the short socket into the DO tip.





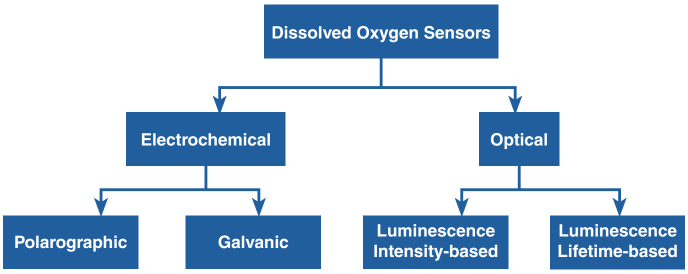
  3. Wrap the DO tip with aluminum foil. You may reuse the original packaging, if it is still in good condition. Alternatively, place the DO tip in a bottle containing drying agent and store in a cool, dark place.



Galvanic vs Optical Dissolved Oxygen Sensors

Modern method of dissolved oxygen (DO) measurement in the lab or field involves a DO sensor connected to a meter that records calibration and measurement data. DO sensors can be designed for discrete sampling, biological oxygen demand (BOD) tests, or long-term monitoring applications while DO meters can be equipped with internal barometer, compensation algorithms and other special functions, and be linked to a computer for data transfer.

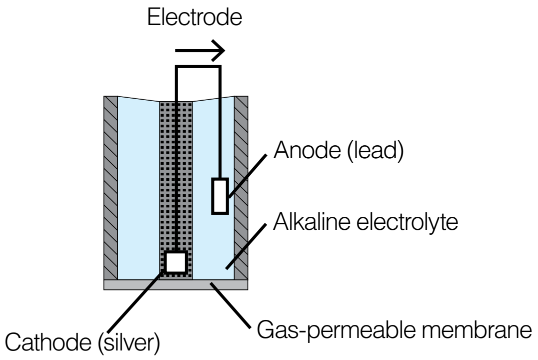
There are two types of DO sensors—electrochemical and optical. Electrochemical DO sensors, also known as amperometric or Clark-type sensors, measure dissolved oxygen concentration in water based on electrical current produced. Polarographic and galvanic are types of electrochemical DO sensors. The advantages of galvanic sensors over polarographic sensors are that they don't require outside voltage source and warm-up time to operate and their electrolyte can be used for a long time. Optical DO sensors, popularly known as luminescent DO sensors (LDO) but some are called fluorescent sensors, measure dissolved oxygen concentration in water based on the quenching of luminescence in the presence of oxygen. They can measure either the intensity or the lifetime of the luminescence as oxygen affects both.[1] The advantages of luminescence lifetime-based sensors over luminescence intensity-based sensors are that they are less susceptible to light source and detector drift, changes in optical path, and drift due to dye degradation or leaching.[2] They exhibit long-term stability[2] and maintain their accuracy even with some photodegradation.[1]



HORIBA offers galvanic electrochemical DO sensors and luminescence lifetime-based optical DO sensors. Both sensors are maintenance-free and designed with plug-and-play configuration that consists of two parts—robust sensor body with built-in thermistor and different cable lengths and replaceable DO sensor tip/cap—providing easy, quick, and accurate dissolved oxygen and temperature measurements. To learn more about these DO sensors, please read on.

A. Schematic

Galvanic DO Sensor



Components:

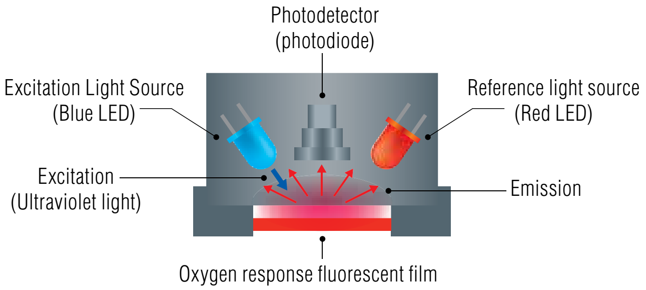
1. **Cathode**
2. **Anode**
3. **Electrolyte**
4. **Membrane**

The cathode and anode are dissimilar metals (different electro-potentials). In order to reduce oxygen without an external applied potential, the difference in potential between the anode and the cathode should be at least 0.5V. When placed in an electrolyte solution, the potential between dissimilar metals causes them to self-polarize with the electrons travelling internally from the anode to the cathode. For this reason, galvanic DO sensor does not require any warm-up time.

The cathode (e.g., Ag or another noble metal) accepts electrons from the anode via an internal circuit and passes them on to the oxygen molecules. It does not interfere in the reaction. Thus, the anode (e.g., Zn, Pb, or another active metal) is oxidized and oxygen is reduced at the surface of the cathode.

Both the cathode and anode are submerged in an electrolyte (e.g., NaOH, NaCl, or another inert electrolyte) and enclosed in a cap fitted with thin hydrophobic, oxygen-permeable membrane.

Optical DO Sensor



Components:

1. **Light-emitting diodes (LEDs)**
2. **Photodetector**
3. **Luminescent dye**
4. **Membrane**

Dual LED referencing system – blue LED emits light that excites the dye causing its luminescence. The red LED emits light but simply reflected back by the dye and does not cause luminescence. It serves as a reference to ensure accuracy.

Sensor film – a luminescent dye entrapped in a film. When exposed to blue light, the dye becomes excited (electrons gaining energy) and emits light as the electrons return to their normal energy state.

Photodetector – photodiode measures the intensity or lifetime of luminescence from the dye.

The sensor film is coated on the sensor cap while the LEDs and photodetector are housed in the sensor body.

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B. Working principle

Galvanic DO Sensor

When galvanic DO sensor is immersed in water sample, oxygen that diffuses across the oxygen-permeable membrane at a rate proportional to the pressure of oxygen in the water is reduced and consumed at the cathode. This reaction produces an electrical current that is directly related to the oxygen concentration. This current is carried by the ions in the electrolyte and runs from the cathode to the anode.

Anode (Pb) – lead oxidation reaction: $2Pb \rightarrow 2Pb^{2+} + 4e^-$
Cathode (Ag) – oxygen reduction reaction: $\underline{O_2 + 4e^- + 2H_2O \rightarrow 4OH^-}$
Overall reaction: $O_2 + 2H_2O + 2Pb \rightarrow 2Pb(OH)_2$

The current produced is proportional to oxygen consumed and thus to the partial pressure of oxygen in the sample.

The white solid, $Pb(OH)_2$, that is produced by these reactions is precipitated out into the electrolyte solution. It neither coats the anode nor consumes the electrolyte, and thus does not affect the sensor's performance until the quantity becomes excessive. If this happens, it may interfere with the ions' ability to carry current.

As galvanic DO sensor is self-polarizing, the anode is continuously consumed even when the sensor is not in use. When there is no measurement for a long period, the DO tip should be disconnected and stored according to the manual.

Optical DO Sensor

When an optical DO sensor is immersed in water sample, oxygen crosses the membrane and interacts with the dye. This quenches or reduces the intensity and lifetime of the dye's luminescence, which is measured by the photodetector and used to calculate the DO concentration.

The intensity and lifetime of luminescence when dye is exposed to blue light is inversely proportional to the amount of oxygen in the sample.

Lifetime is monitored as a function of oxygen concentration using the phase fluorometry technique, where an oxygen-sensitive phase difference is measured between the modulated luminescence signal and a modulated reference signal.[2]

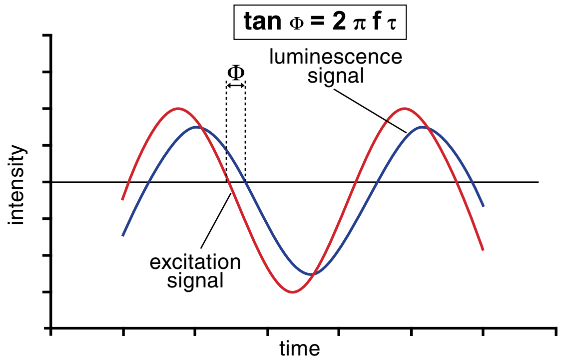

Fig. 1. Principle of phase fluorometric technique

If the excitation signal is sinusoidally modulated, the dye's luminescence is also modulated but is time delayed or phase shifted relative to the excitation signal. This phase shift is illustrated in Fig. 1. The blue and red LEDs are alternately switched in order to determine the phase difference, $Ø_{ref}$, due to electronics alone. This phase shift is subtracted in real time from the oxygen-dependent phase shift, $Ø_{sig}$, to obtain the specific sensor output phase shift.[2]

C. Calibration

Galvanic DO Sensor	Optical DO Sensor
100% DO Calibration	
Calibration is performed in clean air after allowing the sensor to sit for approximately 20 minutes. When galvanic DO sensor is connected to any 100 or 200 Series DO meters, the meter will show 105% DO after calibration in percent saturation DO mode. This is equivalent to 100% DO saturation in water. HORIBA determined 5% as the difference between the sensor current i n air and in water based on experimental results.	Calibration is performed in the air calibration bottle that comes with the sensor. The bottle has wet sponge at the bottom to create an environment with water vapor pressure. When optical DO sensor is connected to any WQ-300 series meters, the meter will show 100% DO after calibration in percent saturation DO mode.
0% Calibration	
Calibration is performed in fresh oxygen-free solution which can be prepared by dissolving 2 g of sodium sulfite (Na_2SO_3), an oxygen scavenger, with 1 L of distilled or deionized water in a container. The membrane and thermistor of the DO sensor should be fully immersed in the solution during calibration. Meter will show 0% DO after calibration in percent saturation DO mode.	

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D. Advantages and Disadvantages

	Galvanic DO Sensor	Optical DO Sensor
Stirring	• Required	• Not required
Warm-up time	• Not required	• Not required
Response time	• Faster than optical DO sensor	• Fast but takes 2-4x longer than electrochemical DO sensor
Power consumption	• Require less power than optical DO sensor	• Usually require more power than electrochemical DO sensor
Calibration	• Retains calibration data in the meter • Tends to drift away from calibration so frequent calibration is required	• Retains calibration data in the sensor head • Hold calibration better with little drift but regular calibration is still recommended
Membrane	• Vulnerable to damage and wear and tear	• Durable
Lifetime	• Shorter than optical DO sensor	• Longer than electrochemical DO sensor
Replacement Frequency	• DO tip replacement is every after 6 months depending on the application and handling. • When the sensor reading is unusually low or unstable or the sensor will not calibrate, the sensor tip needs to be replaced.	• DO sensor cap replacement is every after 12 months depending on the application and handling. • The dye degrades over time. When the sensor will not calibrate, the sensor cap needs to be replaced.
Warranty	• 6 months	• 12 months
Cost	• Cheaper than optical DO sensor	• More expensive than electrochemical DO sensor
Applications	• Not suitable for samples containing strong acids and hydrogen sulfide gas	• Suitable for samples containing strong acids and hydrogen sulfide gas • More accurate to low DO concentrations • Require less sample volume

E. Models

Type	Galvanic DO Sensor			Optical DO Sensor
Model	9520-10D (1m cable)	9551-20D (2m cable) 9551- 100D (10m cable)	9552-20D (2m cable) 9552-50D (5m cable)	300-D-2 (2m cable) 300-D-5 (5m cable)
DO Tip	7541	5401	5402	300-D-M
DO Range	0.00 – 20.00 mg/L			
Temperature Range	0 to 45 °C	0 to 40 °C	0 to 50 °C	
Accessories Included	DO sensor tip, stainless steel DO sensor protective guard			DO sensor cap, air calibration bottle, stainless steel DO sensor protective guard
Application	For laboratory use	For laboratory and field use		
Compatible Meters	100 Series, 200 Series			WQ-300 Series

References

1. Li, D. & Liu S. Water Quality Monitoring and Management: Basis, Technology and Case Studies. pp 7-15.

2. McDonagh, C., Kolle C., McEvoy A.K., Dowling, D.L., Cafolla, A.A., Cullen, S.J., MacCraith, B.D., (2001). Phase fluorometric dissolved oxygen sensor. Sensors and Actuators, 124-130

7 February 2020, Rev.0

Preparation Checklist for Ion Measurement

Meter

1. Go to the meter settings. Depending on the meter model, set either the ion valence (see table below) or the electrode model (e.g. 6583S-10C).

Combination ISE	Ion Valence
Potassium (K^+)	1
Ammonia (NH_3), Chloride (Cl^-), Fluoride (F-), Nitrate (NO_3^-)	-1
Calcium (Ca^{2+})	2

2. Set the unit of measurement (e.g. mg/L).
3. Depending on the meter model, set other settings required (e.g., number of calibration points).

Meter Model: ____________________
Mfg. No. : ____________________
Electrode Model Set: ____________________
Ion Valence: ____________________
Unit: ____________________
Other settings: ____________________
____
____
____
____
____

Ion Selective Electrode

1. Attach the electrode tip to the electrode body.
2. Using a dropper, fill the electrode body with filling solution up to a level below the fill hole.
    - Dislodge any bubbles formed.
    - Check if the filling solution flows out smoothly from the junction by suspending it in air while the fill hole is open.
3. Condition the electrode tip by soaking the electrode in 100ppm standard solution (with or without ISA) for at least 1 hour.

ISE Model: ____________________
Mfg. No. : ____________________
Electrode Tip Model: ____________________
Mfg. No. : ____________________
Filling Solution Model: ____________________
Filling Solution Level: ____________________
Electrode flow? ☐ Yes ☐ No
Conditioning Solution: ____________________
Conditioning Time: ____________(hr)

Standard Solutions

1. Prepare at least two standard solutions that are ten-fold apart and that bracket the expected ion concentration in the sample (e.g. 10 and 100ppm Ca^{2+} standard solutions for 20ppm Ca^{2+} sample).
2. Add ionic strength adjuster (ISA) to each standard solution and sample.
    - Follow the volume ratio of ISA to standard/sample indicated in the ISE manual.
    - Stir all standard solutions and samples after adding ISA.

Note: For ammonia, perform calibration or measure sample immediately after adding ISA.

ISA Model: ____________________

Standard Solution 1
- Model: ____________________
- Lot no. : ____________________
- Concentration: ____________________
- Amount used: ____________ ml
- ISA added: ____________ ml
- Stir? ☐ Yes ☐ No

Standard Solution 2
- Model: ____________________
- Lot no. : ____________________
- Concentration: ____________________
- Amount used: ____________ ml
- ISA added: ____________ml
- Stir? ☐ Yes ☐ No

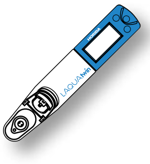
Calibration

1. Follow the ion calibration procedure in the meter manual. Wait for stable reading before entering and confirming the standard concentration into the meter.
2. Record the mV of each standard, temperature, and slope.

Stable readings during calibration?
☐ Yes ☐ No
Good readings after calibration?
☐ Yes ☐ No
Standard Solution 1: ____________mV
Standard Solution 2: ____________mV
Temperature: ____________°C
Slope: ____________%

Observations

Write the standard solution preparation, electrode behaviour, or any message that appears in the meter during measurement.



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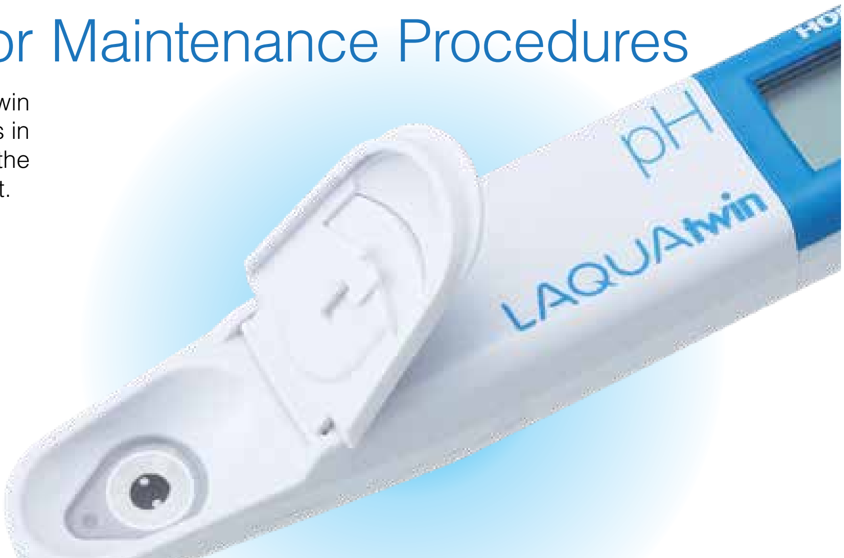
LAQUAtwin pH Sensor Maintenance Procedures



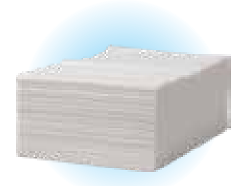
Proper usage and maintenance of the LAQUAtwin pH meter, especially the pH sensor that comes in contact with samples, is important to maintain the accuracy and prolong the life span of the instrument.

Materials Needed

pH 7.00 buffer (Part no. 3999960109)

Clean water (e.g. distilled, deionized, tap)

Cotton buds



Soft tissue

Cleaning Solution 220 (Part no. 3014028653) - contains 10% thiourea and 1% hydrochloric acid (HCl) for removing inorganic residues on sensing membrane and junction

Cleaning Solution 250 (Part no. 3200366771) – contains < 0.5% enzyme protease, < 0.1% sodium azide, and other ingredients (See SDS) for removing protein residues on sensing membrane and junction

Conditioning

A dry pH sensor may give erratic reading or slow response. Condition the pH sensor before using it for the first time and after storing it dry. If there is white powder or salt buildup on the junction after dry storage, simply rinse off with water. This is normal.

1. Place few drops of pH 7.00 buffer onto the pH sensor. Make sure that the whole flat sensor is covered with the solution.
2. Leave the pH buffer for at least 1 hour to allow the solution to hydrate the pH sensor.
3. Rinse the pH sensor with water and blot it dry with soft tissue.
4. Perform calibration with fresh pH buffers prior to sample measurement.

Cleaning

A clean pH sensor is necessary for performing an accurate pH measurement. The cleaning solution will depend on what sample was tested with the sensor.

Read the safety data sheet (SDS) of the cleaning solution to be used and wear the proper personal protective equipment before handling. Download the SDSs of HORIBA cleaning solutions at www.horiba-laqua.com.

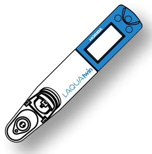
1. Remove unwanted sample residues left on the pH sensor by using an appropriate cleaning solution. For most samples, use mild detergent and clean water. For samples containing oil, proteins, and stain-causing substances, use the indicated cleaning solutions below.
    - Oils – place few drops of warm water and mild detergent solution onto the sensor. Never use any organic solvent (e.g., acetone, ethanol, etc.) to clean the pH sensor as it may cause damage and shorten the sensor lifespan. This usage will also void the sensor warranty.
    - Proteins – place few drops of cleaning solution 250 onto the sensor and leave for 30 minutes.
    - Stains - place few drops of cleaning solution 220 or 0.1 M HCl onto the sensor and leave for 30 minutes.
2. Gently, wipe the sensor using a cotton bud. Avoid applying pressure and repeat step 1, if needed.
3. Rinse the pH sensor with water and condition it (See Conditioning).

If calibration with fresh buffers failed repeatedly and cleaning did not restore the pH sensor performance, replace the pH sensor with a new one (Model S010, Part no. 3200459834). The pH sensor is a consumable product and its performance deteriorates over time even under normal operating condition.

If disinfection is needed, wipe the surface of meter body and sensor with a clean cloth wet with ethanol or use alcohol wipes. For the flat sensor, place drops of 5% sodium hypochlorite (NaClO) solution for 5 to 30 minutes then rinse thoroughly with sterile water.

Storage

Store the clean pH sensor in dry condition. Never leave distilled or deionized water on the pH sensor for long period as salts may leach out and reduce sensor life. Condition the pH sensor prior to next use (See Conditioning).



Troubleshooting Guide for LAQUAtwin pH Pocket Meters

Most problems associated with LAQUAtwin pH pocket meters are attributed to dry, dirty, or damaged sensors, which come in direct contact with samples. Please refer to the following table for the problems and their corresponding possible causes and solutions encountered with LAQUAtwin pH-11, pH-22, pH-33 pocket meters and flowchart for troubleshooting the LAQUAtwin S010 sensor.

The meter and sensor are warranted against manufacturing defects for 24 months and 6 months, respectively, from the date of purchase. Problems arising from mishandling and application are not covered in the warranty.

Problem	Possible Cause	Solution
Same pH value	Damaged sensor – cracked or broken membrane (Figure 1.2)	Replace the sensor.
	Auto hold mode – the meter is set to auto hold	Press MEAS key to refresh the reading.
Error 1, 2, 3	Defective meter internal IC	Reset the meter. If problem persists, replace the meter.
Error 4	Dry sensor - the sensor is new or stored for long period making it dehydrated.	Condition the sensor by soaking with pH 7.00 buffer for at least 1 hr. Clear the existing calibration data or reset the meter then calibrate.
	Wrong pH buffer group – the pH buffer group selected in the set-up mode does not match the set of pH buffers in use.	If NIST pH buffer group is desired, select NIST in the set-up mode, clear the existing calibration data, and calibrate. If USA pH buffer group is desired, reset the meter and calibrate. • USA - 1.68, 4.01, 7.00, 10.01, & 12.46 pH buffers • NIST – 1.68, 4.01, 6.86, 9.18, & 12.46 pH buffers
	Interfering old calibration data – the meter overrides one existing calibration point during calibration and uses other existing calibration point in the meter to compute slope.	Clear the existing calibration data or reset the meter and calibrate.
	Readings are out of the calibration window or acceptable slope range – measure the mV readings of pH 4.01 and 7.00 buffers with the meter	Clean and condition the sensor and reset the meter. Calibrate. If problem persists, replace the sensor.
Blinking Or (Over range) / Ur (Under range)	The measured pH of sample is not within pH 0-14 range.	Measure a pH buffer. If the meter shows the expected value of the pH buffer, it confirms that the meter is not able to measure the sample's pH. Use a laboratory pH electrode and meter.
	Damaged sensor and/or meter – e.g. deformed sensor contact sheet (Figure 2.1) and/or bent or broken meter pins (Figure 3.1)	Visually inspect the sensor and meter and substitute the part in question with known good working one. Replace the sensor and/or meter, whichever is found damaged.
Blinking °C	The measured temperature of sample is not within 5 to 40°C range.	Measure a pH buffer at room temperature. If the meter shows the expected temperature of the pH buffer, it confirms that the sample's temperature is not within the range. Allow the sample temperature to fall within the range or use a laboratory pH electrode and meter.
	Damaged sensor and/or meter – e.g. deformed sensor contact sheet (Figure 2.1) and/or bent or broken meter pins (Figure 3.1)	Visually inspect the sensor and meter and substitute the part in question with known good working one. Replace the sensor and/or meter, whichever is found damaged.
Meter does not power on.	Batteries are drained or not properly inserted.	Re-insert or replace both batteries. If problem persists, replace the meter.

Continued on the next page

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Continued from previous page


Figure 1: Normal sensor


Figure 1.1: KCl salts build-up on the sensors is a normal occurence


Figure 1.2: Sensor with cracked or broken membrane


Figure 2: Normal contact sheet inside the sensor


Figure 2.1: Deformed contact sheet inside the sensor


Figure 3: Normal pins inside the meter

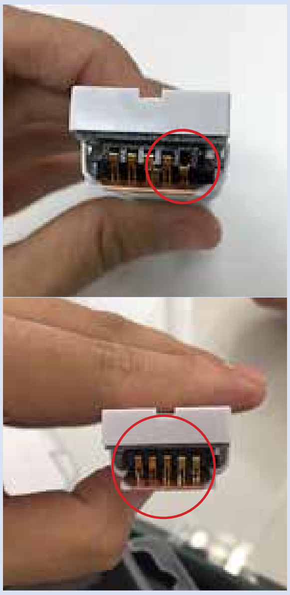
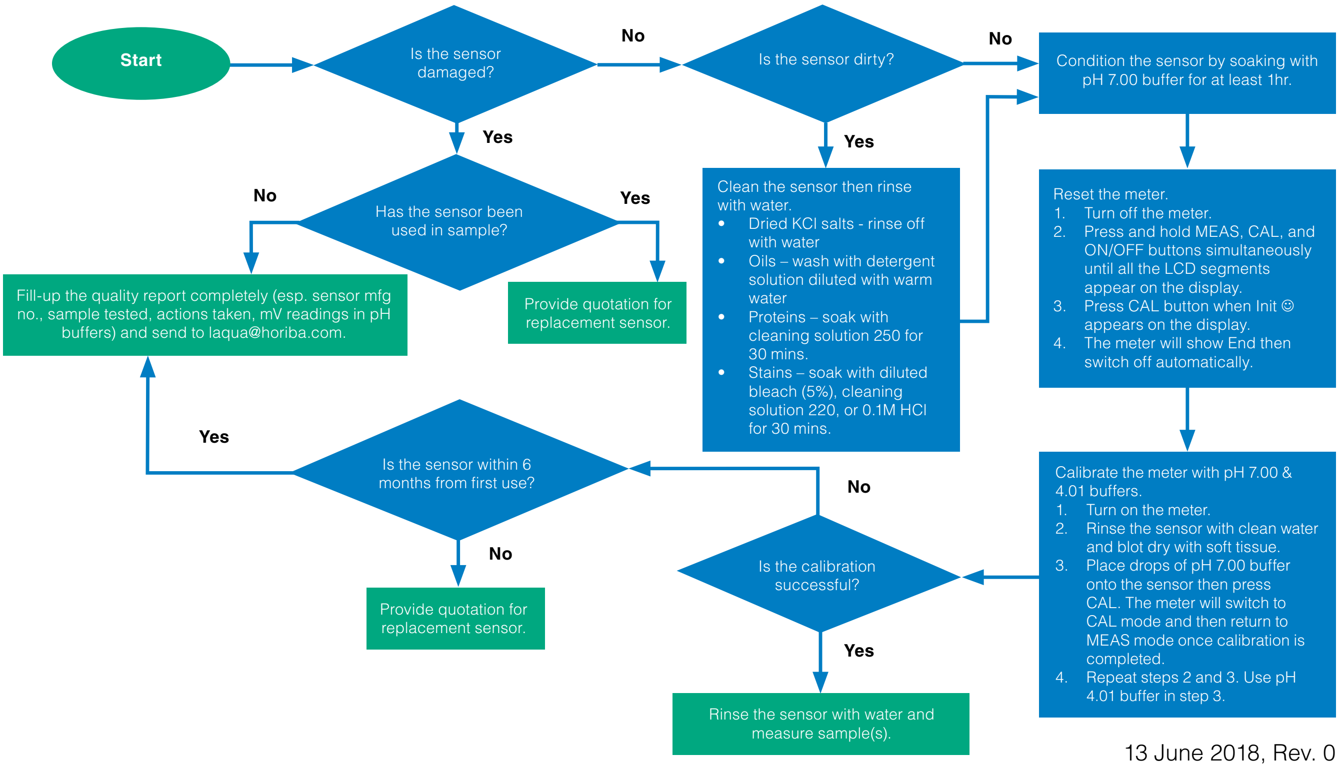


Figure 3.1: Bent pins inside the meter

Troubleshooting Guide for LAQUAtwin pH Sensor


Start

Is the sensor damaged?

No

Is the sensor dirty?

No

Condition the sensor by soaking with pH 7.00 buffer for at least 1hr.

Yes

Has the sensor been used in sample?

No

Fill-up the quality report completely (esp. sensor mfg no., sample tested, actions taken, mV readings in pH buffers) and send to laqua@horiba.com.

Yes

Provide quotation for replacement sensor.

Yes

Clean the sensor then rinse with water.

- Dried KCl salts - rinse off with water
- Oils – wash with detergent solution diluted with warm water
- Proteins – soak with cleaning solution 250 for 30 mins.
- Stains – soak with diluted bleach (5%), cleaning solution 220, or 0.1M HCl for 30 mins.

Reset the meter.

1. Turn off the meter.
2. Press and hold MEAS, CAL, and ON/OFF buttons simultaneously until all the LCD segments appear on the display.
3. Press CAL button when Init ☺ appears on the display.
4. The meter will show End then switch off automatically.

Calibrate the meter with pH 7.00 & 4.01 buffers.

1. Turn on the meter.
2. Rinse the sensor with clean water and blot dry with soft tissue.
3. Place drops of pH 7.00 buffer onto the sensor then press CAL. The meter will switch to CAL mode and then return to MEAS mode once calibration is completed.
4. Repeat steps 2 and 3. Use pH 4.01 buffer in step 3.

Is the calibration successful?

Yes

Rinse the sensor with water and measure sample(s).

No

Is the sensor within 6 months from first use?

Yes

No

Provide quotation for replacement sensor.

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LAQUAtwin Conductivity Sensor Maintenance Procedures

Proper usage and maintenance of the LAQUAtwin conductivity meter, especially the conductivity sensor that comes in contact with samples, is important to maintain the accuracy and prolong the life span of the instrument.

Materials Needed

Conditioning Solution (Part no. 3999960114) - contains 5% surfactant for removing dirt on sensor surface

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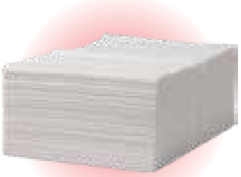
Clean water (e.g. distilled, deionized, tap)



Soft tissue

Cleaning Solution 220 (Part no. 3014028653) - contains 10% thiourea and 1% hydrochloric acid (HCl) for removing stubborn deposits on sensor surface

Mild detergent solution (5ml liquid detergent diluted to 100ml with water)

Conditioning

Condition the conductivity sensor before using it for the first time.

1. Place few drops of the conditioning solution onto the conductivity sensor. Make sure that the whole sensor is covered with the solution and there are no bubbles formed or trapped on the sensor.
2. Leave the conditioning solution for 10 to 30 minutes.
3. Rinse the conductivity sensor with water and blot it dry with soft tissue.
4. Perform calibration with fresh conductivity standard solutions prior to sample measurement.

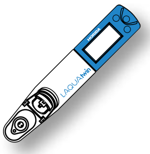
Cleaning

A clean conductivity sensor is necessary for performing an accurate conductivity measurement. If the meter reading is incorrect or an error appeared on the display, the conductivity sensor requires cleaning.

1. Remove dirt or unwanted sample residues on the sensor by performing the conditioning procedure above. If conditioning solution is not available, a diluted detergent solution (e.g., 5ml liquid detergent diluted to 100ml with water) can be used.
2. If the conditioning procedure failed to restore the sensor performance and there are stubborn deposits on the sensor surface, use a stronger cleaning solution such as cleaning solution 220 and follow the procedure above.
    - Download and read the safety data sheet (SDS) of cleaning solution 220 at www.horiba-laqua.com before handling.
    - Never use any organic solvent (e.g., acetone, ethanol, etc.) to clean the conductivity sensor as it may cause damage and shorten the sensor lifespan. This usage will also void the sensor warranty.
3. If calibration with fresh conductivity standard solutions failed repeatedly and cleaning did not restore the conductivity sensor performance, replace the sensor with a new one (Model S070, Part no. 3200459672). The conductivity sensor is a consumable product and its performance deteriorates over time even under normal operating condition.
4. If disinfection is needed, wipe the surface of meter body and sensor with a clean cloth wet with ethanol or use alcohol wipes. For the flat sensor, place drops of 5% sodium hypochlorite (NaClO) solution for 5 to 30 minutes then rinse thoroughly with sterile water.

Storage

Store the clean conductivity sensor in dry condition.



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LAQUAtwin Ion Pocket Meters

LAQUAtwin Ion Sensor Maintenance Procedures

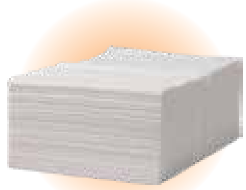
Proper usage and maintenance of the LAQUAtwin Ion meter, especially the ion sensor that comes in contact with samples, is important to maintain the accuracy and prolong the life span of the instrument.

Materials Needed

2000ppm Ion
Standard Solution

Clean water
(e.g. distilled,
deionized, tap)

Cotton buds



Soft tissue

Household bleach
(< 5% sodium hypochlorite or NaClO)

Mild detergent

Conditioning

A dry ion sensor may give erratic reading or slow response. Condition the ion sensor before using it for the first time and after storing it dry. If there is white powder or salt buildup on the junction after dry storage, simply rinse off with water. This is normal.

1. Place few drops of 2000ppm ion standard solution onto the ion sensor. Make sure that the whole flat sensor is covered with the solution.
2. Leave the standard solution on the ion sensor for 10 minutes to 1 hour.
3. Rinse the ion sensor with water and blot it dry with soft tissue.
4. Perform calibration with fresh ion standard solutions prior to sample measurement.

Cleaning

The performance of the ion sensor may deteriorate, especially when it is used in testing dirty samples such as soil, plant tissue sap, etc. To restore the performance of the ion sensor, remove any unwanted sample residues on the flat sensor surface by cleaning it with mild detergent and water. If there are stains or stubborn deposits left, perform the following:

1. Place few drops of household bleach with less than 5% sodium hypochlorite onto the sensor and leave for 5 to 30 minutes (maximum).
2. Gently, wipe the sensor using a cotton bud. Avoid applying pressure and repeat step 1, if needed.
3. Rinse the ion sensor with water and condition it (See Conditioning).

Sodium hypochlorite (NaClO) salt is the active ingredient of bleach, which is often used in disinfection and stain removal. Generally, household bleach in the market contains 3 to 8% NaClO. For cleaning the sensor, a cleaning solution with less than 5% NaClO is recommended, so dilute bleach if necessary. Never use any organic solvent (e.g., acetone, ethanol, etc.,) to clean the sensor as it may cause damage and shorten the sensor lifespan. This usage will also void the sensor warranty.

If disinfection is needed, wipe the surface of meter body and sensor with a clean cloth wet with ethanol or use alcohol wipes. For the flat sensor, rinse it thoroughly with sterile water after cleaning with NaClO.

If calibration with fresh ion standard solutions failed repeatedly and cleaning did not restore the ion sensor performance, replace the sensor with a new one (See Part Numbers below). The ion sensor is a consumable product and its performance deteriorates over time even under normal operating condition.

- S022 Part no. 3200459867 – Sodium Ion Sensor
- S030 Part no. 3200459868 – Potassium Ion Sensor
- S040 Part no. 3200459870 – Nitrate Ion Sensor
- S050 Part no. 3200459869 – Calcium Ion Sensor

Storage

Store the clean ion sensor dry. Make sure to condition the sensor prior to next use (See Conditioning).

Procedure for Setting mmol/L Unit in LAQUAtwin Ion Pocket Meters

This procedure is only applicable for LAQUAtwin Na-11, K-11, NO3-11, and Ca-11 models, which have special set-up mode to show reading in mmol/L unit. Note that the mmol/L unit itself is not indicated in the special set-up mode and will not appear on the LCD after following this procedure.

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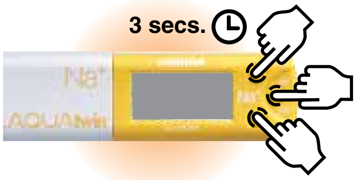
LAQUAtwin Ion Pocket Meters

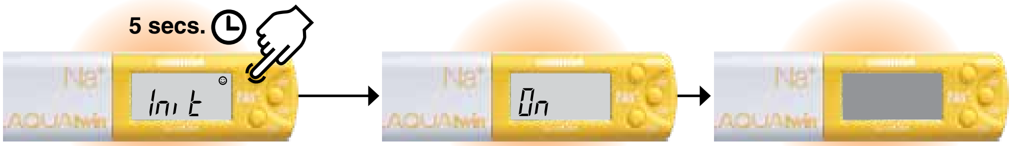
1. Press ON/OFF button to switch off the meter.

2. Press and hold MEAS, CAL, and ON/FF buttons simultaneously for 3 seconds.



3. Wait for the meter to display Init.

4. Press and hold MEAS button for 5 seconds. The meter will display ON and switch off automatically.



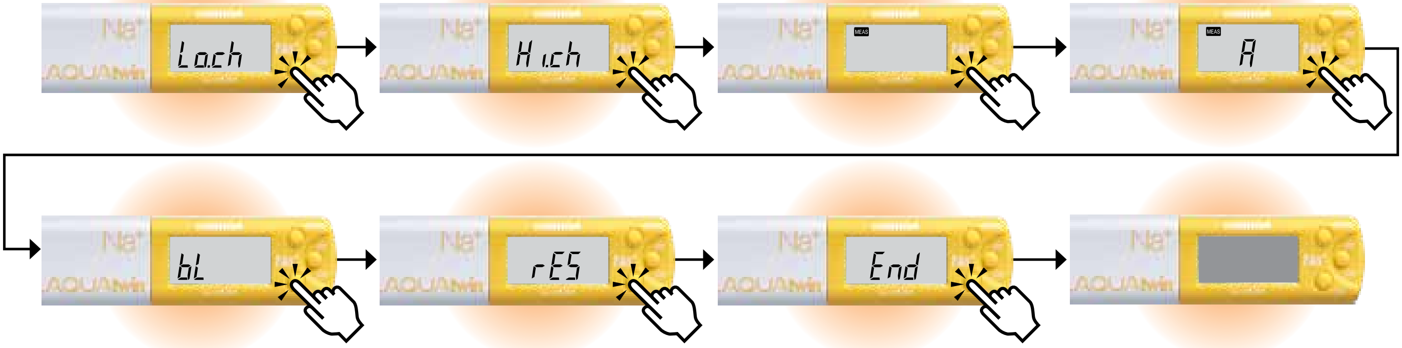
5. Press MEAS and ON/OFF buttons simultaneously for 3 seconds.

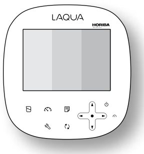
6. Wait for the meter to display unit setting.

7. Press MEAS button repeatedly until both ppm and mg/L units disappear and Unit alone is displayed.

This indicates mmol/L unit but does not display mmol/L on the LCD

8. Press CAL button repeatedly until the meter switches off.





Automatic Temperature Compensation in pH Measurement

If you have been looking for a pH meter, you have probably seen the words “Automatic Temperature Compensation” or ATC in the specifications or advertisements of various pH meter brands and wondered what it means. This technical tip answers the three frequently asked questions about ATC in pH measurement.

Question 1: How does ATC work in pH measurement?

Since temperature affects pH, the actual temperatures of pH buffers and samples must be measured and take into account in calibration and measurement.

A 3-in-1 pH electrode (combination pH electrode with built-in temperature sensor) or a combination pH electrode together with a separate temperature probe is recommended to be used with the pH meter. When immersed in solution, the temperature sensor or probe measures the actual temperature, which is then transmitted directly to the pH meter.

9615S-10D Standard ToupH electrode (3-in-1)

9425-10C pH electrode (combination)

4163-10T temperature probe

Figure 1: Examples of 3-in-1 pH electrode and combination pH electrode and separate temperature probe

During calibration, the pH meter automatically corrects the reading of the pH buffer in use to the expected value at the actual temperature.

Prior to measurement, pH calibration must be performed with the pH meter and pH electrode using at least two pH buffers that bracket the pH values of samples. HORIBA pH meters are programmed with the expected pH values of commonly used sets of pH buffers (e.g., USA, NIST, DIN) at different temperatures. For the pH meter to recognize and calibrate the pH buffers correctly, the appropriate pH buffer group must be selected and set in the set-up mode of the pH meter. The use of pH buffers not matching the pH buffer group setting results in error code on the pH meter or inaccurate calibration leading to unreliable measurements.

Table 1: Values of pH Buffers at Different Temperatures

°C	pH Buffers at 25°C						
	1.68	**4.01**	**6.86**	**7.00**	**9.18**	**10.01**	**12.46**
0	1.67	4.01	6.98	7.12	9.46	10.32	13.47
5	1.67	4.01	6.95	7.09	9.39	10.25	13.25
10	1.67	4.00	6.92	7.06	9.32	10.18	13.03
15	1.67	4.00	6.90	7.04	9.27	10.12	12.83
20	1.68	4.00	6.88	7.02	9.22	10.06	12.64
25	1.68	4.01	6.86	7.00	9.18	10.01	12.46
30	1.69	4.01	6.85	6.98	9.14	9.97	12.29
35	1.69	4.02	6.84	6.98	9.10	9.93	12.14
40	1.70	4.03	6.84	6.97	9.07	9.89	11.99
45	1.70	4.04	6.83	6.97	9.04	9.86	11.86
50	1.71	4.06	6.83	6.97	9.01	9.83	11.73
55	1.72	4.08	6.83	6.97	8.99	9.81	11.61

During calibration, the pH meter detects the temperature measured by the temperature sensor or probe as well as the potential (mV) measured by the pH electrode. The pH meter then recognizes the pH buffer in use based on the measured potential and assigns the correct value of the pH buffer based on the measured temperature. To verify whether the pH meter has calibrated the correct value of the pH buffer at the measured temperature, refer to the pH vs temperature table on the label of the pH buffer bottle.

Figure 2: Screenshots of F-74 meter before, during, and after calibration with pH 7 buffer at 25°C

Temperature also affects the pH electrode slope.

The pH electrode behaviour follows the Nernst equation: $E = E_0 + 2.303\,(RT/nF)\log a_{H^+}$ where slope, also called sensitivity, is denoted by $-2.303\,RT/nF$ and pH is equal to $-\log a_{H^+}$. Since R, F, and n are constants, the slope changes with temperature and this effect can be compensated by a pH meter with ATC capability.

$$E = E^0 + 2.303\ (RT/nF) \log a_{H^+}$$

where:

- E = potential (in mV) of the sensing reference electrode
- E_0 = potential of the reference electrode
- R = Gas constant (8.314 J/mol • K)
- T = Temperature (K)
- n = valency of ion (1 for H)
- F = Faraday constant (96485 C/mol)
- a_{H^+} = Activity of H^+

Figure 3: Nernst equation

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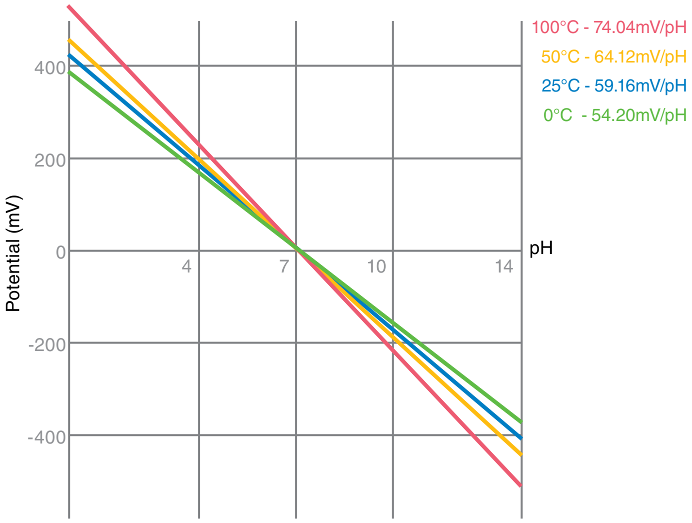
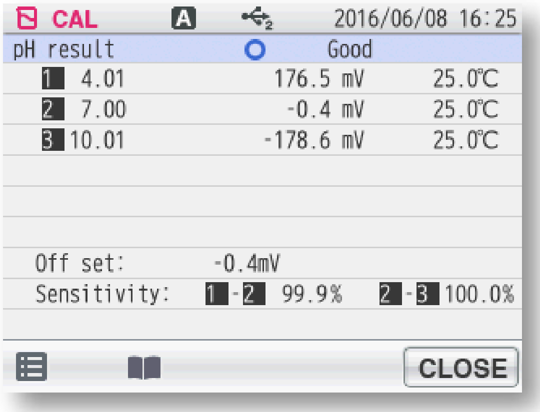


Figure 4: Theoretical slopes of an ideal pH electrode at different temperatures

After calibration, the pH meter generates slope at the measured temperature according to the Nernst equation. HORIBA pH meters report slope for every two consecutive calibration points in percentage (% = actual / theoretical slope x 100). The slope should be within the range 90-105%.



pH result	○	Good
1 4.01	176.5 mV	25.0℃
2 7.00	-0.4 mV	25.0℃
3 10.01	-178.6 mV	25.0℃

Off set: -0.4mV
Sensitivity: 1-2 99.9% 2-3 100.0%

Figure 5: Example of pH calibration result

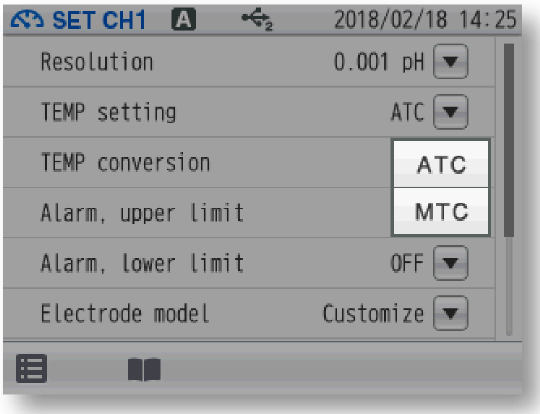
During measurement, the pH meter applies the slope to calculate the pH values of samples.

To obtain accurate results, samples should be at the same (or as close as possible) temperature as the pH buffers used in calibration. This can be achieved by allowing the pH buffers and samples to equilibrate at room temperature or by placing them in a water bath with temperature control.

Question 2: I'm using a combination pH electrode and I have no separate temperature probe. How to compensate the temperature effect in pH measurement?

In this case, the pH meter shows the default temperature 25°C. It is more convenient to use a 3-in-1 pH electrode because the measured temperature is automatically transmitted to the pH meter and only one electrode is immersed in each solution. However, if a 3-in-1 pH electrode or separate temperature probe is not available, you may manually enter the temperatures of your pH buffers and samples into the pH meter. To do this, measure the temperatures using a calibrated thermometer or other temperature measuring device and then enter the temperatures into the manual temperature compensation (MTC) setting of the pH meter before doing calibration and measurement. Refer to the meter instruction manual for the location of the MTC setting in the set-up mode and the procedure for entering the temperature.

HORIBA pH meters have ATC and MTC settings. The ATC is used to correct the temperature reading of the temperature sensor or probe connected to the meter while the MTC is used to enter the temperature reading of a separate temperature measuring device into the meter.

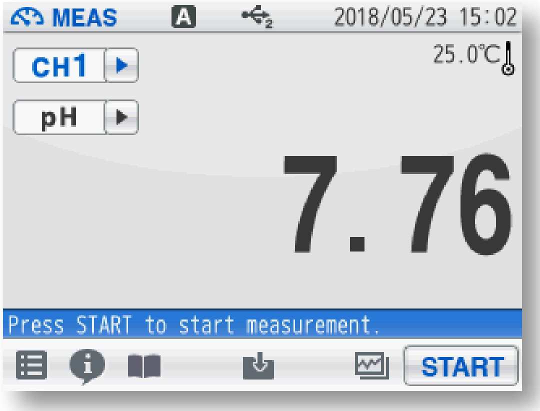


Resolution 0.001 pH
TEMP setting ATC
TEMP conversion
Alarm, upper limit
Alarm, lower limit OFF
Electrode model Customize

Figure 6: ATC and MTC settings in F-74 meter

Question 3: Does ATC work in sample?

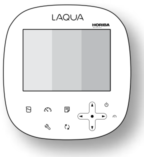
No. Just like pH buffers, the chemical compositions of samples may vary and therefore samples may react differently to temperature. Also, laboratory pH meters are typically not programmed to correct the pH values of samples at the actual or other temperature. As such, it is important to record the pH value together with the temperature after measuring a sample.



25.0℃
7.76
Press START to start measurement.

Figure 7: Record the pH and temperature of each sample

HORIBA F-70 series colour touchscreen pH bench meters have temperature conversion feature, which can be utilized if the temperature coefficient of a sample is known.



Password Reset Procedure for LAQUA 1000 Series Bench Meters

If you've forgotten the password for your PH1100, PH1200, PH1300, EC1100, or PC1100 meter, follow these steps to reset the password.

Scan QR code with your mobile device to know more about LAQUA 1000 Series Bench Meters

1 Press the SET key and MODE key simultaneously for 5 seconds.

2 Press ENT key.

3 Press SET key.

4 Press down arrow key until GEN appears on the screen.

5 Press ENT key.

6 Press down arrow key again until PASS appears on the screen.

7 Press ENT key twice.

8 Enter a new 4-digit password using the arrow keys: left/right arrows—to move to the left or right digit, up/down arrows—to increase or decrease the digit.

9 Press ENT key to save the new 4-digit password.

10 New password is set.

Notes

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Water Quality Analyzers

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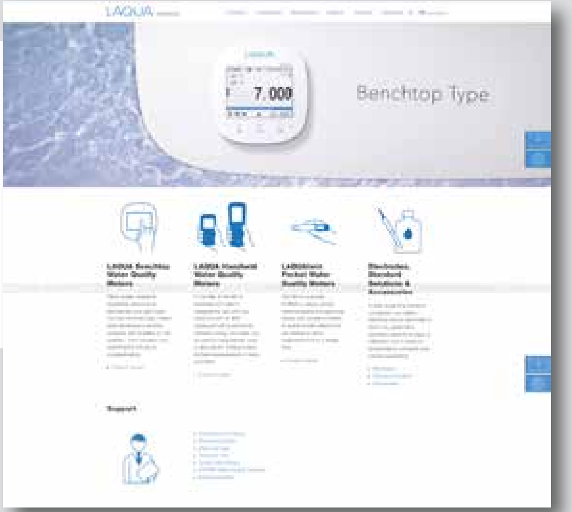
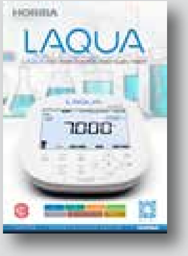
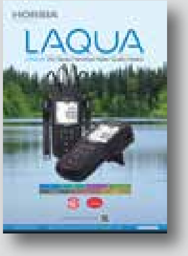
With over 60 years of engineering excellence, HORIBA's diverse range of water quality analyzers and electrodes are ideal for everyday laboratory needs through to the most demanding of applications. Visit our website for a wealth of useful information and water quality measurement tips to help you obtain the best results in your work.

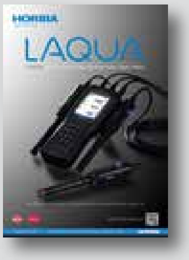




Benchtop Meters

Developed using extensive feedback from users, our new LAQUA meters deliver the best solution for water quality analysis. Our LAQUA website features an online 'Selection Guide' to enable you to find the perfect LAQUA meter and electrode for your need.



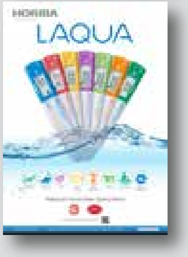


Handheld Meters

In the lab, in the field or anywhere you need it. LAQUA Handheld meters are designed for use with one hand and with an IP67 waterproof rating and shock-resistant casing. Meters can be used for long periods, even in dark places, making it ideal for field measurements in rivers and lakes.

Electrodes

Various electrodes to match any application. A wide range of products for both benchtop and portable systems are available, including easy and reliable standard models, application-focused models for small samples or large containers, and special electrodes for specific sample characteristics.



Pocket Meters

Analyzing water quality is simplified when using our LAQUAtwin range of meters. Designed to produce accurate and reliable results. Anyone, anywhere, at any time can measure samples easily with a LAQUAtwin meter. See just how good they are at our website.

Application Notes

LAQUAtwin pocket meters offer quick and convenient alternative to analyze important parameters with high accuracy. Several application notes are available at (http://goo.gl/znwE6j) detailing the use of LAQUAtwin and the results achieved for the respective applications. Additional application notes will be added when available.

Visit the **HORIBA LAQUA Singapore** Channel on YouTube and subscribe to see more of our videos.

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