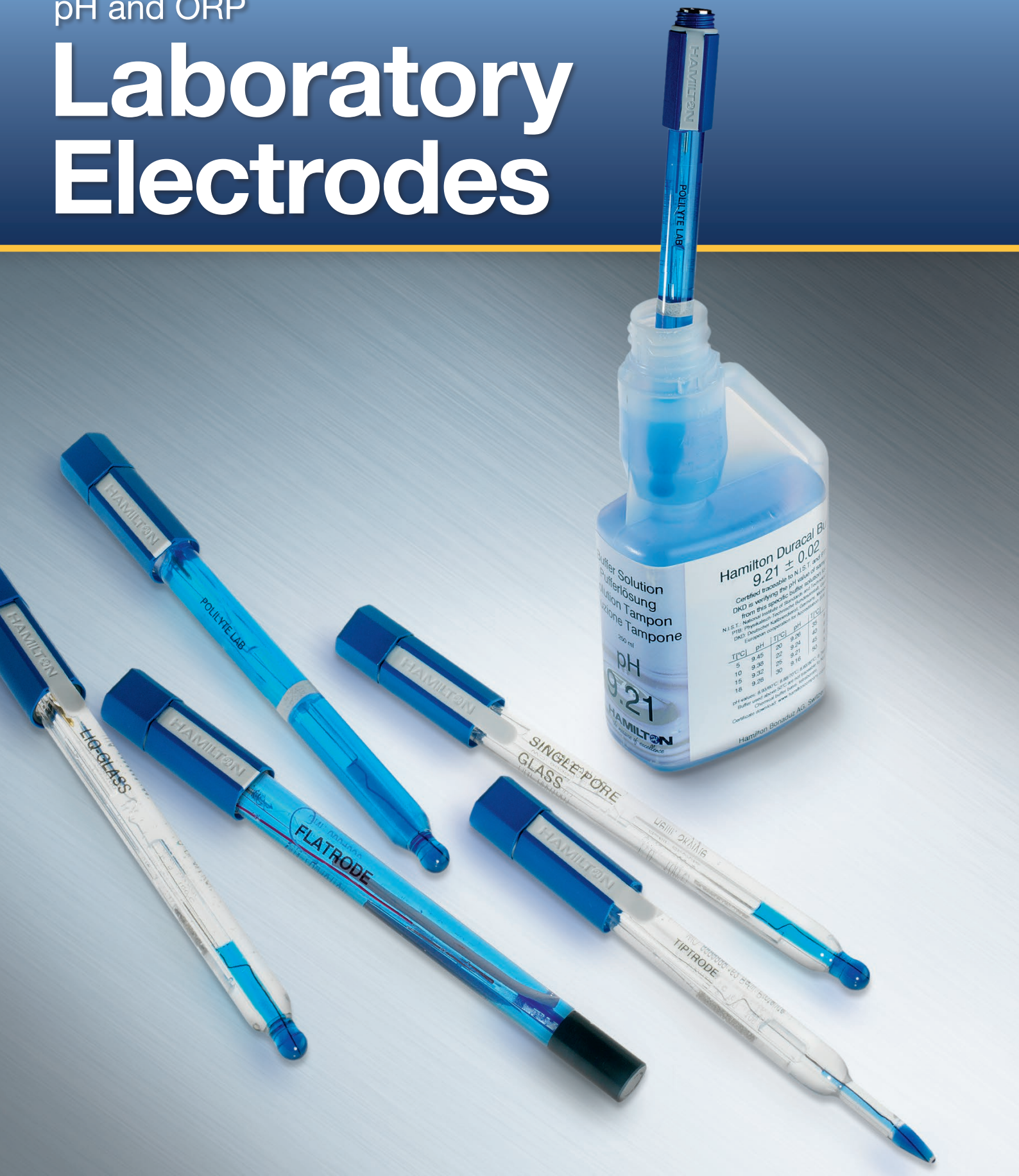
pH and ORP

Laboratory Electrodes



HAMILTON®

Polilyte™ Lab

See more on page 9

Single Pore® Glass

See more on page 9

DuraCal™ Buffers

See more on page 18

Table of contents

Why choose a Hamilton laboratory electrode?

Hamilton electrodes are precision instruments known for high quality, long lifetime and remarkable performance in a wide range of applications. The sensors are designed to help you with the daily work in GLP environments. Due to the indelible serial number on the sensor and a certificate with serial number and the measured millivolt values for your documentation, traceability is guaranteed.

Hamilton can also supply the most accurate laboratory electrode in the market. Our Single Pore Glass was tested by PTB (Physikalisch-Technische Bundesanstalt, Germany) and has reached in a comparison study the best accuracy.

Further advantages of the electrodes are their functional design and the leak proof watering cap.

Design offers many advantages

- All electrodes are printed with an indelible serial number
- Ergonomic electrode head
- Proven electrolyte sealing system for the refill opening
- Blue inner buffer provides visual indication of contact with the pH membrane
- High-quality seal between electrode head and cable (IP 68)

Watering cap with screw lock

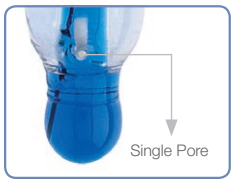
- Easy removal by means of the screw lock
- Secure sealing
- No spilling of electrolyte

Individual test certificates with measured millivolt values

The Single Pore® concept

Precise, reliable and rapid readings with a patented liquid junction ensuring optimal contact between electrolyte and sample

Since its introduction in 1991, the Single Pore concept continues to prove its reliability. Instead of the many tiny pores in a ceramic diaphragm, a Single Pore about 200 times larger in cross-section (in the form of a capillary) ensures reliable contact to the sample. This Single Pore is practically impossible to clog. In combination with a dedicated electrolyte, the flow rate through the pore is defined, resulting in enhanced contact between the reference electrode and the measurement medium. This leads to a faster electrode response and more accurate readings.



Even after 20 very successful years, Hamilton continues to improve the design of the Single Pore glass electrode is even more robust and user-friendly than ever.

Note: PTB (Physikalisch-Technische Bundesanstalt/Physical-Technical Federal Institute) in Braunschweig, Germany, in a very wide-ranging and well documented study, determined the Single Pore pH electrode to be the most accurate laboratory electrode in the test. Further information can be found in "Traceability of pH measurement" by Petra Spitzer: ISBN 3-89429-877-4 or ISSN 0947-7063.

Polisolve™ and Polisolve™ Plus electrolyte

The innovative polymer reference electrolyte that solves so many application problems

Contrary to the widespread belief that pH electrodes with a polymer electrolyte cannot be used over the entire pH or temperature range, Hamilton has succeeded in developing the innovative polymer electrolyte that can be used over the complete pH range from 0 to 14, and in a temperature range from -10°C to 130°C.

Polisolve is compatible with most organic solvents, and is completely acrylamide free. The combination of Polisolve electrolyte with the modified Single Pore concept results in an extremely versatile laboratory electrode that is perfectly suited for pH measurement in a wide range of uses and difficult samples such as:

- Ground water and coolants
- Solutions containing color pigments
- Suspensions
- Galvanic baths
- Samples containing oil and fat
- Solutions containing protein

The Everef™ reference system

Long electrode life thanks to stable reference potentials

Stable reference systems are at the heart of reliable, long-life electrodes. This is why many Hamilton electrodes are equipped with reference systems from the Everef family. The silver chloride reservoir is separated from the reference electrolyte by a diffusion distance that prevents the loss of silver chloride during temperature swings yielding silver-free electrolyte.

The Everef B labyrinth system used in the Polilyte Lab electrodes further extends the diffusion distance, considerably lengthening electrode life in aggressive media. These electrodes provide outstanding results in ion-weak and partially aqueous solutions.

Hamilton pH membrane glass

Guarantees the accuracy of your measurements

The continuous improvement of our pH membrane glass offers many previously unavailable benefits. Most laboratory electrodes have a “V” or a “HF” type glass membrane. These unique glasses possess excellent mechanical stability and very low membrane resistance, making measurements possible in low conductivity solutions.
“HF” glass was developed to guarantee the longest possible electrode life in processes containing hydrofluoric acid. In addition, this glass is well suited to the production of flat pH

membranes, allowing readings, for example with the FlaTrode™ in small volumes or on flat surface areas. Hamilton “H” glass shows excellent performance and stable measurement values in media with low water content, for example in anhydrous or only partially aqueous solutions. The low alkali error of “H” glass ensures accurate measurements even at high pH values.

Conductivity standards

Certified by an independant accredited laboratory
Fulfills all requirements of United States Pharmacopia USP Chapter 625

Hamilton is the first vendor in the world of conductivity standards to offer 1.3 and 5 µS/cm with a certified accuracy of ±1 % and a lifetime of 1 and 3 years, respectively. The composition of these standards is patented. The measurement procedure for determining conductivity has been developed in collaboration with DFM[1].

Several metrological institutes dealing with measurements of electrolytic conductivity have started using these Hamilton standards, since they cover the low conductivity range and exhibit a previously unknown level of stability, confirmed by measurements performed by PTB[2].
For this reason, in an inter-laboratory test among prestigious European metrological institutes (PTB, DFM, DAkkS[3]), Hamilton standards were used as measurement solutions.

See page 20 for details

DuraCal™ pH buffers

Certified by an independant accredited laboratory
Easy handling and 5-year stability

DuraCal pH buffers consist of a complete range of patented stable pH buffer solutions from pH 1.09 to 12.00. Hamilton guarantees that they last for five years from the date of manufacture. pH buffers 9.21 and 10.01 are even stable in air. High buffer capacities enable quick, stable calibrations. Closed-loop traceability: In contrast to other manufacturers, who use only hierarchical (top-down) traceability, Hamilton has developed a new approach featuring “closed-loop” traceability for the values 4.01, 7.00, 9.21 and 10.01. For users of DuraCal pH buffer solutions, this ensures a unique level of reliability.

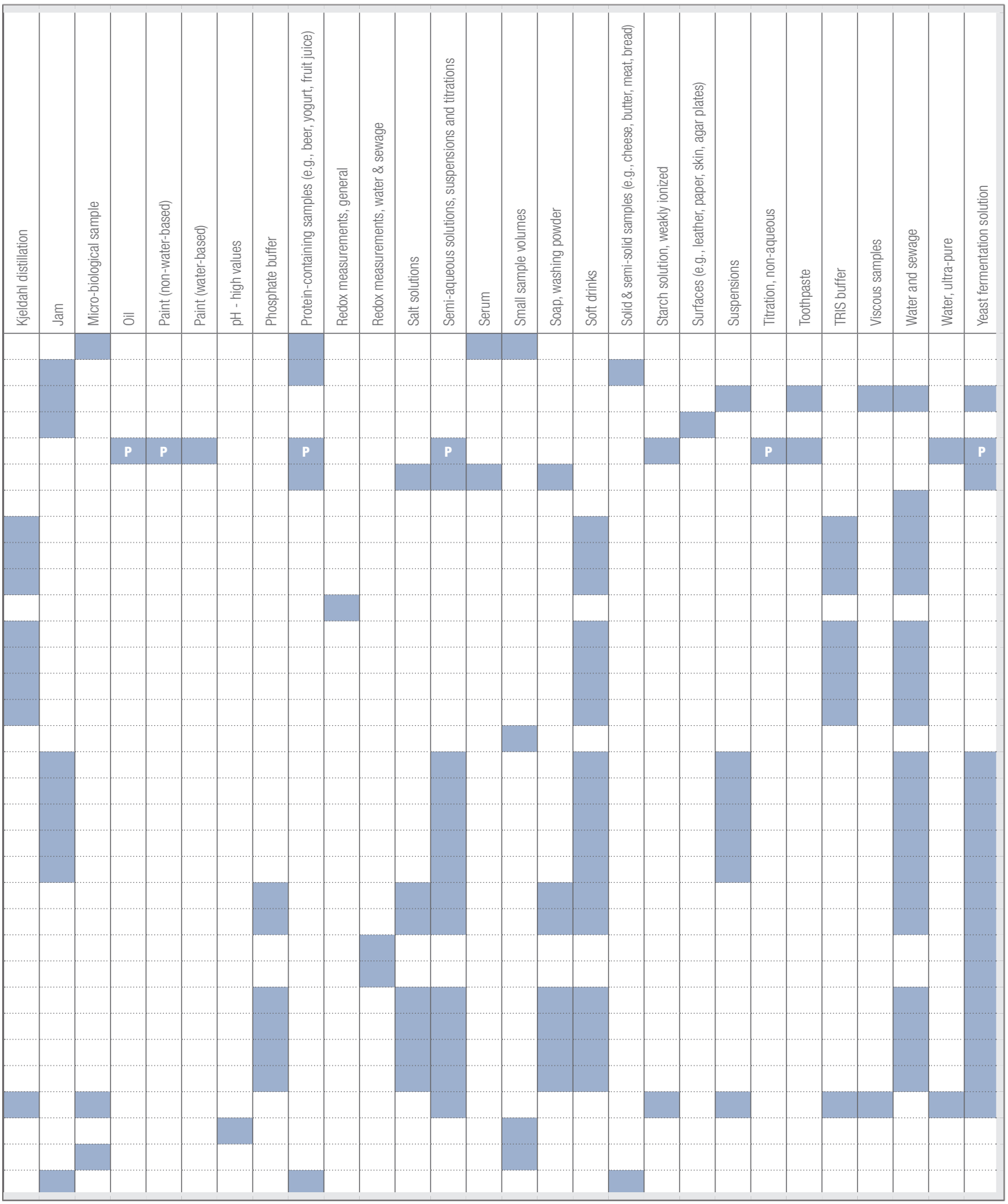
Top-down traceability: With Hamilton, the pH value of the DuraCal buffer is determined by a comparison with two secondary reference solutions. Bottom-up traceability: From each batch manufactured, a representative quantity is measured at DAkkS[3]. This ensures an external, independent verification by an accredited institute. DAkkS issues an official calibration certificate for the corresponding DuraCal production batch.

See page 18 for details

1) DFM: Danish Institute of Fundamental Metrology, Danemark
2) PTB: Physikalisch-Technische Bundesanstalt, Braunschweig
3) DAkkS: Deutsche Akkreditierungsstelle

ELECTRODE SELECTION TABLE

	Electrode	PN	Page	Acid, battery	Acid, hydrofluoric	Aqueous emulsions, suspensions	Aqueous solutions	Calcium oxide solution	Calcium sulphate solution	Copper bath	Cosmetics	Crème fraîche, milk, cream	Cyanide decontamination	Disinfectant	Earth	Emulsions	Fat	Fertilizer solutions	Field measurements	Fixing baths	Fruit & vegetables	Galvanic baths	Hydrogen peroxide (30%)	Infusion solutions
	BioTrode	238140	11												■		■				■			
	Double Pore	238400	12									■			■		■				■			
	FillTrode	242064	10		■		■					■				■			■					
	FlaTrode	238401	11		■												■							
	FlushTrode*	238060	10					■	■		P	P	■									■		
	FoodTrode	238285	12									■												
	Gel-Glass	238025	10				■																	
Liq-Glass Family	Liq-Glass	238000	8	■			■							■						■				
	Liq-Glass BNC	238180	8	■			■							■						■				
	Liq-Glass DIN	238185	8	■			■							■						■				
	Liq-Glass ORP	238145	15																					
	Liq-Glass Temp BNC	242056	8	■			■							■						■				
	Liq-Glass Temp BNC/Cinch	242055	8	■			■							■						■				
	Liq-Glass Temp DIN	238406	8	■			■							■						■				
	Liq-Glass Temp Lemo	242054	8	■			■							■						■				
	MiniTrode	238100	11																					
Polilyte Family	Polilyte Lab	238403	9			■	■	■								■		■						
	Polilyte Lab Temp BNC/Cinch	242059	9			■	■	■								■								
	Polilyte Lab Temp BNC	242060	9			■	■	■								■								
	Polilyte Lab Temp DIN	242058	9			■	■	■								■								
	Polilyte Lab Temp Lemo	242062	9			■	■	■								■								
Polyplast Family	Polyplast	238380	13				■											■	■					
	Polyplast BNC	238381	13			■	■											■	■					
	Polyplast ORP	238385	15																					
	Polyplast ORP BNC	238384	15																					
	Polyplast Temp BNC	242050	13			■	■											■	■					
	Polyplast Temp BNC/Cinch	242051	13			■	■											■	■					
	Polyplast Temp DIN	238404	13			■	■											■	■					
	Polyplast Temp Lemo	242052	13			■	■											■	■					
	Single Pore Glass	238160	9	■					■	■				■		■		■				■	■	■
	SlimTrode	238150	10																					
	SpinTrode	238197	11																					
	TipTrode	238080	12												■		■				■			



** For samples containing protein (P), replace the electrolyte 3 M KCl with the separately available electrolyte Protelyte (see page 17).*

Liq-Glass™ Family

- Robust, combination pH electrode for daily laboratory use
- Universally applicable, in strong acids as well as in strong bases
- Ideally suited for acid/base titrations
- Serial number, certificate

Specifications	
pH	0 to 14
Temp.	-10 to 100°C
Electrolyte	3M KCl (refillable)
Shaft material	Glass
Liquid junction	Ceramic diaphragm
Reference system	Everef

Liq-Glass PN 238000

Temperature sensor: No
Electrical connection: S7 connector head

Liq-Glass

PN 238180 Liq-Glass BNC
PN 238185 Liq-Glass DIN

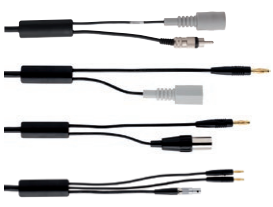
Temperature sensor: No
Electrical connection: 1m cable with BNC or DIN plug

Liq-Glass Temp

PN 242055 Liq-Glass Temp BNC/Cinch
PN 242056 Liq-Glass Temp BNC
PN 238406 Liq-Glass Temp DIN
PN 242054 Liq-Glass Temp Lemo

Temperature sensor: NTC 30 kOhm (PN 238406, 242055);
Pt1000 (PN 242054, 242056)

Electrical connection:



PN 242055: 1m BNC cable/1 x cinch plug

PN 242056: 1m BNC cable / 1 x 4 mm banana plug

PN 238406: 1m DIN cable/1 x 4 mm banana plug

PN 242054: 1m LEMO cable/2 x 2 mm banana plug
(2 adapters for 4 mm banana plug included)

Single Pore Glass PN 238160

- Highest accuracy and fast response time thanks to the patented Single Pore
- Robust design for easy cleaning
- Wide applicability, use for emulsions, ion-weak media or general laboratory applications
- Reported by PTB to be the most accurate laboratory electrode tested
- Minimal alkali error
- Serial number, certificate

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	0 to 100°C
Electrolyte	Skylyte™-CL (refillable)
Shaft material	Glass
Liquid junction	Single Pore
Reference system	Everef

Polilyte Lab Family

- Maintenance-free, robust, combination pH electrode that is easy to use
- Universally applicable; well suited for measurements in emulsions and suspensions
- Thanks to the Single Pore, clogging of the liquid junction is impossible
- Serial number, certificate

Specifications

pH	0 to 14
Temp.	-10 to 80°C
Electrolyte	Polisolve (maintenance-free)
Shaft material	Glass
Liquid junction	Single Pore
Reference system	Everef-B

Polilyte Lab PN 238403

Temperature sensor: No
Electrical connection: S7 connector head

Polilyte Lab Temp

PN 242059 Polilyte Lab Temp BNC/Cinch
PN 242060 Polilyte Lab Temp BNC
PN 242058 Polilyte Lab Temp DIN
PN 242062 Polilyte Lab Temp Lemo

Temperature sensor: NTC 30 kOhm (PN 242058, 242059):
Pt1000 (PN 242060, 242062)

Electrical connection:

PN 242059: 1m BNC cable/1 x cinch plug

PN 242060: 1m BNC cable / 1 x 4 mm banana plug

PN 242058: 1m DIN cable/1 x 4 mm banana plug

PN 242062: 1m LEMO cable/2 x 2 mm banana plug
(2 adapters for 4 mm banana plug included)

FlushTrode™ PN 238060

- Easy-to-clean, combination glass electrode with sleeve diaphragm
- Ideally suited for viscous samples, ion-weak media or media containing protein (e.g., cosmetics)
- For samples containing protein, the electrolyte should be replaced with Protelyte™ (PN 238038)
- Serial number, certificate

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	-10 to 80°C
Electrolyte	3M KCl (refillable)
Shaft material	Glass
Liquid junction	Sleeve diaphragm
Reference system	Everef

SlimTrode™ PN 238150

- pH electrode with 6 mm shaft diameter; for measurements in test tubes
- Universally applicable, even in strong acids as well as in normal laboratory use
- Long-term stable Everef system
- Serial number, certificate

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	0 to 100°C
Electrolyte	3M KCl (refillable)
Shaft material	Glass
Liquid junction	Ceramic diaphragm
Reference system	Everef

FillTrode™ PN 242064

- Robust pH electrode with plastic shaft
- Multiple applications, thanks to its flat membrane: (e.g., for viscous media)
- Easy to clean
- The ring diaphragm prevents clogging
- Serial number, certificate

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	0 to 60°C
Electrolyte	Polisolve (maintenance-free)
Shaft material	Plastic
Liquid junction	Ring diaphragm
Reference system	Everef

Gel-Glass™ PN 238025

- Maintenance-free, excellent value pH electrode for less rigorous applications
- Serial number, certificate

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	-10 to 60°C
Electrolyte	Gel (maintenance-free)
Shaft material	Glass
Liquid junction	Ceramic diaphragm
Reference system	Ag/AgCl

BioTrode™ PN 238140

- Combination pH electrode for measurements in very small volumes (e.g., microtiter plates)
- Ideally suited for solutions containing protein as Protelyte prevents clogging of the diaphragm
- Long-term stable Everef system
- Requires an immersion depth of only 7 mm
- Serial number, certificate
- 3 mm shaft diameter

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	0 to 100°C
Electrolyte	Protelyte (refillable)
Shaft material	Glass
Liquid junction	Ceramic diaphragm
Reference system	Everef

MiniTrode™ PN 238100

- Combination pH electrode for measurements in very small volumes (e.g., vials)
- Long-term stable Everef system
- Requires an immersion depth of only 7 mm
- Serial number, certificate
- 3 mm shaft diameter

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	0 to 100°C
Electrolyte	3M KCl (refillable)
Shaft material	Glass
Liquid junction	Ceramic diaphragm
Reference system	Everef

SpinTrode™ PN 238197

- Combination pH electrode for measurements in very small volumes, e.g. NMR tubes
- Long-term stable Everef system
- Requires an immersion depth of only 7 mm
- Serial number, certificate

Temperature sensor: no
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	0 to 100°C
Electrolyte	3M KCl (refillable)
Shaft material	Glass
Liquid junction	Ceramic diaphragm
Reference system	Everef

FlaTrode™ PN 238401

- pH electrode with a true flat membrane for measurements of surfaces, e.g. paper, agar plates
- Robust plastic shaft and ring diaphragm
- Ring diaphragm guarantees quick response time because of enhanced contact between sample and reference
- Long-term stable Everef system
- Serial number, certificate

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	0 to 60°C
Electrolyte	Polisolve (maintenance-free)
Shaft material	Plastic
Liquid junction	Ring diaphragm
Reference system	Everef

FoodTrode™ PN 238285

- Robust combination pH electrode for measurements in media containing proteins
- 3 ceramic diaphragms guarantee quick and accurate measurements
- Easy to clean
- Long-term stable thanks to Everef system
- Serial number, certificate

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	-10 to 100°C
Electrolyte	Protelyte (refillable)
Shaft material	Glass
Liquid junction	3 ceramic diaphragms
Reference system	Everef

Double Pore™ PN 238400

- Maintenance-free combination pH puncture electrode
- Pointed tip, especially for use with solid and semisolid samples
- Ideally suited for measurements in meat and cheese
- 2 Single Pores make clogging of the liquid junction impossible
- Serial number, certificate

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	0 to 60°C
Electrolyte	Polisolve (maintenance-free)
Shaft material	Glass
Liquid junction	2 Single Pores
Reference system	Ag/AgCl

TipTrode™ PN 238080

- Refillable combination pH puncture electrode
- Pointed membrane tip, especially for use with solid and semisolid samples
- Long-term, stable Everef system
- Serial number, certificate

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

pH	0 to 14
Temp.	0 to 100°C
Electrolyte	Protelyte (refillable)
Shaft material	Glass
Liquid junction	Ceramic diaphragm
Reference system	Everef

Polyplast™ Family

- Robust maintenance-free, combination pH electrode
- Shatter-proof plastic shaft
- Exellent for water and sewage
- Serial number, certificate

Specifications	
pH	0 to 14
Temp.	0 to 60°C
Electrolyte	Polisolve (maintenance-free)
Shaft material	Plastic
Liquid junction	Single Pore
Reference system	Ag/AgCl

Polyplast PN 238380

Temperature sensor: No
Electrical connection: S7 connector head

Polyplast BNC PN 238381

Temperature sensor: No
Electrical connection: 1m cable with BNC Plug

Polyplast Temp

PN 242051 Polyplast Temp BNC/Cinch
PN 242050 Polyplast Temp BNC
PN 238404 Polyplast Temp DIN
PN 242052 Polyplast Temp Lemo

Temperature sensor: NTC 30 kOhm (PN 238404, 242051):
Pt 1000 (PN 242050, 242052)

Electrical connection:

PN 242051: 1m BNC cable/1 x cinch plug

PN 242050: 1m BNC cable / 1 x 4 mm banana plug

PN 238404: 1m DIN cable/1 x 4 mm banana plug

PN 242052: 1m LEMO cable/2 x 2 mm banana plug
(2 adapters for 4 mm banana plug included)

These electrodes are especially well suited for Knick® Portamess® equipment
The electrode head creates a hermetic seal with the Portamess® storage tube

Liq-Glass Knick® PN 242068 Liq-Glass Knick® Temp DIN

- Combination electrode for daily laboratory use with glass shaft
- Universally applicable, even in strong acids as well as strong bases
- Serial number, certificate

Temperature sensor: Pt1000
Electrical connection: 1m cable + DIN plug/1 x 4mm banana plug

Specifications

pH	0 to 14
Temp.	-10 to 100°C
Electrolyte	3M KCl (refillable)
Shaft material	Glass
Liquid junction	Ceramic diaphragm
Reference system	Everef

Polyplast Knick® PN 242070 Polyplast Knick® Temp DIN

- Robust plastic shaft
- Ideally suited for field measurements
- Clog-free Single Pore guarantees quick and reliable measurements
- Serial number, certificate

Temperature sensor: Pt1000
Electrical connection: 1m cable + DIN plug/1 x 4mm banana plug

Specifications

pH	0 to 14
Temp.	0 to 60°C
Electrolyte	Polisolve (maintenance-free)
Shaft material	Plastic
Liquid junction	Single Pore
Reference system	Ag/AgCl

Double Pore Knick® PN 242066

- Robust PEEK shaft
- Smallest possible surface sample contact with glass
- Ideally suited for measurements of solid and semisolid samples (e.g., cheese, meat)
- 2 Single Pores make clogging of the liquid junction impossible
- Serial number, certificate

Temperature sensor: No
Electrical connection: 1m cable + DIN plug

Specifications

pH	0 to 14
Temp.	0 to 60° C
Electrolyte	Polisolve (maintenance-free)
Shaft material	PEEK (high-performance plastic)
Liquid junction	2 Single Pores
Reference system	Ag/AgCl

Liq-Glass ORP PN 238145

- Robust combination ORP electrode for all usual ORP measurements in the laboratory
- Universally applicable, in strong acids as well as in strong bases
- Long-term stable Everef system
- Serial number, certificate

Temperature sensor: No
Electrical connection: S7 connector head

Specifications

Redox	± 2000 mV
Temp.	-10 to 100°C
Electrolyte	3M KCl (refillable)
Shaft material	Glass
Liquid junction	3 ceramic diaphragms
Reference system	Everef

Polyplast ORP Family

- Robust, maintenance-free, combination ORP electrode
- Shatter-proof plastic shaft
- Excellent for water and sewage
- Serial number, certificate

Specifications

Redox	± 2000 mV
Temp.	0 to 60°C
Electrolyte	Polisolve (maintenance-free)
Shaft material	Plastic
Liquid junction	Single Pore
Reference system	Ag/AgCl

Polyplast ORP PN 238385

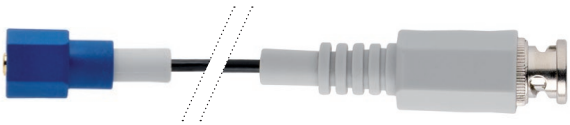
Temperature sensor: No
Electrical connection: S7 connector head

Polyplast ORP BNC PN 238384

Temperature sensor: No
Electrical connection: 1m cable with BNC plug

Cables

Cables are fitted with an S7 socket. The equipment-side plug must be chosen to fit the pH meter (see page 28).
The cables have a diameter of 3 mm and a standard length of 1m, 3m and 5m, respectively.



1m cable S7/BNC*	**PN 355173**
3m cable S7/BNC*	**PN 355176**
5m cable S7/BNC*	**PN 355178**

1m cable S7/DIN	**PN 355174**
3m cable S7/DIN	**PN 355177**
5m cable S7/DIN	**PN 355179**

1m cable S7/Lemo	**PN 355175**

* All BNC plugs have a moveable protective cover.
This helps ensure consistent results as the plug is better protected from fluid splashes.

Electrolytes and Solutions

Electrolyte

3M KCl	**100 ml**	**PN 238036**
3M KCl	**500 ml**	**PN 238936**
Skylyte-CL	**100 ml**	**PN 242080**
Protelyte	**100 ml**	**PN 238038**

Storage solution

For long life and faster electrode response times, it is best to store electrodes in our storage solution. This is an acid-buffered solution that in addition to providing optimized storage, also ensures regeneration of the electrode.

Storage solution	**500 ml**	**PN 238931**

Cleaning solution set

Depending on the type of application the pH glass or diaphragm can become contaminated through various ingredients of the measuring solution. This is indicated by slow response of the electrode, or even incorrect readings. To overcome these problems, Hamilton has developed a cleaning solution set.

The intention of Hamilton is to have an overall cleaning of the pH glass as well as the diaphragm. The cleaning itself should be easy and fast.

The set comprises Cleaning Solution A, Cleaning solution B and a storage solution. To clean the electrode put it into each solution for 15 - 30 minutes, and your electrode is ready for new measurements again.

Cleaning solution set	**PN 238290**

Buffer Solutions you can Trust

All calibration procedures assume that the labeled values of the calibration buffers are correct. But buffer values can change over time and so can your results. A complete range of patented buffer solutions provides pH stability up to 5 years, something never achieved before. The pH buffers 9.21 and 10.01 are even stable in air. High buffering capacity provides rapid, stable calibration. The growth of fungus and micro-organisms is prevented.

Traceability

An important issue for the production of Certified Reference Materials is to ensure traceability through an unbroken chain of comparisons to reference material of the highest metrological quality (Primary Reference Material) from NIST[1] and PTB[2]. Unlike other manufacturers, where only top-down traceability is applied, Hamilton works with circular or closed-loop traceability, providing unique reliability of Hamilton DuraCal buffers.

Features

- Convenient 250 mL or 500 mL bottle with built-in calibration compartment
- Economical, only about 15 mL of buffer is used per calibration
- Certified pH value from a DAkkS laboratory accredited for pH measurement
- First class certificate with traceability to international standards
- Certificates available at www.hamiltoncompany.com
- Expiration date on the bottle
- Immune to microbial growth

Top-down traceability: At Hamilton, the pH value of DuraCal buffers is determined by comparison against two secondary reference buffer solutions from accredited suppliers of secondary reference materials. The solutions themselves are compared against primary reference solutions from PTB[1] or NIST[2]. The measurement uncertainties of every measurement comparison are known and documented.

Bottom-up traceability: To ensure the highest possible accuracy and full reliability of the pH value, a representative number of samples from every single production lot is verified by an external, independent and impartial DAkkS laboratory. The DuraCal samples are compared against secondary reference solutions from DAkkS and these are referenced themselves to primary reference solutions from PTB or NIST. At this stage, the traceability loop is closed. DAkkS provides Hamilton with a calibration certificate for every DuraCal production batch.

Certified reference material: Due to the complete traceability of the measurement procedure and the assignment of uncertainties to the particular testing steps, the buffers pH 4.01, 7.00, 9.21 and 10.01 are classified as “Certified Reference Material” (CRM).

1) NIST: National Institute of Standards and Technology, Gaithersburg, MD, USA
2) PTB: Physikalisch Technische Bundesanstalt, Braunschweig, Germany
3) DAkkS: Deutsche Akkreditierungsstelle GmbH (D-K-15186-01-00), Zentrum for Messen und Kalibrieren GmbH, Wolfen, Germany

pH Buffers

pH Value	Accuracy	Stability*	Certified By	Packaging Unit	PN
1.09	±0.02	60	Hamilton	500 mL	238271
1.68	±0.02	60	Hamilton	500 mL	238272
2.00	±0.02	60	Hamilton	500 mL	238273
3.06	±0.02	60	Hamilton	500 mL	238274
4.01	±0.01/±0.02	24/60	DAkkS	250 mL	238317
4.01	±0.01/±0.02	24/60	DAkkS	500 mL	238217
4.01	±0.01/±0.02	24/60	DAkkS	3 x 500 mL	238917
4.01	±0.01/±0.02	24/60	DAkkS	5 L	238332
4.01	±0.01/±0.02	24/60	DAkkS	10 L	238194
4.01	±0.01/±0.02	24/60	DAkkS	1000 L	238895
5.00	±0.02	60	Hamilton	500 mL	238275
6.00	±0.02	60	Hamilton	500 mL	238276
7.00	±0.01/±0.02	24 / 60	DAkkS	250 mL	238318
7.00	±0.01/±0.02	24 / 60	DAkkS	500 mL	238218
7.00	±0.01/±0.02	24 / 60	DAkkS	3 x 500 mL	238918
7.00	±0.01/±0.02	24 / 60	DAkkS	5 L	238333
7.00	±0.01/±0.02	24 / 60	DAkkS	10 L	238188
7.00	±0.01/±0.02	24 / 60	DAkkS	1000 L	238896
8.00	±0.02	60	Hamilton	500 mL	238277
9.21	±0.02	60	DAkkS	250 mL	238319
9.21	±0.02	60	DAkkS	500 mL	238219
9.21	±0.02	60	DAkkS	3 x 500 mL	238919
9.21	±0.02	60	DAkkS	10 L	238216
9.21	±0.02	60	DAkkS	1000 L	238897
10.01	±0.02	60	DAkkS	250 mL	238321
10.01	±0.02	60	DAkkS	500 mL	238223
10.01	±0.02	60	DAkkS	3 x 500 mL	238923
10.01	±0.02	60	DAkkS	10 L	238187
10.01	±0.02	60	DAkkS	1000 L	238898
11.00	±0.02	24	Hamilton	500 mL	238278
12.00	±0.02	24	Hamilton	500 mL	238279
4.01/7.00/9.21	±0.01/±0.02	24/60	DAkkS	500 mL, mixed	238922
4.01/7.00/10.01	±0.01/±0.02	24/60	DAkkS	500 mL, mixed	238924

ORP Buffers

pH Value	Accuracy	Stability*	Certified By	Packaging Unit	PN
271 mV	±5 mV	24	None	500 mL	238228
475 mV	±5 mV	24	None	250 mL	238322
475 mV	±5 mV	24	None	500 mL	238227

** In months*

Simple handling for professional results

Step 1 Open bottle

Step 2 Fill calibration compartment

Step 3 Calibrate electrode

Step 4 Empty calibration compartment

Hamilton Conductivity Standards

Long-term stability and accuracy

For measurements in the low conductivity range stable and reliable calibration standards have been completely lacking up to now. Since a conductivity standard is not a buffer solution, the lower the value of the conductivity standard, the greater the effect of entry of CO_2 or contamination. Hamilton is the first manufacturer to offer patented conductivity standards of 1.3 and 5 µS/cm with a certified accuracy of ±1% and a lifetime of 1 and 3 years, respectively. The procedure for determining conductivity was developed in collaboration with DFM[1]. Many metrological institutes choose Hamilton standards because of their unprecedented stability and independent verification by PTB (see illustration on page 21). During an interlaboratory test among prestigious European metrological institutes (PTB, DFM, DAkkS[3]) Hamilton standards were used as measurement solutions.

Hamilton is Different

Hamilton offers conductivity standards whose stability of ±1% is guaranteed over a lifetime of up to 3 years. They can be used repeatedly under the condition that the bottle is not left open for more than 1 hour in total.

A representative number of bottles from every batch are measured by DFM. Their value is recorded on the calibration certificate and on every bottle. DFM enjoys the highest prestige in Europe in the area of electrolytic conductivity and is equipped with an absolute measurement cell that was developed in collaboration with NIST, and is accredited by the Danish accreditation agency DANAK to a conductivity of 0.9 µS/cm. DFM and NIST[4] have made comparisons of their measurement uncertainty and have confirmed in a series of scientific publications that the measurement accuracy is in each case the same. Because no primary standards exist in the low conductivity range, measurements depend on absolute measurement cells which trace electrical conductivity back to the SI units: meter and volt. Testing of Hamilton standards is thus carried out on the most precise measurement apparatus in the world, and certified accordingly.

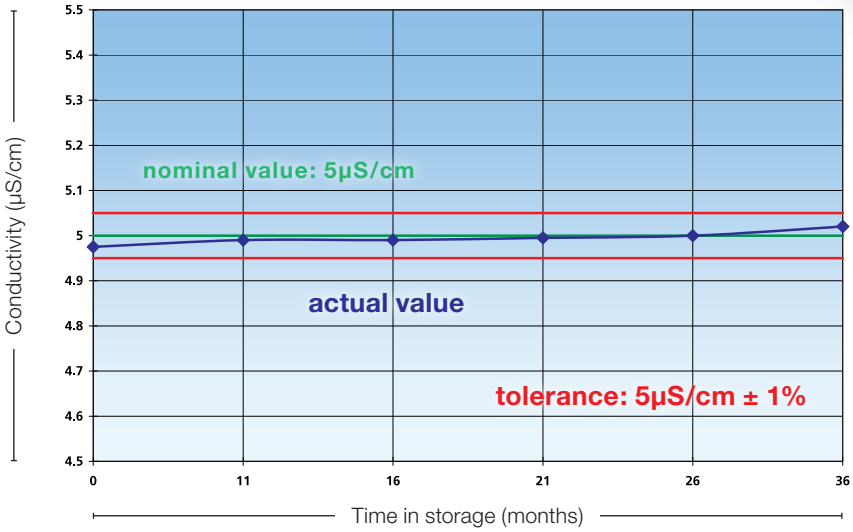
1) DFM: Danish Institute of Fundamental Metrology, Dänemark
2) PTB: Physikalisch-Technische Bundesanstalt, Braunschweig
3) DAkkS: Deutsche Akkreditierungsstelle
4) NIST: National Institute of Standards and Technology, Gaithersburg MD, USA

Unique advantages:

- Remains stable for a minimum of 1 year for 1.3 µS/cm, and up to 3 years for all other values
- Certificate with calibration document from DFM (available at www.hamiltoncompany.com)
- Expiration date shown on every bottle
- Bottles are permitted to stay open for a total of 60 minutes

Stability of the Hamilton 5µS/cm Conductivity Standard over 36 months

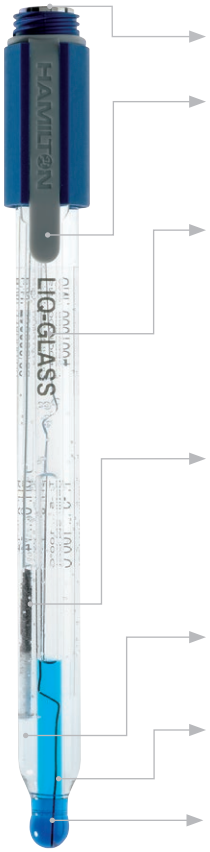
Check measurement by PTB[2]



Value at 25°C	Accuracy	Stability (in months)	Certificate From	Packaging Unit	Volume	PN
1.3 µS/cm	±1%	12	DFM	Glass bottle	300 mL	238973
5 µS/cm	±1%	36	DFM	Glass bottle	300 mL	238926
15 µS/cm	±1%	36	DFM	Glass bottle	300 mL	238927
84 µS/cm	±1%	18	DFM	Calpack bottle	500 mL	238984
100 µS/cm	±1%	36	DFM	Glass bottle	300 mL	238934
147 µS/cm	±1%	18	DFM	Calpack bottle	500 mL	238985
1413 µS/cm	±1%	36	DFM	Glass bottle	300 mL	238928
1413 µS/cm	±1%	18	DFM	Calpack bottle	500 mL	238986
12880 µS/cm	±1%	18	DFM	Calpack bottle	500 mL	238988

pH Measurement

Construction of a pH electrode



Connector head S7

Electrolyte plug
For easy refilling and secure closure

Reference electrolyte
All Hamilton electrolytes are silver-free for trouble free measurements

Everef reference system
Guarantees stable measurement and reduces measurement errors

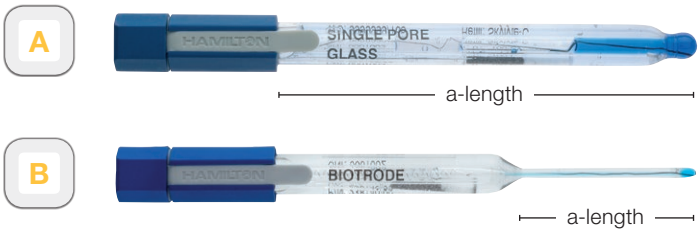
Diaphragm/Single Pore

Inner buffer

pH membrane
Shape and glass type are optimized for each application

Length of the electrode
What is a-length, and where does it start?

The length depends on the construction of the electrode. With electrodes that have a 12 mm shaft passing all the way through the body (see picture A) a-length is measured from the connector head to the end of the electrode. With electrodes that have a shaft diameter of less than 12 mm, a-length begins at the smaller diameter (see picture B).



Definition of pH value

The pH value describes if a solution is acid, neutral or basic. Most aqueous solutions have a pH value between 0 (strong acid) and 14 (strong base). A very small part of pure water decomposes to ions namely to hydronium ions (H_3O^+) and to hydroxide ions (OH^-). Only in neutral water is the proportion of both ions 1:1. This proportion is defined by the equilibrium constant of water:

$KW = [H_3O^+]\,[OH^-] = 10^{-14}\ (mol/L)^2$

To characterize the proportion of the two ions it is sufficient to know one of the concentrations. Normally the hydronium (hydrogen) ion concentration is measured and varies between 1 and 10^{-14} mol/L.

pH can also be described as the negative logarithm of the hydronium ion concentration in a solution, where a low pH indicates a high concentration of hydronium ions and a high pH indicates a low concentration of hydronium ions.

$pH = -lg\,[H_3O^+]$

The pH Measurement

The determination of the pH values is based on the principle of the potentiometric measurement - the measurement of electrical voltage. A pH electrode consists of two electrodes (pH glass membrane and reference) that are combined into one device, in a combination pH electrode. Between these two electrodes a voltage is measured. The pH membrane of the electrode is made of special glass that is impermeable and electrically isolating. This glass (pH glass) forms a hydrated layer in water and responds selectively to hydrogen ions (H^+). Sodium ions (Na^+) of the glass are replaced by hydrogen ions (H^+), causing an electrical potential that the pH meter measures.
The number of Na^+ and H^+ exchanges across the pH glass depends strongly on the pH of the solution. The higher the pH the less hydrogen ions are in the solution, therefore less sodium ions are replaced across the pH glass. The liquid inside the pH glass is a buffer solution with a known and constant hydrogen ion concentration. Depending on the difference in pH between the inner buffer and the measuring

solution, a galvanic voltage is produced between the inner and the outer layer of the pH glass. This voltage is measured by two Ag/AgCl electrodes. One electrode is located in the inner buffer the other in the reference electrolyte. Most pH electrodes show nearly linear behavior in the measuring range of pH 0 to 14. Therefore, a pH electrode is calibrated with the help of two buffer solutions with exactly determined pH values, for example pH 4.01 and 7.00. Based on these two measuremen points, a calibration curve is obtained by linear inter and extrapolation.

If you would like to get more information regarding pH measurement you may contact us at contact@hamilton.ch or sales@hamiltoncompany.com to get a pH measurement guide for free.

Calibration and measurement

- For quick and accurate results, the electrolyte plug should be open during measurements (Note: polymer electrolytes do not have an electrolyte plug).
- The electrode should be immersed far enough to cover the liquid junction. The height to which the electrolyte is filled must always be above that of the sample. This prevents the sample solution from entering into the electrode.
- Always wait for the electrode to reach the same temperature as the sample.
- Between measurements, the electrode should be rinsed with deionized water. If necessary, dab it dry with a paper towel. Never rub the electrode dry, as it will become electrostatically charged and slow response will result.
- To prevent problems, calibrate with DuraCal buffers (see page 18). If you do not use DuraCal buffers, never calibrate in the original bottle. Always use fresh buffer solution for calibration. Close the bottle after use.
- Dispose of used buffer responsibly.
- Read the operating instructions of the pH measurement device.

Temperature influences

Both the pH/redox value of the sample and the characteristics of the electrode are temperature dependent. Usually, the temperature dependency of the sample is unknown. It is important to always record the measurement temperature together with the measured value. The automatic temperature

compensation of the measurement devices can only compensate for the temperature dependence of the electrode's characteristics curve (Nernst-equation). For this purpose, temperature sensors (e.g., Pt1000 or NTC 30 kOhm) are used. In order to obtain the most accurate measurement, the electrode should always be calibrated at the same temperature at which measurements will later take place. For measurements that will serve as a comparison between laboratory and process values, make sure that the laboratory measurement takes place at the same temperature as the process measurement.

Storage

Store the electrode (with closed electrolyte plug) in the reference electrolyte, or better, in the Hamilton storage solution (PN 238931). The storage solution helps to clean both the diaphragm and the pH glass. Electrodes must never be stored in deionized water.

Cleaning

Contamination of the liquid junction is the most frequent cause of measurement problems. Problems with the pH glass membrane are not very common. The diaphragm and the pH membrane should therefore be kept clean in order to avoid measurement errors and long response times. Use soap and water to remove oil, fat and organic substances. In the event of contamination of the electrode by proteins, submerge the electrode in a fresh solution of 0.4% HCl and 5 g/l pepsin. After every cleaning, the electrode should be conditioned in Hamilton storage solution for at least 2 hours. After cleaning always perform a new calibration before carrying out measurements. To simplify cleaning, Hamilton has developed a special cleaning set (PN 238290) for easy removal of most types of contamination from electrode liquid junction and pH glass.

Most frequent causes of calibration problems

The following three problems occur most often during calibration:

- Zero calibration error
- Electrode slope too low
- Slow response (e.g., longer than 3 minutes)

There is a variety of causes for the problems named above. The most frequent ones are:

1) The buffer solutions used are either contaminated, out of date or labelled incorrectly. Therefore, never store buffer solutions in unmarked or dirty containers. Dispose solutions after use.
2) The reference electrolyte and/or the diaphragm are contaminated.
3) An old or defective electrode is used.
4) An electrode is used that has not been hydrated long enough (after dry storage or after cleaning with strong caustic solution).
5) The pH membrane of the electrode is mechanically damaged and has cracks.
6) The electrode is electrostatically charged (through rubbing of the electrode shaft with a cloth instead of careful dabbing with soft paper).
7) The temperature difference between electrode and buffer solution is more than 10°C.
8) The connection between electrode and measurement device can also cause problems. For instance, a break in the cable or a short-circuit caused by moisture in the cable or electrode plug.


HAMILTON
DOUBLE PORE

pH Electrodes

	Nominal Measurement Range	Temperature Range	Reference Electrolyte	Reference System	Shaft Material	Shaft Diameter (mm)	Shaft Diameter Below (mm)
BioTrode	0 to 14	0 to 100°C	Protelyte	Everef	Glass	12	3
Double Pore	0 to 14	0 to 60°C	Polisolve	Ag/AgCl	Glass	12	6
Double Pore Knick®	0 to 14	0 to 60°C	Polisolve	Ag/AgCl	PEEK	12	6
FillTrode	0 to 14	0 to 60°C	Skylyte-CL	Everef	Plastic	12	12
FlaTrode	0 to 14	0 to 60°C	Skylyte-CL	Everef	Plastic	12	12
FlushTrode*	0 to 14	-10 to 80°C	3M KCL	Everef	Glass	12	12
FoodTrode	0 to 14	-10 to 100°C	Protelyte	Everef	Glass	12	12
Gel-Glass	0 to 14	-10 to 60°C	GEL	Ag/AgCl	Glass	12	12
Liq-Glass	0 to 14	-10 to 100°C	3M KCL	Everef	Glass	12	12
Liq-Glass BNC	0 to 14	-10 to 100°C	3M KCL	Everef	Glass	12	12
Liq-Glass DIN	0 to 14	-10 to 100°C	3M KCL	Everef	Glass	12	12
Liq-Glass Temp BNC/Cinch	0 to 14	-10 to 100°C	3M KCL	Everef	Glass	12	12
Liq-Glass Temp BNC	0 to 14	-10 to 100°C	3M KCL	Everef	Glass	12	12
Liq-Glass Temp DIN	0 to 14	-10 to 100°C	3M KCL	Everef	Glass	12	12
Liq-Glass Temp Lemo	0 to 14	-10 to 100°C	3M KCL	Everef	Glass	12	12
Liq-Glass Knick®	0 to 14	-10 to 100°C	3M KCL	Everef	Glass	12	12
MiniTrode	0 to 14	0 to 100°C	3M KCL	Everef	Glass	12	3
Polilyte Lab	0 to 14	-10 to 80°C	Polisolve	Everef-B	Glass	12	12
Polilyte Lab Temp BNC/Cinch	0 to 14	-10 to 80°C	Polisolve	Everef-B	Glass	12	12
Polilyte Lab Temp BNC	0 to 14	-10 to 80°C	Polisolve	Everef-B	Glass	12	12
Polilyte Lab Temp DIN	0 to 14	-10 to 80°C	Polisolve	Everef-B	Glass	12	12
Polilyte Lab Temp Lemo	0 to 14	-10 to 80°C	Polisolve	Everef-B	Glass	12	12
Polyplast	0 to 14	0 to 60°C	Polisolve	Ag/AgCl	Plastic	12	12
Polyplast BNC	0 to 14	0 to 60°C	Polisolve	Ag/AgCl	Plastic	12	12
Polyplast Temp BNC/Cinch	0 to 14	0 to 60°C	Polisolve	Ag/AgCl	Plastic	12	12
Polyplast Temp BNC	0 to 14	0 to 60°C	Polisolve	Ag/AgCl	Plastic	12	12
Polyplast Temp DIN	0 to 14	0 to 60°C	Polisolve	Ag/AgCl	Plastic	12	12
Polyplast Temp Lemo	0 to 14	0 to 60°C	Polisolve	Ag/AgCl	Plastic	12	12
Polyplast Knick®	0 to 14	0 to 60°C	Polisolve	Ag/AgCl	Plastic	12	12
Single Pore Glass	0 to 14	0 to 100°C	Skylyte-CL	Everef	Glass	12	12
SlimTrode	0 to 14	0 to 100°C	3M KCL	Everef	Glass	12	6
SpinTrode	0 to 14	0 to 100°C	3M KCL	Everef	Glass	12	3
TipTrode	0 to 14	0 to 100°C	Protelyte	Everef	Glass	12	6

ORP Electrodes

	Nominal Measurement Range	Temperature Range	Reference Electrolyte	Reference System	Shaft Material	Shaft Diameter (mm)	Shaft Diameter Below (mm)
Liq-Glass ORP	± 2000 mV	-10 to 100°C	3M KCL	Everef	Glass	12	12
Polyplast ORP	± 2000 mV	0 to 60°C	Polisolve	Ag/AgCl	Plastic	12	12
Polyplast ORP BNC	± 2000 mV	0 to 60°C	Polisolve	Ag/AgCl	Plastic	12	12

Shaft Length (a)	Membrane Glass	Membrane Shape	Liquid junction	Number of Diaphragms	Minimum Immersion Depth (mm)	Electrode Head	Temperature Sensor
60 mm	HF glass	Cylindrical	Ceramic	1	7	S7	No
35 mm	HF glass	Spear	Single Pore	2	15	S7	No
35 mm	V glass	Spear	Single Pore	2	15	Fixed cable with DIN plug	No
120 mm	HF glass	Flat	Ring	1	4	S7	No
120 mm	HF glass	Flat	Ring	1	1	S7	No
120 mm	HF glass	Cylindrical	Ground sleeve	1	30	S7	No
120 mm	HF glass	Cylindrical	Ceramic	3	20	S7	No
120 mm	HF glass	Cylindrical	Ceramic	1	15	S7	No
120 mm	HF glass	Cylindrical	Ceramic	1	15	S7	No
120 mm	HF glass	Cylindrical	Ceramic	1	15	Fixed cable with BNC plug	No
120 mm	HF glass	Cylindrical	Ceramic	1	15	Fixed cable with DIN plug	No
120 mm	HF glass	Cylindrical	Ceramic	1	15	Fixed cable with BNC plug/1x Cinch	NTC 30 kOhm
120 mm	HF glass	Cylindrical	Ceramic	1	15	Fixed cable with BNC plug/1 x 4 mm banana plug	Pt1000
120 mm	HF glass	Cylindrical	Ceramic	1	15	Fixed cable with DIN plug/1 x 4 mm banana plug	NTC 30 kOhm
120 mm	HF glass	Cylindrical	Ceramic	1	15	Fixed cable with Lemo plug/2 x 2 mm banana plug**	Pt1000
110 mm	HF glass	Cylindrical	Ceramic	1	15	Fixed cable with DIN plug/1 x 4 mm banana plug	Pt1000
60 mm	HF glass	Cylindrical	Ceramic	1	7	S7	No
120 mm	HF glass	Cylindrical	Single Pore	1	15	S7	No
120 mm	HF glass	Cylindrical	Single Pore	1	15	Fixed cable with BNC plug/1x Cinch	NTC 30 kOhm
120 mm	HF glass	Cylindrical	Single Pore	1	15	Fixed cable with BNC plug/1 x 4 mm banana plug	Pt1000
120 mm	HF glass	Cylindrical	Single Pore	1	15	Fixed cable with DIN plug/1 x 4 mm banana plug	NTC 30 kOhm
120 mm	HF glass	Cylindrical	Single Pore	1	15	Fixed cable with Lemo plug/2 x 2 mm banana plug**	Pt1000
120 mm	V glass	Cylindrical	Single Pore	1	10	S7	No
120 mm	V glass	Cylindrical	Single Pore	1	10	Fixed cable with BNC plug	No
120 mm	V glass	Cylindrical	Single Pore	1	10	Fixed cable with BNC plug/1x Cinch	NTC 30 kOhm
120 mm	V glass	Cylindrical	Single Pore	1	10	Fixed cable with BNC plug/1 x 4 mm banana plug	Pt1000
120 mm	V glass	Cylindrical	Single Pore	1	10	Fixed cable with DIN plug/1 x 4 mm banana plug	NTC 30 kOhm
120 mm	V glass	Cylindrical	Single Pore	1	10	Fixed cable with Lemo plug/2 x 2 mm banana plug**	Pt1000
110 mm	V glass	Cylindrical	Single Pore	1	10	Fixed cable with DIN plug/1 x 4 mm banana plug	Pt1000
120 mm	H glass	Cylindrical	Single Pore	1	15	S7	No
100 mm	HF glass	Cylindrical	Ceramic	1	15	S7	No
180 mm	HF glass	Cylindrical	Ceramic	1	7	S7	No
25 mm	HF glass	Spear	Ceramic	1	17	S7	No

Shaft Length (a)	Membrane Glass	Membrane Shape	Diaphragm	Number of Diaphragms	Minimum Immersion Depth (mm)	Electrode Head	Temperature Sensor
120 mm	Platin	Cylindrical	Ceramic	3	15	S7	No
120 mm	Platin	Cylindrical	Single Pore	1	10	S7	No
120 mm	Platin	Cylindrical	Single Pore	1	10	Fixed cable with BNC plug	No

** For samples containing protein, replace the 3 M KCl with the separately obtainable Protelyte electrolyte (see page 17).*

*** Adapter for 4 mm banana plug included.*

Blue squares indicate compatible electrodes and meters.

For connections to meters not listed above, please contact your Hamilton laboratory electrode supplier.

Manufacturer	Model		238140 BioTrode	238400 Double Pore	242064 FillTrode	238401 FlaTrode	238060 FlushTrode	238285 FoodTrode	238025 Gel-Glass	238000 Liq-Glass	238180 Liq-Glass BNC	238185 Liq-Glass DIN	238145 Liq-Glass ORP	242055 Liq-Glass Temp BNC/Cinch	242056 Liq-Glass Temp BNC	238406 Liq-Glass Temp DIN	242054 Liq-Glass Temp Lemo	238100 MiniTrode	238403 Polilyte Lab	242059 Polilyte Lab Temp BNC/Cinch	242060 Polilyte Lab Temp BNC	242058 Polilyte Lab Temp DIN	242062 Polilyte Lab Temp Lemo	238380 Polyplast	238381 Polyplast BNC	238385 Polyplast ORP	238384 Polyplast ORP BNC	242051 Polyplast Temp BNC/Cinch	242050 Polyplast Temp BNC	238404 Polyplast Temp DIN	242052 Polyplast Temp Lemo	238160 Single Pore Glass	238150 SlimTrode	238197 SpinTrode	238080 TipTrode
CRISON®	PH 25	BNC	■	■	■	■	■	■	■	■	■		■		■			■	■		■			■	■	■	■	■			■	■	■	■
	Basic 20	BNC	■	■	■	■	■	■	■	■	■		■		■			■	■		■			■	■	■	■	■			■	■	■	■
	GLP 21	BNC	■	■	■	■	■	■	■	■	■		■	■	■			■	■		■			■	■	■	■	■			■	■	■	■
	GLP 22	BNC	■	■	■	■	■	■	■	■	■		■	■	■			■	■		■			■	■	■	■	■			■	■	■	■
Eutech®	EcoScan™ pH 5 / pH6	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	CyberScan™ pH 11	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	CyberScan™ pH 110	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	CyberScan™ pH 300	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	CyberScan™ pH 310	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	CyberScan™ pH 510	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	CyberScan™ pH 1100	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	CyberScan™ pH 2100	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	CyberScan™ pH 1500	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	CyberScan™ pH 6000	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	CyberScan™ pH 6500	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
Hanna Instruments Inc.®	HI 901 / 902	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	HI 9813-6	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	HI 9813-5	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	HI 9813-0	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	HI 8010	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
	HI 4212 / 4211	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■				■	■	■	■
Metrohm®	pH Meter 780	Lemo	■	■	■	■	■	■	■	■			■				■	■	■				■	■	■		■				■	■	■	■
	pH/Ion Meter 781	Lemo	■	■	■	■	■	■	■	■			■				■	■	■				■	■	■		■				■	■	■	■
	pH Mobile 826	Lemo	■	■	■	■	■	■	■	■			■				■	■	■				■	■	■		■				■	■	■	■
	pH Lab 827	Lemo	■	■	■	■	■	■	■	■			■				■	■	■				■	■	■		■				■	■	■	■
Mettler-Toledo®	SevenEasy™ S20	BNC	■	■	■	■	■	■	■	■	■		■	■				■	■	■				■	■	■	■	■				■	■	■	■
	SevenMulti™ S40 / S47 / S80	BNC	■	■	■	■	■	■	■	■	■		■	■				■	■	■	■			■	■	■	■	■				■	■	■	■
	S400 Seven Excellende pH	BNC	■	■	■	■	■	■	■	■	■		■	■				■	■	■				■	■	■	■	■				■	■	■	■
	S220 Seven Compact pH	BNC	■	■	■	■	■	■	■	■	■		■	■				■	■	■				■	■	■	■	■				■	■	■	■
	FE 20-Five Easy pH	BNC	■	■	■	■	■	■	■	■	■		■	■				■	■	■				■	■	■	■	■				■	■	■	■
	FE 20-Five Easy Plus pH	BNC	■	■	■	■	■	■	■	■	■		■	■				■	■	■				■	■	■	■	■				■	■	■	■
	pH Meter 1120 (-X)	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	pH Meter 1140 (-X)	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	SevenGo™ pH SG2	BNC	■	■	■	■	■	■	■	■	■		■	■				■	■	■				■	■	■	■	■				■	■	■	■
SCHOTT Instruments®	CG 842 / 843 / 843 P	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	Handylab pH 11 / 12	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	Handylab pH/LF 12	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	Lab 850 / 860 / 870	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	Lab 850 / 860 / 870 BNC	BNC	■	■	■	■	■	■	■	■	■		■	■				■	■	■				■	■	■	■	■				■	■	■	■
	ProLab 1000	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	ProLab 1000 BNC	BNC	■	■	■	■	■	■	■	■	■		■	■				■	■	■				■	■	■	■	■				■	■	■	■
	ProLab 2000	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	ProLab 2000 BNC	BNC	■	■	■	■	■	■	■	■	■		■	■				■	■	■				■	■	■	■	■				■	■	■	■
	ProLab 3000	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	ProLab 3000 BNC	BNC	■	■	■	■	■	■	■	■	■		■	■				■	■	■				■	■	■	■	■				■	■	■	■
Testo	Testo 230	BNC	■	■	■	■	■	■	■	■	■		■					■	■					■	■	■	■					■	■	■	■
WTW	InoLab® pH Level 1 / 2 / 3	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	PH 540 GLP	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	InoLab® 720 / 730	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	InoLab® 740 / 750	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	InoLab® pH 7110 / pH 7310	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	InoLab® Multi 9310 IDS*	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	ProfiLine 197i / 1970i	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	ProfiLine pH 3110 / 3210 / 3310	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	Portable Meter 315 / 330	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■
	Portable Meter 340 / 350	DIN	■	■	■	■	■	■	■	■		■	■			■		■	■			■		■		■				■	■	■	■	■	■

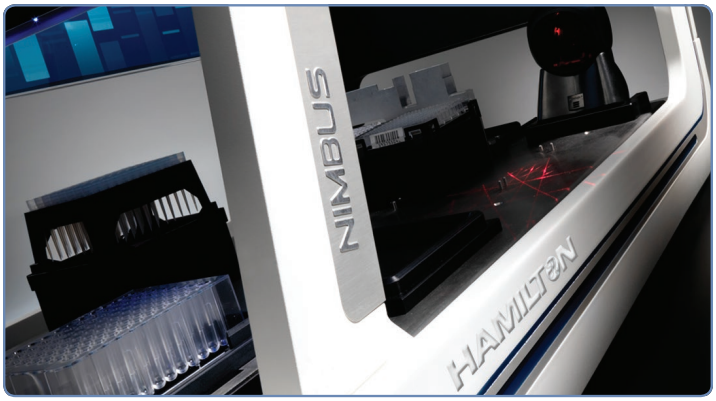
NOTE

About Hamilton Company

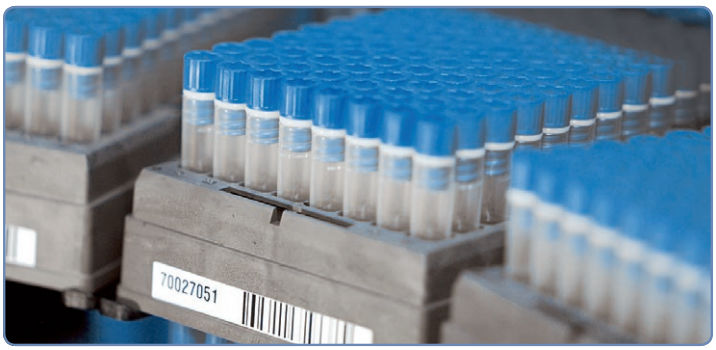
Hamilton Company is a global enterprise with headquarters in Reno, Nevada, Hopkinton, Massachusetts and Bonaduz, Switzerland and subsidiary offices throughout the world.

We are an industry leader in the design and manufacture of liquid handling, process analytics, robotics and automated storage solutions. For more than 50 years, Hamilton has been satisfying customer needs by combining quality materials with skilled workmanship to ensure the highest level of performance. Hamilton's lifelong commitment to precision and quality has earned us global ISO 9001 Certification.

Founded on the technology of analytical Microliter™ and Gastight® syringes, Hamilton has a broad offering of laboratory products including manual and semi-automated precision fluid measuring instruments, chromatography products, process sensors, laboratory electrodes, pipettes and more. Top innovations from these lines include Arc™ pH, DO and conductivity intelligent sensors, the BioLevitator™, Microlab® 600 diluters/dispensers and the DeCapper™.



A pioneer in liquid handling equipment and laboratory automation technology, Hamilton Robotics is known for advancing life science and biotechnology industries through reliability, performance and flexibility. Hamilton continues to be the market leader with patented technologies such as Compression-induced O-Ring Expansion (CO-RE™), Total Aspiration and Dispensing Monitoring (TADM) and Anti Droplet Control (ADC). Hamilton's feature platform, Microlab STAR, is the highest selling automated pipetting platform for several years running, while Microlab NIMBUS® is the first in class of compact, high-speed personalized pipetting workstations.



The Hamilton Storage Technologies division offers comprehensive ultra-low temperature automated sample management systems for a broad array of life science processes. Its line of biobanking, compound storage and consumable solutions consists of products such as BiOS™, SAM™ and ASM™, designed for sample integrity, flexibility and reliability.

Hamilton Company is focused on blending invention and accuracy to deliver customers unparalleled products.

Your Hamilton Representative

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