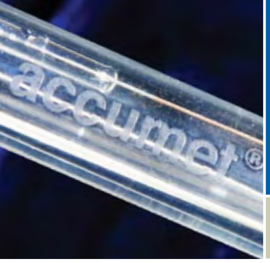


Fisher Scientific accumet® Electrodes

When selecting a pH system, choose your meter based on what features you need, i.e. resolution, output, memory, etc. Choose the corresponding pH electrode for your meter based primarily on your sample type and conditions, i.e. wastewater with sulfides, room temperature, student use, 5 days/week, etc.

Take a glance in the Fisher Scientific catalog and you will find 100's of pH electrodes to choose from. While many electrodes might be work adequately for a particular application, not all will perform equally or last as long as others. Usually in situations in which a pH electrode "didn't last long", the electrode is not matched well for the application resulting in poor performance, and ultimately failure. Understanding the different electrode options that are available and knowing how to use them to your advantages is a critical step to getting the most out of your pH measurement system.

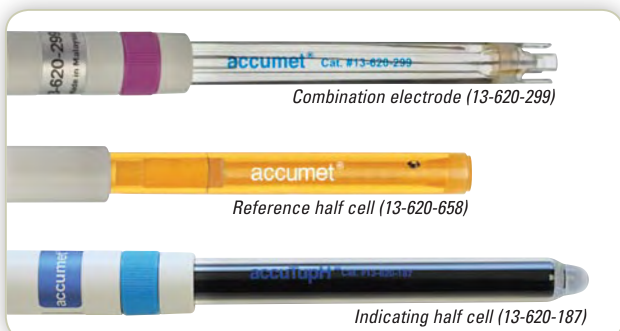
The following guide is designed to help you understand the ABC's of electrode selection. If you are still undecided or have questions regarding any product, your Fisher Scientific representative and our electrochemistry experts (888-358-4706 or accumet@fishersci.com) are there to help guide you!

» The ABC's Of Electrode Selection

Combination Or Half-Cell

There are two components within a pH electrode system. A pH indicating (or sensing) electrode develops a potential dependent on the pH, and the reference electrode which provides a constant potential to completes the electrical circuit. Combination electrodes have both the indicating and reference electrodes "combined" into one electrode. Alternatively, separate half-cell electrodes can be used. Since reference electrodes often outlast sensing electrodes, replacing indicating electrodes can mean lower replacement costs than replacing an equivalent combination electrode.

In practical terms, nearly all electrodes used today are combination electrodes. There are many reasons including; many pH meters require an adapter to accept half-cell electrodes, handling multiple electrodes is un-desirable (or impossible with small samples!), half cells don't have built in ATC and therefore require a third electrode for temperature compensation, the complexity of diagnosing electrode problems and most of all, the reduced cost and performance of today's combination electrode designs.



Combination electrode (13-620-299)

Reference half cell (13-620-658)

Indicating half cell (13-620-187)

Verdict: Use a combination electrode unless the method you must follow calls for half-cells. You'll have many more choices available to you. Combination cells may or may not have a temperature sensor built-in.

Glass Or Plastic Body

It probably goes without saying, but if an electrode literally breaks into pieces, it is useless and can not be repaired. Combination glass and combination plastic electrodes use an indicating electrode with a glass sensing bulb on the end. This is important for several reasons. First, plastic electrodes are not immune from breakage. Second, if an electrode breaks it will likely be at the tip, not the body itself. A plastic electrode with little to no bulb protection defeats the purpose of a plastic electrode in the first place.

To decide on which to use, let us look at the advantages and disadvantages of each, starting with the glass body electrode. Glass electrodes are easier to clean and maintain since they can tolerate just about any solvent and inorganic material (with the exception of HF!) and can handle higher temperatures quite nicely – typically to 100 °C. The fact that glass electrodes also have a glass sensing bulb is also an advantage. Since the seal that combines the bulb to the body is similar material, it is one less thing that can go wrong during measurement and doesn't become the source of junction potential as it does in plastic electrodes. This is especially important consideration for applications that have repeated and extreme heating and cooling – the expansion and contraction that occurs is handled much better by glass electrodes. The downside of glass electrodes is fairly easy – they are generally more expensive then plastic, and they have a greater potential for breakage.

Plastic electrodes are less expensive than glass equivalents and can usually take much abuse in the lab and in the field. Most electrodes with built-in temperature compensation elements are plastic due to the complexity in manufacturing them. As a result, they are most popular with field and portable meters, but can also be used in laboratory environments (such as 13-620-631). To protect the glass sensing bulb, many plastic electrodes use an integral housing that limit the bulb exposure, but often can be difficult to clean.

Verdict: Glass electrodes are definitely worth the upgrade if you have significant temperature fluctuations. If bulb breakage is a concern, consider Fisher Scientific accumet® accuTupH electrodes with thick glass bulbs! If you want ATC built-in to your electrode, expect to settle for plastic.

Refillable Or Non-Refillable (Gel)

All pH electrodes use/leak solution. Refillable electrodes do so more quickly, and can be replenished when they require more filling solution. Gel filled electrodes do so very slowly and when they run out or the gel is no longer flowing, can not be replenished and must be replaced.

Refillable electrodes are generally more expensive than gel-filled equivalent electrodes but respond much faster. They also last longer, because the filling solution can be replaced indefinitely; however the periodic addition of filling solution that is required also happens to be the main disadvantage. Another downside is that when the filling hole is left open for an extended period, dried salt may be left behind which often involves cleaning. The act of refilling and opening and closing the fill hole with Fisher Scientific accumet® electrodes is extremely easy due to the patented filling mechanism. It takes just seconds to open the hole and a few seconds more to fill the probe.

Gel-filled electrodes are less expensive, require less maintenance, and are usually plastic. High quality gel formulations have also extended the once limited shelf-life in recent years.

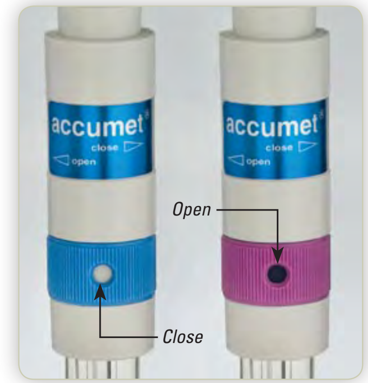
Verdict: Refillable electrodes are usually worth the extra maintenance – especially if it's a Fisher Scientific accumet® electrode.

Single Or Double-Junction (Tris Compatible)

The single-junction electrode on the left has a black, clogged junction and is no longer responsive.

This decision is extremely important and should not be overlooked. If you will be measuring samples that have sulfides, proteins, heavy metals, TRIS, or anything that might react with silver, or if you will be testing samples that are unknown, use a double-junction electrode. Calomel electrodes would also be suitable but have fallen out of favor due to mercury content and regulations that ban shipments of them in specific states in the US. Single-junction electrodes are less expensive, but offer no other advantages. If you use a single-junction electrode in a solution with TRIS, it's just a matter of time before it fails.

Verdict: If you will only measure drinking water, you can save money by using a single-junction pH electrode. If you have TRIS, sulfides, proteins, heavy metals or are measuring samples that are unknown, look for a Fisher Scientific accumet® electrode with a purple ring – indicating that is it compatible.



Refillable electrodes use our patented twist open and close mechanism.

Color coded electrode bands simplify electrode selection:

- **Purple = TRIS Compatible**
- **Blue = General Purpose**

Over 30 years of experience in the design, development, and manufacture of electrodes go into each Fisher Scientific accumet® electrode.

We offer electrodes that provide fast, accurate measurements in hundreds of different applications – including yours!

A complete line for every application: made with care and precision. All Fisher Scientific accumet® electrodes feature continuous electrical shielding and insulation of the internal elements, cable and connectors for extremely stable, reproducible readings with a minimum of electrical noise. Each electrode is individually tested, serialized to meet GLP requirements, and backed by a knowledgeable support staff **(888-358-4706 or accumet@fishersci.com)** and 1 year warranty.

Fisher Scientific accumet® pH Electrodes

High Performance Models For Critical Research

State-of-the-art design for fast, accurate measurements despite sample temperature differences – plus extra durability. Feature innovative reference system that controls chemical equilibria, prevents precipitation of solution components at reference element from 0 to 100 °C; plus internal electrolyte with minimal temperature coefficient. Result: highly predictable, super reliable electrodes that respond quickly at any temperature. Cycle between 25 and 80 °C samples, reach reproducible pH in 30 seconds (vs. 1 to 3 minutes for other electrodes). Drift and accuracy problems are virtually eliminated.

Read sample pH in <20 seconds, correct to ±0.02 pH; pH value stays constant at any temperature. Best of all, these electrodes read pH consistently at elevated temperatures – and without premature loss in performance.

Choice of standard-size glass body, epoxy body with flushable junction, and glass body with flushable junction.

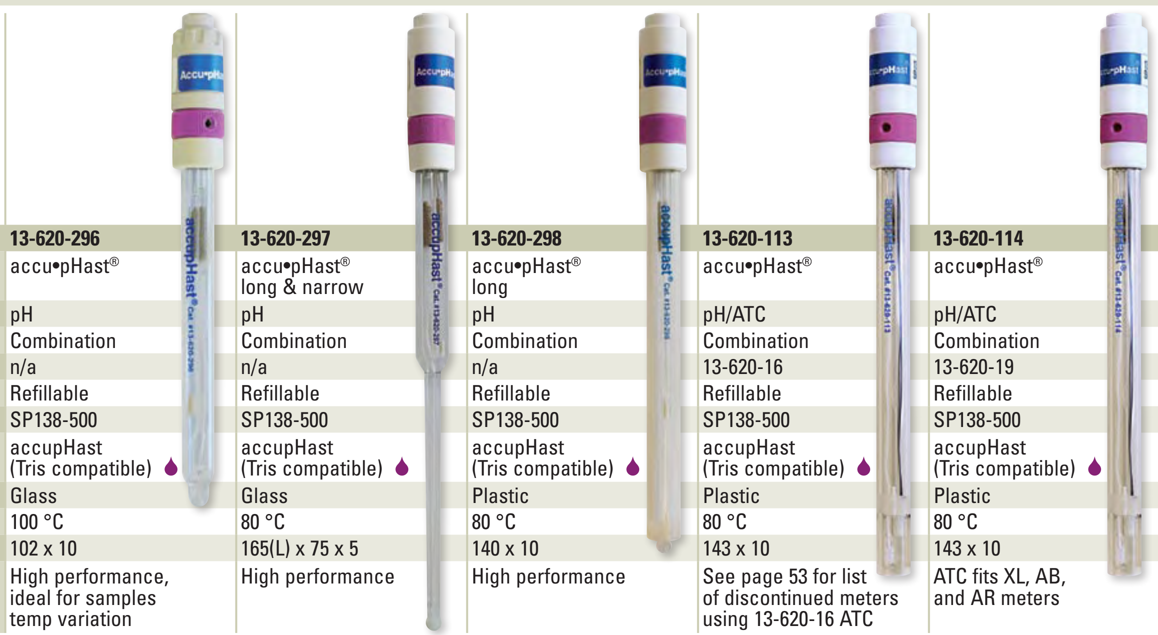
accu•pHast® R pH Electrodes

Catalog No.	13-620-195	13-620-196	13-620-197
Special	accu•pHast® R	accu•pHast® R accuFlow	accu•pHast® R accuFlow
Parameter	pH	pH	pH
Combination Or Half Cell	Combination	Combination	Combination
ATC Connection	n/a	n/a	n/a
Refillable Or Gel (Sealed)	Refillable	Refillable	Refillable
Refill Solution	SP138-500	SP138-500	SP138-500
Junction Type	Double	Double	Double
Glass Or Plastic Body	Glass	Plastic	Glass
Max Temp	100 °C	80 °C	100 °C
Length x Diameter (mm)	102 x 12	102 x 12	102 x 12
Note:	High performance, ideal for samples temp variation	High performance, flushable junction for tough samples	High performance, flushable junction for tough samples

Fast and accurate for samples at widely varying temperatures. Patented design: dual ceramic junctions, sealed reference, and special internal electrolyte to eliminate slow response when measuring samples at different temperatures in quick succession. Accurate to ±0.01 pH at 25 °C and ±0.05 pH from -5 to 100 °C. Response times of 20 seconds or less. Negligible drift.

Isolated reference and outer KCl fill solution prevent clogging from silver-compound precipitates. Unique pH bulb is filled with special crystals to speed thermal equilibrium. Choice of four styles: standard-size glass body, MicroProbe™ extra-long glass body, extra-long epoxy body, and pH/ATC epoxy body.

accu•pHast® pH Electrodes



Catalog No.	13-620-296	13-620-297	13-620-298	13-620-113	13-620-114
Special	accu•pHast®	accu•pHast® long & narrow	accu•pHast® long	accu•pHast®	accu•pHast®
Parameter	pH	pH	pH	pH/ATC	pH/ATC
Combination Or Half Cell	Combination	Combination	Combination	Combination	Combination
ATC Connection	n/a	n/a	n/a	13-620-16	13-620-19
Refillable Or Gel (Sealed)	Refillable	Refillable	Refillable	Refillable	Refillable
Refill Solution	SP138-500	SP138-500	SP138-500	SP138-500	SP138-500
Junction Type	accupHast (Tris compatible)	accupHast (Tris compatible)	accupHast (Tris compatible)	accupHast (Tris compatible)	accupHast (Tris compatible)
Glass Or Plastic Body	Glass	Glass	Plastic	Plastic	Plastic
Max Temp	100 °C	80 °C	80 °C	80 °C	80 °C
Length x Diameter (mm)	102 x 10	165(L) x 75 x 5	140 x 10	143 x 10	143 x 10
Note:	High performance, ideal for samples temp variation	High performance	High performance	See page 53 for list of discontinued meters using 13-620-16 ATC	ATC fits XL, AB, and AR meters

Fisher Scientific accumet® pH Electrodes

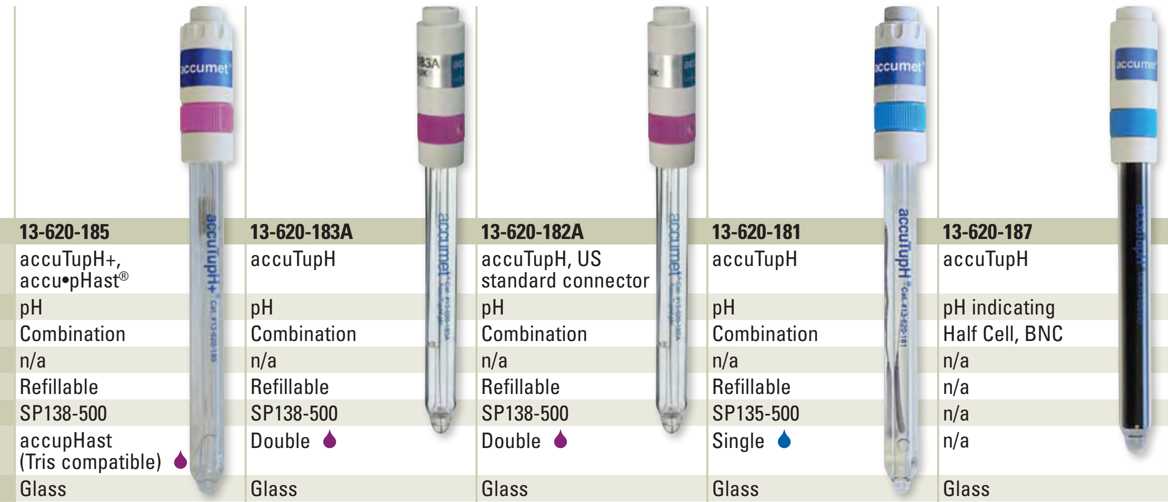
Top Selling Rugged Glass And Capillary Junction Electrodes

Five times thicker than conventional glass pH electrodes. For applications where glass bulbs break frequently and epoxy body electrodes aren't practical. Up to 40 times tougher than conventional glass pH electrodes, without sacrificing response times.

13-620-185 also utilizes accupHast temp reference for top performance from a rugged glass electrode.

8-mil standard electrode — *40-mil accuTupH rugged bulb*

accuTupH+ & accuTupH pH Electrodes

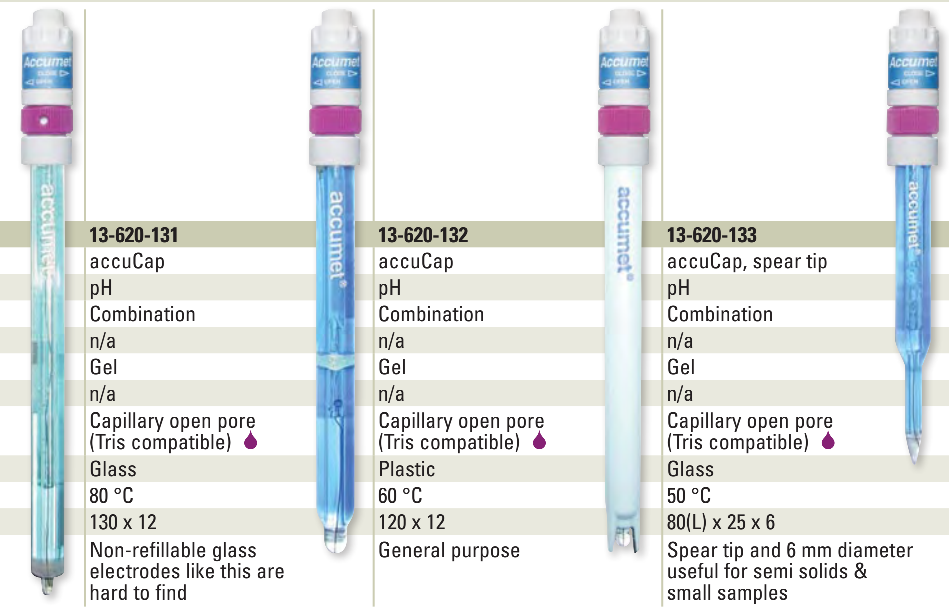


Catalog No.	13-620-185	13-620-183A	13-620-182A	13-620-181	13-620-187
Special	accuTupH+, accu•pHast®	accuTupH	accuTupH, US standard connector	accuTupH	accuTupH
Parameter	pH	pH	pH	pH	pH indicating
Combination Or Half Cell	Combination	Combination	Combination	Combination	Half Cell, BNC
ATC Connection	n/a	n/a	n/a	n/a	n/a
Refillable Or Gel (Sealed)	Refillable	Refillable	Refillable	Refillable	n/a
Refill Solution	SP138-500	SP138-500	SP138-500	SP135-500	n/a
Junction Type	accupHast (Tris compatible)	Double	Double	Single	n/a
Glass Or Plastic Body	Glass	Glass	Glass	Glass	Glass
Max Temp	100 °C	100 °C	100 °C	100 °C	100 °C
Length x Diameter (mm)	102 x 10	102 x 12	102 x 10	102 x 10	106 x 12
Note:	Rugged & fast temp response, high performance, includes bulb protector	Rugged, Tris compatible, includes bulb protector. Included with AB15+ & AB15 Bio kits	Rugged, Tris compatible, includes bulb protector. US std connector (not BNC)	Rugged, general purpose. includes bulb protector	Rugged, use with reference half cell

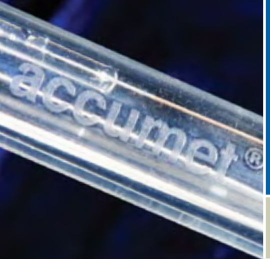
Single-pore capillary junction provides a flow channel about 200 times larger than typical reference junctions. Combined with a specially formulated flowing gel reference electrolyte (13-636-430), provides a fast, virtually clog-free reference. The result is a faster, more stable pH measurement.

accuCap® Capillary Junction Electrodes

Electrolyte & syringe (13-636-430)



Catalog No.	13-620-130	13-620-131	13-620-132	13-620-133
Special	accuCap	accuCap	accuCap	accuCap, spear tip
Parameter	pH	pH	pH	pH
Combination Or Half Cell	Combination	Combination	Combination	Combination
ATC Connection	n/a	n/a	n/a	n/a
Refillable Or Gel (Sealed)	Refillable	Gel	Gel	Gel
Refill Solution	13-636-430	n/a	n/a	n/a
Junction Type	Capillary open pore (Tris compatible)	Capillary open pore (Tris compatible)	Capillary open pore (Tris compatible)	Capillary open pore (Tris compatible)
Glass Or Plastic Body	Glass	Glass	Plastic	Glass
Max Temp	80 °C	80 °C	60 °C	50 °C
Length x Diameter (mm)	160 x 12	130 x 12	120 x 12	80(L) x 25 x 6
Note:	Research quality, included with XL series pH kits	Non-refillable glass electrodes like this are hard to find	General purpose	Spear tip and 6 mm diameter useful for semi solids & small samples



Fisher Scientific accumet® pH Electrodes

pH Electrodes To Match Your Application Type

Refillable Glass pH Electrodes

Catalog No.	13-620-285	13-620-223A	13-620-291	13-620-292	13-620-293
Special	n/a	n/a	Semi-micro	Semi-micro	Semi-micro
Parameter	pH	pH	pH	pH	pH
Combination Or Half Cell	Combination	Combination	Combination	Combination	Combination
ATC Type	n/a	n/a	n/a	n/a	n/a
Refillable Or Gel (Sealed)	Refillable	Refillable	Refillable	Refillable	Refillable
Refill Solution	SP135-500	SP138-500	SP135-500	SP135-500	SP138-500
Junction Type	Single	Double	Single	Single	Calomel
Glass Or Plastic Body	Glass	Glass	Glass	Glass	Glass
Max Temp	100 °C	100 °C	100 °C	100 °C	80 °C
Length x Diameter (mm)	102 x 12	102 x 12	100 x 6	150 x 6	160(L) x 120 x 6
Note:	General purpose. Included with AB15+ and AB15 kits. Includes bulb protector	Tris compatible, includes bulb protector	6 mm diameter for small samples, test tubes	Same as 13-620-291 but longer	Tris compatible

Refillable Plastic pH Electrodes

Catalog No.	13-620-287A	13-620-221	13-620-300	13-620-288	13-620-289
Special	n/a	n/a	n/a	n/a	Flat surface
Parameter	pH	pH	pH	pH	pH
Combination Or Half Cell	Combination	Combination	Combination	Combination	Combination
ATC Type	n/a	n/a	n/a	n/a	n/a
Refillable Or Gel (Sealed)	Refillable	Refillable	Refillable	Refillable	Refillable
Refill Solution	SP135-500	SP138-500	SP138-500	SP138-500	SP135-500
Junction Type	Single	Double	Calomel	Calomel	Single
Glass Or Plastic Body	Plastic	Plastic	Plastic	Plastic	Plastic
Max Temp	80 °C	80 °C	80 °C	80 °C	80 °C
Length x Diameter (mm)	106 x 12	102 x 10	106 x 12	106 x 12	114 x 13
Note:	Same as 13-620-530A without ATC	Tris compatible, includes bulb protector	Tris compatible, with integral bulb guard	Tris compatible	Flat surface for agar, cheese, food, and more

Micro pH And pH/ATC Refillable Electrodes

Catalog No.	13-620-95	13-620-96	13-620-530A	13-620-631
Special	MicroProbe	MicroProbe	n/a	n/a
Parameter	pH	pH	pH/ATC	pH/ATC
Combination Or Half Cell	Combination	Combination	Combination	Combination
ATC Type	n/a	n/a	13-620-19	13-620-19
Refillable Or Gel (Sealed)	Refillable	Refillable	Refillable	Refillable
Refill Solution	SP138-500	SP138-500	SP135-500	SP138-500
Junction Type	accupHast (Tris compatible)	accupHast (Tris compatible)	Single	Double
Glass Or Plastic Body	Glass body / Teflon stem	Glass body / Teflon stem	Plastic	Plastic
Max Temp	80 °C	80 °C	80 °C	80 °C
Length x Diameter (mm)	254(L) x 150 x 3	127(L) x 38 x 3	106 x 12	106 x 12
Note:	Tris compatible, small samples, long test tubes / NMR	Tris compatible, small samples	ATC for AB, AR, and XL meters	Tris compatible, ATC for AB, AR, and XL meters, included with AB15E kits

Gel-Filled Plastic pH Electrodes

Catalog No.	13-620-108A	13-620-290	13-620-299A	13-620-111	13-620-112
Special	n/a	Long & thin	n/a	n/a	n/a
Parameter	pH	pH	pH	pH/ATC	pH/ATC
Combination Or Half Cell	Combination	Combination	Combination	Combination	Combination
ATC Type	n/a	n/a	n/a	13-620-19	13-620-16
Refillable Or Gel (Sealed)	Gel	Gel	Gel	Gel	Gel
Refill Solution	n/a	n/a	n/a	n/a	n/a
Junction Type	Single	Single	Double	Double	Double
Glass Or Plastic Body	Plastic	Plastic	Plastic	Plastic	Plastic
Max Temp	80 °C	80 °C	80 °C	80 °C	80 °C
Length x Diameter (mm)	106 x 12	178 x 6	106 x 12	106 x 12	106 x 12
Note:	Ecomomical, general purpose	Tall flasks, bottles	Ecomomical, Tris compatible	ATC for AB, AR, and XL meters	See page 53 for list of discontinued meters using 13-620-16 ATC

Fisher Scientific accumet® pH Electrodes

New pH/ATC Electrodes For Non-accumet® Meters

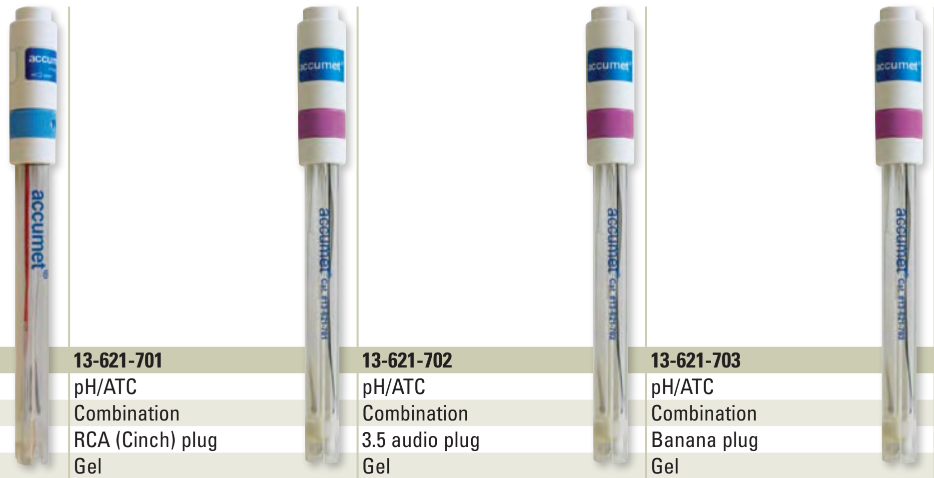
Fisher Scientific accumet® pH And Half Cell Electrodes

pH/ATC Electrodes For Portable Fisher Scientific accumet® Meters

- Combination pH mercury-free electrodes with built-in temperature compensation
- Fast, accurate response from 5 to 80 °C
- Double-junction pH/ATC electrodes compatible with Tris, proteins and sulfides
- Epoxy body is impact resistant and ideal for rough handling

All electrodes have a BNC connector and ATC connector; ATC will differ with meter type. 3-ft cable and electrode storage bottle are included, refillable models also include a 30 mL bottle of filling solution.

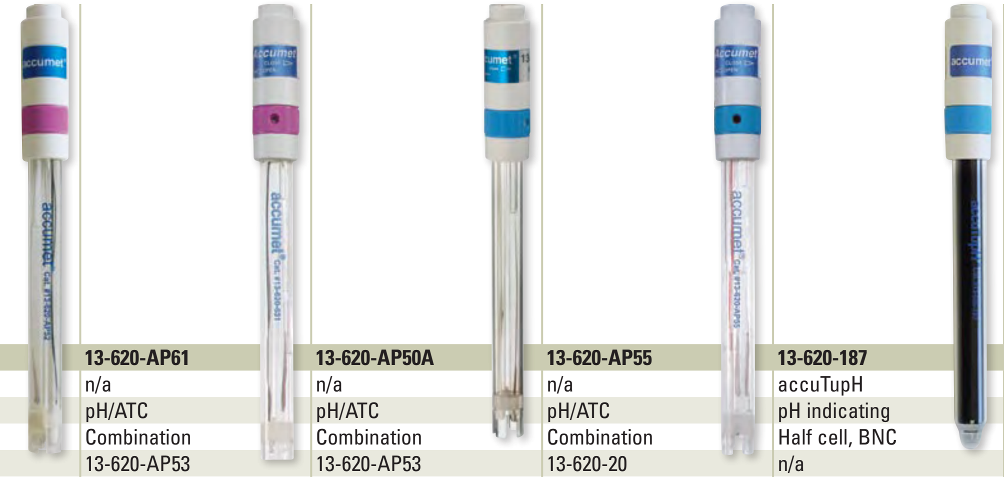
Universal pH/ATC Electrodes



Catalog No.	13-620-31C	13-621-701	13-621-702	13-621-703
Parameter	pH/ATC	pH/ATC	pH/ATC	pH/ATC
Combination Or Half Cell	Combination	Combination	Combination	Combination
ATC Connection	RCA (Cinch) plug	RCA (Cinch) plug	3.5 audio plug	Banana plug
Refillable Or Gel (Sealed)	Refillable	Gel	Gel	Gel
Refill Solution	SP135-500	n/a	n/a	n/a
Junction Type	Single	Double	Double	Double
Glass Or Plastic Body	Plastic	Plastic	Plastic	Plastic
Max Temp	80 °C	80 °C	80 °C	80 °C
Length x Diameter (mm)	106 x 12	106 x 12	106 x 12	106 x 12
Note:	ATC for Mettler®, Pinnacle® and Corning® meters	ATC for Mettler®, Pinnacle® and Corning® meters	ATC for Beckman® meters	ATC for WTW® and Pinnacle® (part numbers ending with "P")

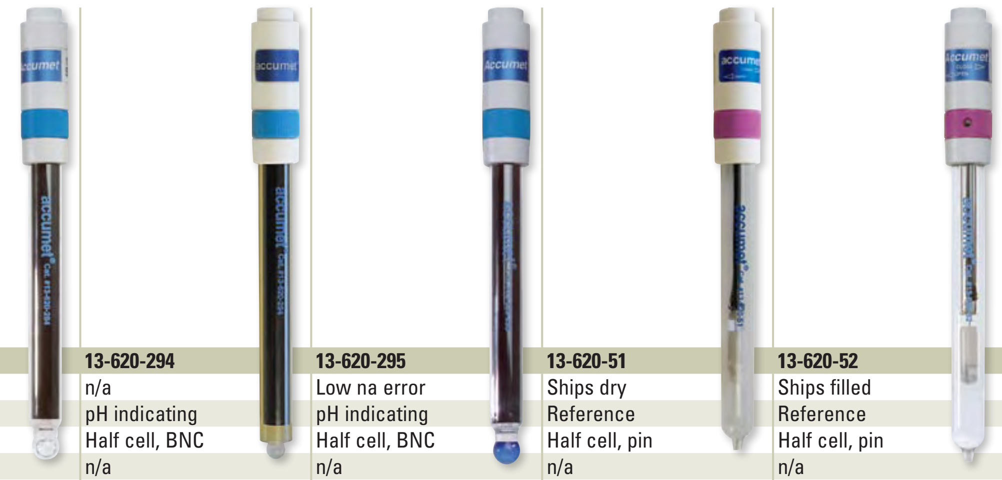
Catalog No.	13-620-111T	13-620-111	13-620-631
Parameter	pH/ATC	pH/ATC	pH/ATC
Combination Or Half Cell	Combination	Combination	Combination
ATC Connection	Mini DIN	Mini phone	Mini phone
Refillable Or Gel (Sealed)	Gel	Gel	Refillable
Refill Solution	n/a	n/a	SP138-500
Junction Type	Double	Double	Double
Glass Or Plastic Body	Plastic	Plastic	Plastic
Max Temp	80 °C	80 °C	80 °C
Length x Diameter (mm)	106 x 12	106 x 12	106 x 12
Note:	ATC for Thermo Scientific Star meters	ATC for Denver meters	ATC for Denver meters

pH/ATC Electrodes For Field Use, accuTupH Half Cell



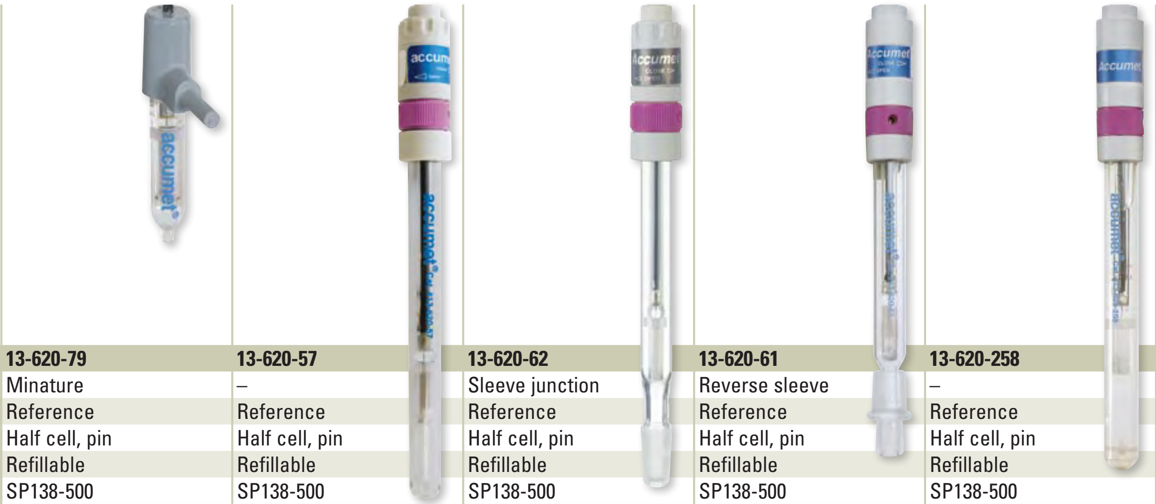
Catalog No.	13-620-AP52	13-620-AP61	13-620-AP50A	13-620-AP55	13-620-187
Special	n/a	n/a	n/a	n/a	accuTupH
Parameter	pH/ATC	pH/ATC	pH/ATC	pH/ATC	pH indicating
Combination Or Half Cell	Combination	Combination	Combination	Combination	Half cell, BNC
ATC Type	13-620-16	13-620-AP53	13-620-AP53	13-620-20	n/a
Refillable Or Gel (Sealed)	Gel	Refillable	Refillable	Refillable	n/a
Refill Solution	n/a	SP138-500	SP135-500	SP135-500	n/a
Junction Type	Double	Double	Single	Single	n/a
Glass Or Plastic Body	Plastic	Plastic	Plastic	Plastic	Glass
Max Temp	80 °C	80 °C	80 °C	80 °C	100 °C
Length x Diameter (mm)	102 x 12	102 x 12	102 x 12	102 x 12	106 x 12
Note:	ATC for AP60 & AP100 series meters	ATC for AP60 & AP100 series meters. Replaces 13-620-AP51	ATC for AP60 & AP100 series meters	ATC for AP70 & AP80 series meters	Rugged, use with reference half cell

Half-Cell Electrodes

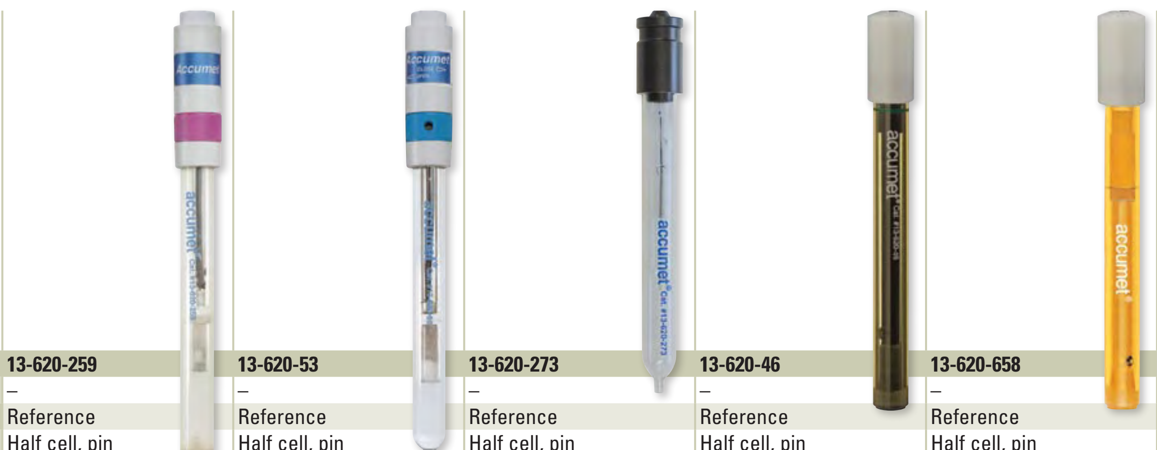


Catalog No.	13-620-284	13-620-294	13-620-295	13-620-51	13-620-52
Special	n/a	n/a	Low na error	Ships dry	Ships filled
Parameter	pH indicating	pH indicating	pH indicating	Reference	Reference
Combination Or Half Cell	Half cell, BNC	Half cell, BNC	Half cell, BNC	Half cell, pin	Half cell, pin
ATC Type	n/a	n/a	n/a	n/a	n/a
Refillable Or Gel (Sealed)	n/a	n/a	n/a	Refillable	Refillable
Refill Solution	n/a	n/a	n/a	SP138-500	SP138-500
Junction Type	n/a	n/a	n/a	Calomel	Calomel
Glass Or Plastic Body	Glass	Plastic	Plastic	Glass	Glass
Max Temp	100 °C	80 °C	80 °C	80 °C	80 °C
Length x Diameter (mm)	106 x 12	106 x 12	106 x 12	106 x 12	106 x 12
Note:	Use with reference half cell	Use with reference half cell	Ideal for samples >pH 11, use with reference half cell	Pin connector, use with indicating half cell	Pin connector, use with indicating half cell

Half Cell Reference Electrodes

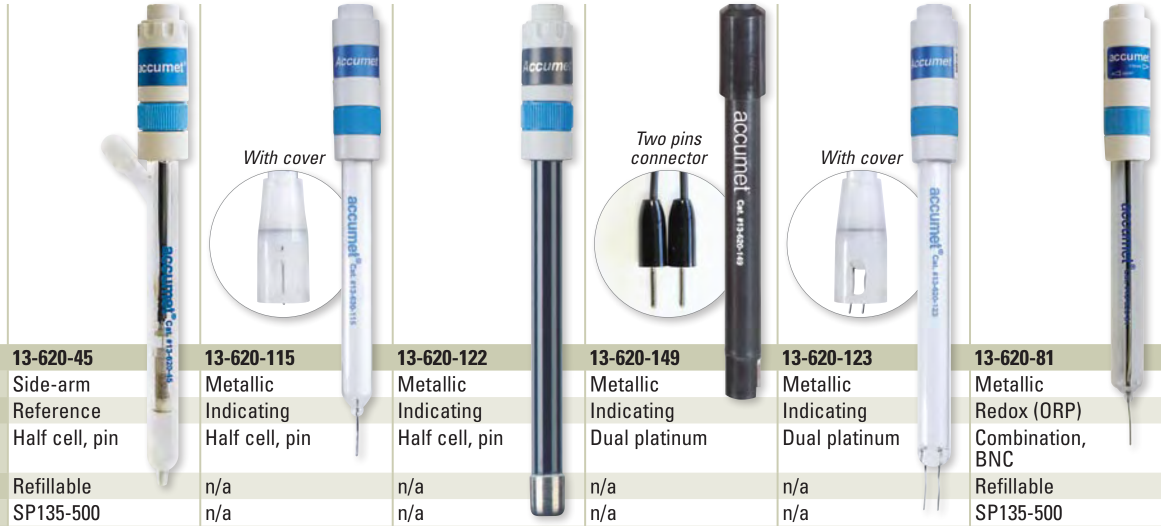


Catalog No.	13-620-79	13-620-57	13-620-62	13-620-61	13-620-258
Special	Minature	–	Sleeve junction	Reverse sleeve	–
Parameter	Reference	Reference	Reference	Reference	Reference
Combination Or Half Cell	Half cell, pin	Half cell, pin	Half cell, pin	Half cell, pin	Half cell, pin
Refillable Or Gel (Sealed)	Refillable	Refillable	Refillable	Refillable	Refillable
Refill Solution	SP138-500	SP138-500	SP138-500	SP138-500	SP138-500
Junction Type	Calomel	Calomel	Calomel	Calomel	Calomel
Glass Or Plastic Body	Glass	Glass	Glass	Glass	Plastic
Max Temp	80 °C	80 °C	80 °C	80 °C	80 °C
Length x Diameter (mm)	41 x 12	106 x 12	106 x 12, 16 (with sleeve)	106 x 12, 16 (with sleeve)	106 x 12
Note:	Pin connector, use with indicating half cell	Pin connector, non-aqueous samples, use with indicating half cell	Pin connector, for viscous samples, use with indicating half cell	Pin connector, for viscous samples, use with indicating half cell	Pin connector, use with indicating half cell



Catalog No.	13-620-259	13-620-53	13-620-273	13-620-46	13-620-658
Special	–	–	–	–	–
Parameter	Reference	Reference	Reference	Reference	Reference
Combination Or Half Cell	Half cell, pin	Half cell, pin	Half cell, pin	Half cell, pin	Half cell, pin
Refillable Or Gel (Sealed)	Gel	Refillable	Refillable	Refillable	Refillable
Refill Solution	n/a	SP135-500	SP138-500	SP135-500	Inner 13-620-433 Outer 13-620-434
Junction Type	Calomel	Single	Double	Single	Double
Glass Or Plastic Body	Plastic	Glass	Glass	Plastic	Plastic
Max Temp	80 °C	100 °C	100 °C	100 °C	100 °C
Length x Diameter (mm)	106 x 12	106 x 12	106 x 12	108 x 13	108 x 13
Note:	Pin connector, use with indicating half cell	Pin connector, use with indicating half cell	Pin connector, use with indicating half cell	Pin connector, use with indicating half cell	Pin connector, bromide, chloride, copper, iodide, lead, nitrate, silver/sulfide, redox, and pH applications requiring sample-compatible electrolyte, use with indicating half cell

Reference, Metallic, And ORP Electrodes



Catalog No.	13-620-45	13-620-115	13-620-122	13-620-149	13-620-123	13-620-81
Special	Side-arm	Metallic	Metallic	Metallic	Metallic	Metallic
Parameter	Reference	Indicating	Indicating	Indicating	Indicating	Redox (ORP)
Combination Or Half Cell	Half cell, pin	Half cell, pin	Half cell, pin	Dual platinum	Dual platinum	Combination, BNC
Refillable Or Gel (Sealed)	Refillable	n/a	n/a	n/a	n/a	Refillable
Refill Solution	SP135-500	n/a	n/a	n/a	n/a	SP135-500
Junction Type	Single	Redox	Redox	Redox	Redox	Redox
Glass Or Plastic Body	Glass	Glass	Glass	Plastic	Glass	Glass
Max Temp	100 °C	100 °C	100 °C	80 °C	100 °C	100 °C
Length x Diameter (mm)	106 x 12	140 x 12	140 x 12	114 x 13	140 x 13	140 x 12
Note:	Pin connector, remote fill with side arm, use with indicating half cell	ORP and titrations	Silver and halide titrations	Chlorine titrations with Cl titrimeter. Connect to BNC using 13-620-488 (page 53)	KF, dead-stop titrations, sulfur	BNC, most ORP measurements, includes bulb protector

See page 53 for adapters.

Combination pH/ATC probe in a completly glass-free design. Uses solid-state Ion-Selective Field Effect Transistor (ISFET) sensing design. Special models for XL meters include cup style for small volume measurements and a flat surface design. Low maintenence, gel-filled electrode with no refill solution or bulb breakage to worry about. Ideal for food testing applications where traditional glass sensors cannot be used.

accuFet pH Electrodes

Catalog No.	13-620-700	13-620-710	13-620-755	13-620-758
Special	accuFet, cone tip	accuFet, cup style	accuFet	accuFet
Parameter	pH/ATC	pH/ATC	pH/ATC	pH/ATC
Combination Or Half Cell	Combination	Combination	Combination	Combination
ATC Connection	accuFet	accuFet	AB15 Plus, AB15	Basic
Refillable Or Gel (Sealed)	Gel	Gel	Gel	Gel
Refill Solution	n/a	n/a	n/a	n/a
Junction Type	Single	Single	Single	Single
Glass Or Plastic Body	Plastic	Plastic	Plastic	Plastic
Max Temp	80 °C	80 °C	80 °C	80 °C
Length x Diameter (mm)	140 x 12	140 x 12	140 x 12	140 x 12
Note:	For XL series pH meters	For XL series pH meters	For AB15+, AB15, and AR series pH meters	For discontinued Basic meters

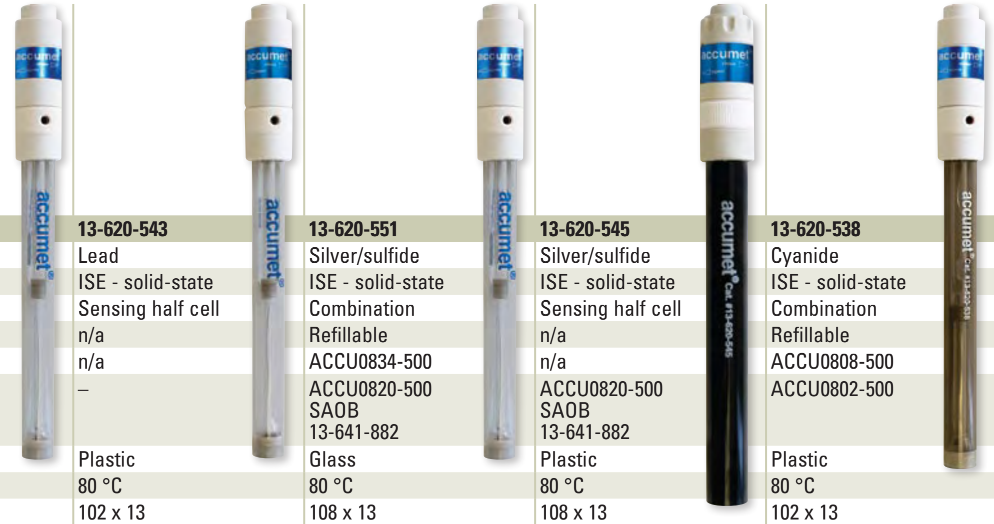
Fisher Scientific accumet® Ion-Selective Electrodes (ISE)

Combination And Half Cell ISE's Have BNC For Universal Meter Use

Polymer Membrane And Solid State ISE

Catalog No.	13-620-536	13-620-534	13-620-532	13-620-521	13-620-525
Parameter	Calcium	Nitrate	Potassium	Bromide	Bromide
Type	ISE - polymer membrane	ISE - polymer membrane	ISE - polymer membrane	ISE - solid-state	ISE - solid-state
Combination Or Half Cell	Combination	Combination	Combination	Sensing half cell	Combination
Refillable Or Gel (Sealed)	Refillable	Refillable	Refillable	n/a	Refillable
Refill Solution	SP138-500	ACCU0807-500	Fill solution (Dilute ISA from 5M to 0.1M)	n/a	ACCU0834-500
Ionic Strength Adjuster	13-641-851	13-641-850	13-641-927	ACCU0820-500	ACCU0820-500
Glass Or Plastic Body	Plastic	Plastic	Plastic	Plastic	Glass
Max Temp	40 °C	40 °C	40 °C	80 °C	80 °C
Length x Diameter (mm)	102 x 13	102 x 13	102 x 13	102 x 13	108 x 13
Connection	BNC	BNC	BNC	BNC	BNC
Interferences	Mg^{++}, Zn^{++}, Ba^{++}, K^{+}, Na^{++}, Ni^{++}, Cu^{++}, Fe^{++}, Sr^{++}, H^{++}, Hg^{++}, Pb^{V}	Cl^{-}, NO_2^{-}, Br^{-}, CN^{-}, ClO_3^{-}, I^{-}, ClO_4^{-}	Cs^{+}, NH_4^{+}, Tl^{+}, H^{+}, Ag^{+}, Tris, Li^{+}, Na^{+}	I^{-}, CN^{-}, S^{--}	S^{--}, I^{-}, CN^{-}, High Cl^{-} levels, NH_3
Range (ppm)	0.2 to 40,000	0.5 to 14,000	0.04 to 39,000	0.4 to 79,000	0.4 to 79,000
Calibration Solutions	100 ppm 13-641-862	1000 ppm = 13-641-910 100 ppm = 13-641-924	1000 ppm = 650016 100 ppm = 649716	1000 ppm ACCU0822-500	1000 ppm ACCU0822-500
0.1 M	$CaCl_2$ (13-641-811)	$NaNO_3$ (13-641-888)	KCl (13-641-917)	NaBr (ACCU0821-500)	NaBr (ACCU0821-500)
Typical Applications & Notes:	Foods, beverages, soil, pharmaceuticals, explosives, fertilizers, plants, EDTA titration endpoint	Pollution testing, foods, pharmaceuticals, fertilizers, plants, meants, pickling baths	Body fluids, soils, sewage, fertilizers, foods, beverages	Biological fluids, soil, plants, foots, effluents, Method ASTM approved. Requires reference half cell	Biological fluids, soil, plants, foots, effluents, Method ASTM approved

Solid State ISE



Catalog No.	13-620-549	13-620-543	13-620-551	13-620-545	13-620-538
Parameter	Lead	Lead	Silver/sulfide	Silver/sulfide	Cyanide
Type	ISE - solid-state	ISE - solid-state	ISE - solid-state	ISE - solid-state	ISE - solid-state
Combination Or Half Cell	Combination	Sensing half cell	Combination	Sensing half cell	Combination
Refillable Or Gel (Sealed)	Refillable	n/a	Refillable	n/a	Refillable
Refill Solution	ACCU0834-500	n/a	ACCU0834-500	n/a	ACCU0808-500
Ionic Strength Adjuster	–	–	ACCU0820-500 SAOB 13-641-882	ACCU0820-500 SAOB 13-641-882	ACCU0802-500
Glass Or Plastic Body	Glass	Plastic	Glass	Plastic	Plastic
Max Temp	80 °C	80 °C	80 °C	80 °C	80 °C
Length x Diameter (mm)	108 x 13	102 x 13	108 x 13	108 x 13	102 x 13
Connection	BNC	BNC	BNC	BNC	BNC
Interferences	Ag^{+}, Hg^{++}, Cu^{++}, CD^{++}, Fe^{++}	Ag^{+}, Hg^{++}, Cu^{++}, CD^{++}, Fe^{++}	Hg^{++}	Hg^{++}	Cl^{-}, Br^{-}, I^{-}, S^{--} absent
Range (ppm)	0.2 to 20,700	0.2 to 20,700	0.01 to 107,900 (Ag^{+}) 0.003 to 32,100 (S^{--})	0.01 to 107,900 (Ag^{+}) 0.003 to 32,100 (S^{--})	0.1 to 260
Calibration Solutions	–	–	–	–	–
0.1 M	$Pb(ClO_4)_2$ (13-641-773)	$Pb(ClO_4)_2$ (13-641-773)	–	–	–
Typical Applications & Notes:	Organic compounds, water/wastewater, plating baths	Organic compounds, water/wastewater, plating baths. Requires reference half cell	Sewage effluent, soils, sediments, plating baths, pulping liquors, photographic fixing solution	Sewage effluent, soils, sediments, plating baths, pulping liquors, photographic fixing solution. Requires reference half cell	Silicon petrochemical, plating water, wastes

Solid State ISE

Catalog No.	13-620-627	13-620-519	13-620-547	13-620-629	13-620-523
Parameter	Chloride	Chloride	Cupric	Fluoride	Fluoride
Type	ISE - solid-state	ISE - solid-state	ISE - solid-state	ISE - solid-state	ISE - solid-state
Combination Or Half Cell	Combination	Sensing half cell	Combination	Combination	Sensing half cell
Refillable Or Gel (Sealed)	Refillable	Sealed	Refillable	Refillable	Sealed
Refill Solution	13-620-432	n/a	ACCU0834-500	13-620-431	n/a
Ionic Strength Adjuster	ACCU0820-500	ACCU0820-500	13-641-852	ACCU0831-500 ACCU0835-500 13-641-874	ACCU0831-500 ACCU0835-500 13-641-874
Glass Or Plastic Body	Plastic	Plastic	Glass	Plastic	Plastic
Max Temp	80 °C	80 °C	80 °C	80 °C	80 °C
Length x Diameter (mm)	110 x 13	102 x 13	108 x 13	110 x 13	102 x 13
Connection	BNC	BNC	BNC	BNC	BNC
Interferences	S^{--}, I^{-}, CN^{-}, OH^{-}, Br^{-}	Br, I^{-}, CN^{-}, S^{--}, OH^{-}	Ag^{+}, Hg^{++}, Cl^{-}, Br^{-}, Fe^{+}, Cd^{++}	OH^{-}	OH^{-}
Range (ppm)	1.8 to 35,500	1.8 to 35,500	0.00064 to 6,350	0.02 to saturated	0.02 to saturated
Calibration Solutions	1000 ppm (ACCU0819-500)	1000 ppm (ACCU0819-500)	1000 ppm (23004)	100 ppm (ACCU0825-500)	100 ppm (ACCU0825-500)
0.1 M	NaCl (ACCU0818-500)	NaCl (ACCU0818-500)	$Cu(NO_3)_2$ (13-641-835)	NaF (ACCU0824-500)	NaF (ACCU0824-500)
Typical Applications & Notes:	Water/wastewater, soil, dairy, meats, tomato/vegetable products, Method ASTM/AOAC approved	Water/wastewater, soil, dairy, meats, tomato/vegetable products, Method ASTM/AOAC approved. Requires reference half cell	Plating baths, water	Drinking water, wastwater and natural waters, stack gases, sea water, minerals, soils, foods, biological fluids, toothpaste, ASTM/EPA Method	Drinking water, wastwater and natural waters, air and stack gases, sea water, minerals, soils, foods, biological fluids, toothpaste

Gas-Sensing And Glass Membrane ISE

Catalog No.	13-620-509	13-620-511	13-620-503A	13-620-501
Parameter	Ammonia	Carbon Dioxide	Sodium	Sodium
Type	ISE - gas sensing	ISE - gas sensing	ISE - glass membrane	ISE - glass membrane
Combination Or Half Cell	Combination	Combination	Combination	Sensing half cell
Refillable Or Gel (Sealed)	Refillable	Refillable	Refillable	Refillable
Refill Solution	ACCU0800-500	ACCU0806-500	SP138-500	SP138-500
Ionic Strength Adjuster	ACCU0802-500	ACCU0805-500	ACCU0832-500	ACCU0832-500
Glass Or Plastic Body	Plastic	Plastic	Plastic	Glass
Max Temp	50 °C	50 °C	60 °C	80 °C
Length x Diameter (mm)	108 x 12	108 x 12	106 x 12	108 x 13
Connection	BNC	BNC	BNC	BNC
Interferences	Volatile amines, metal cations that complex ammonia	Volatile organic acids	Ag^{+}, Li^{+}, K^{+}, NH_4^{+}	Ag^{+}, Li^{+}, K^{+}, NH_4^{+}
Range (ppm)	0.009 to 1,700	0.44 to 1,320	0.023 to 23,000	0.023 to 23,000
Calibration Solutions	1000 ppm ACCU0801-500	–	1000 ppm = ACCU0828-500 100 ppm = ACCU0827-500	1000 ppm = ACCU0828-500 100 ppm = ACCU0827-500
0.1 M	NH4Cl (ACCU0800-500)	$NaHCO_3$ (ACCU0804-500)	10 % NaCl (ACCU0826-500)	10 % NaCl (ACCU0826-500)
Typical Applications & Notes:	Sewage effluent, boiler water, fish tanks, stack gases, sea water, biological samples, fertilizers. Uses 13-620-512 replacement membranes	Measures carbon dioxide, carbonate, bicarbonate in soft drinks, wines, ground/sea water, fermentation. Uses 13-620-513 replacement membranes	Steam condensate, meats, fish, dairy, fruit juices, fermentation, ground/sea water, soils, body fluids	Steam condensate, meats, fish, dairy, fruit juices, fermentation, ground/sea water, soils, body fluids. Requires reference half cell

Conductivity Cells: For Fisher Scientific accumet® And Oakton® Meters

Nominal Cell Constant	Glass Body Cat. No.	Epoxy Body Cat. No.
2-Cell Conductivity Cells Without ATC For AR And AB Series Meters		
0.1	13-620-156	13-620-161
1.0	13-620-155	13-620-160
10.0	13-620-157	13-620-162
2-Cell Conductivity Cells With ATC For XL Series Meters		
0.1	–	13-620-101
1.0	–	13-620-100
10.0	–	13-620-102
4-Cell Conductivity Cells With ATC For AR, AB, And XL Series Meters		
1.0	13-620-163	13-620-165
10.0	13-620-164	13-620-166
Cell For Oakton® CON 11, CON 110, pH/CON 510 And AP75, AP85 Meters		
1.0	Ultem Body	13-620-AP54
Cell For Oakton® 600 Series Meters		
1.0	Ultem Body	13-302-222

13-620-160

13-620-163

13-620-156

13-620-162

13-620-AP54

15-500-012

Dissolved Oxygen Probes: For Fisher Scientific accumet® And Oakton® Meters

Description	Catalog No.
Dissolved Oxygen Probes And Accessories For Fisher Scientific accumet® AR60, AR40, AB40, XL40 And XL60 Benchtop Meters	
Self-Stirring DO/BOD/Temp Probe	13-620-SSP
Adapter To Connect YSI® Self Stirring DO Probes To AR, AB, XL Series Meters	13-637-DOADPT
Membrane Kit For 13-620-SSP. Includes (6) Membrane Caps, Polishing Disk, And Electrolyte Filling Solution	13-637-DOM

Description	Catalog No.
Dissolved Oxygen Probes And Accessories For Fisher Scientific accumet® AP74, AP84, And Oakton® DO 110 Portable Meters	
DO/Temperature Probe With 10-Ft Submersible Cable	15-500-034
DO/Temperature Probe With 25-Ft Submersible Cable	15-500-035
Electrolyte Solution For Dissolved Oxygen Probes, 500 mL	15-500-036
DO Replacement Membrane Assembly, Preassembled Membrane, Membrane Lock, O-ring, Cap	15-500-037
Replacement DO Probe Membranes, Pack Of 25, Requires Membrane Installation Tool	15-500-038
Membrane Installation Tool, Required To Replace Membranes	15-500-039
Replacement Probe For DO 6, Includes 50 mL Electrolyte And Spare Cap	13-200-271

13-620-SSP

15-500-034

13-200-271

ATC/Temperature Probes: For Fisher Scientific accumet® And Oakton® Meters

All temperature probes are stainless steel and have a 3-ft cable.

Description	Catalog No.
ATC For XL, AR, And AB Series Benchtop Meters	13-620-19
ATC For AP72, AP71, And PC 510 Meters	13-620-20
ATC For AP100 And AP60 Series Portable Meters	13-620-AP53
ATC For Discontinued Fisher Scientific accumet® Models 10, 15, 20, 25, 30, 50, 150, 750, 800MP Series, And 900 Series	13-620-16
ATC For Oakton pH 6, 11, 110, 510, 1100, 2100 Meters	15-500-003

13-620-19

Precision Calibration Resistor Kit

Check meter compliance to USP standards. Includes:

- Six precision resistors (nominal values 10 ohm, 100 ohm, 1 kilohm, 10 kilohm, 100 kilohm, and 1 megohm)
- Connectors for Fisher Scientific accumet® XL, AR, and AB conductivity meters
- Foam padded case

Description	Catalog No.
Fisher Scientific accumet® Conductivity Calibration Kit	13-637-674

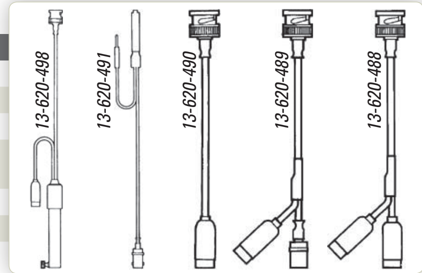
Compact Printer With Date/Time Stamp

Description	Catalog No.
Dot Matrix Portable Printer For AB15P. Includes Cable, Ribbon, Paper, 115 V	13-637-670
Printer Paper	13-637-669
Printer Replacement Ribbon	13-637-668
Printer Cable	13-637-667

13-637-670

BNC Adapter Cables

Description	Catalog No.
U.S. Standard/Pin To BNC Input Jack	13-620-498
BNC Plug To U.S. Standard/Pin Input Jack	13-620-491
Pin Plug To BNC Input Jack. Use With Metallic Electrodes Having Pin Connectors	13-620-490
BNC/Pin Plugs To Single BNC Input Jack	13-620-489
Dual-Pin Plugs To BNC Input Jack	13-620-488

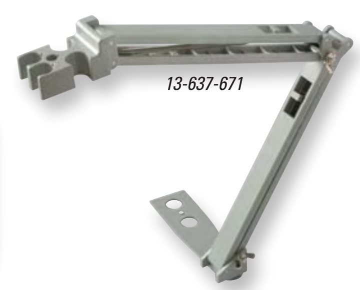


Other Replacement Parts And Accessories

Description	Catalog No.
1.5 V Batteries For Oakton Testrs, Pack Of (6)	S60037BAT
Electrode Arm And Bracket For AR, AB, XL Series Benchtop Meters	13-637-671
Free-Standing Benchtop Electrode Support Arm	50-633-374
110/220 V Power Supply For XL Series Meters	13-636-XL60E
110/220 V Power Supply For AB Series, AP60 Series, AP100 Series	13-636-100
100/240 V Power Supply For Oakton 11, 110, 1100, 2100 Series, US/UK/EUR Plug	13-300-126
100/240 V Power Supply For Oakton 600 Series, US/UK/EUR/JPN Plug	15-500-058
Meter To PC RS-232/Serial Cable, (M)DB9 To (F)DB9	13-637-680

13-636-XL60E

13-620-499



13-637-671

13-637-680

13-637-DOADPT

13-637-DOM

50-633-374

Fisher Chemical Certified Color-Coded pH Buffers

- Color-coded solutions with matching colored labels provides instant recognition
- Tight tolerances:
  - 0.01 for pH 4.0 and 7.0
  - 0.02 for pH 10.0
- Standardized at 25 °C against NIST standard reference material
- Label includes temperature correction chart
- MSDS's available from **www.fishersci.com**

pH	Color	Size	Catalog No.
4.00	Red	500 mL	**SB101-500**
4.00	Red	4 L	**SB101-4**
4.00	Red	20 L	**SB101-20**
7.00	Yellow	500 mL	**SB107-500**
7.00	Yellow	4 L	**SB107-4**
7.00	Yellow	20 L	**SB107-20**
10.00	Blue	500 mL	**SB115-500**
10.00	Blue	4 L	**SB115-4**
10.00	Blue	20 L	**SB115-20**

Buffer-Pac Includes 4, 7, 10 Buffers.

pH	Color	Size	Catalog No.
4.00	Red	500 mL	
7.00	Yellow	500 mL	**SB105-500**
10.00	Blue	500 mL	

Refilling And Storage Solutions

Description	Size	Catalog No.
Saturated KCL. Use With Double-Junction And Calomel pH Electrodes (Purple Ring), Or Fluoride (13-620-529), Sodium, And Calcium Combination Ion Selective Electrodes	500 mL	**SP138-500**
4 M KCL Saturated With AgCl. Use With Single-Junction pH Electrodes (Blue Ring).	500 mL	**SP135-500**
Skylite Electrolyte With Syringe For accuCap 13-620-130 pH Electrode	60 mL	**13-636-430**
pH Electrode Storage Solution	1 L	**SE40-1**
Electrode Storage Bottle	–	**13-620-499**

Fisher Chemical Certified Buffer Solutions

- Stated values certified accurate to 0.02 pH or 0.01 pH at time buffer is bottled
- Label includes temperature correction chart
- 500 mL and 1 L sizes use rugged polyethylene bottles with leak proof screw caps and plastic seals
- 10 L & 20 L quantities come in handy PolyPac* store-and dispense containers

pH	Tolerance	Size	Catalog No.
1.00	±0.02	500 mL	**SB140-500**
2.00	±0.02	500 mL	**SB96-500**
3.00	±0.01	500 mL	**SB97-500**
4.00	±0.01	500 mL	**SB98-500**
4.00	±0.01	1 L	**SB98-1**
4.00	±0.01	10 L	**SB98-10**
4.00	±0.01	20 L	**SB98-20**
4.63	±0.02	1 L	**SB100-1**
5.00	±0.01	500 mL	**SB102-500**
6.00	±0.01	500 mL	**SB104-500**
7.00	±0.01	500 mL	**SB108-500**
7.00	±0.01	1 L	**SB108-1**
7.00	±0.01	10 L	**SB108-10**
7.40	±0.01	500 mL	**SB110-500**
8.00	±0.02	500 mL	**SB112-500**
9.00	±0.02	500 mL	**SB114-500**
10.00	±0.02	500 mL	**SB116-500**
10.00	±0.02	1 L	**SB116-1**
10.00	±0.02	10 L	**SB116-10**

Fisher Chemical Dry pH Buffer Salts

- Easier to store, more stable than solutions
- Supplied in polyethylene-lined GramPac* envelopes
- Each makes 1 L of buffer

pH	Catalog No.
4.00	**B79**
6.86	**B78**
7.41	**B82**
9.18	**B80**
10.4	**B77**

Oakton Conductivity Solutions

- Choose 1 pint (475 mL) plastic bottles or (20) single-use pouches

Value	Quantity	Catalog No.
10 μS	20 pouches	**50-632-479**
23 μS	475 mL	**13-300-114**
84 μS	475 mL	**13-300-111**
447 μS	475 mL	**13-300-117**
447 μS	20 pouches	**13-300-129**
1413 μS	475 mL	**13-300-112**
1413 μS	20 pouches	**13-300-130**
1500 μS	475 mL	**13-300-110**
2070 μS	475 mL	**13-300-115**
2764 μS	475 mL	**13-300-113**
2764 μS	20 pouches	**13-300-131**
8974 μS	475 mL	**13-300-119**
12880 μS	475 mL	**13-300-109**
15000 μS	475 mL	**13-300-118**
15000 μS	20 pouches	**13-300-132**
80000 μS	475 mL	**13-300-116**

» Small footprint saves valuable lab space

» Speed range from 60 to 1200 rpm

Specifications and Ordering Information

Top Plate	
Area	16 sq. in.
Nominal (L x W)	4 x 4" (10.2 x 10.2 cm)
Load Capacity	15 lb (6.8 kg)
Speed	
Range	60 to 1200 rpm
Stability	±20 rpm
Temperature (For Hotplate Stirrers)	
Range	Ambient to 540 °C
Overall	
Operating Temp	4 to 40 °C (39 to 104 °F)
Dimensions (L x W x H)	5.5 x 3.8 x 9.7" (14 x 9.3 x 24.7 cm)
Power	120 V, 50/60 Hz
Approvals	CSA/IEC 1010

Magnetic Stirrer: Includes manual, and a two-year parts, labor, and travel warranty.

Description	Catalog No.
4 x 4 in Magnetic Stirrer	**11-100-16S**
4 x 4 in Hotplate Stirrer	**11-100-16SH**

Accurate pH measurement requires adequate stirring. To ensure the best results from your Fisher Scientific accumet® or Oakton® meter, be sure you use a Fisher Isotemp® magnetic stirrer. This sleek stirrer combines top-of-the-line performance with a low-profile design and one of the smallest footprints available. Ceramic top plate provides a reflective white finish for better viewing of color contrasts in titrations and other applications. Plus, it's acid- and alkali-resistant and easy to clean.

Direct-drive motor delivers quiet, dependable operation and has a speed range of 60 to 1200 rpm with a stirring stability of ±20 rpm. Instant-on operation allows you to start stirring at 60 rpm at the first click – with no splashing. Adjustable control knob has graduations to provide speed references and is easy to grip – even while wearing heavy gloves. Illuminated LED lets you know when stirrer is on.

The hotplate stirrer model provides the option for a sample to be maintained at a constant temperature for consistent pH measurements.

Built-in support rod mount at the rear of stirrer will accommodate a rod up to 13 mm in diameter; includes thumbscrew to secure rod. Unit is designed to prevent liquid spills from damaging the stirrer and can be used in environments from 4 to 40 °C (39 to 104 °F). Operates on 120 V, 50/60 Hz; CSA/IEC 1010 approved. Unit includes a two-year parts, labor, and travel warranty.

About pH, ORP, And ISE Measurement

A Practical Approach To Achieve Best Results

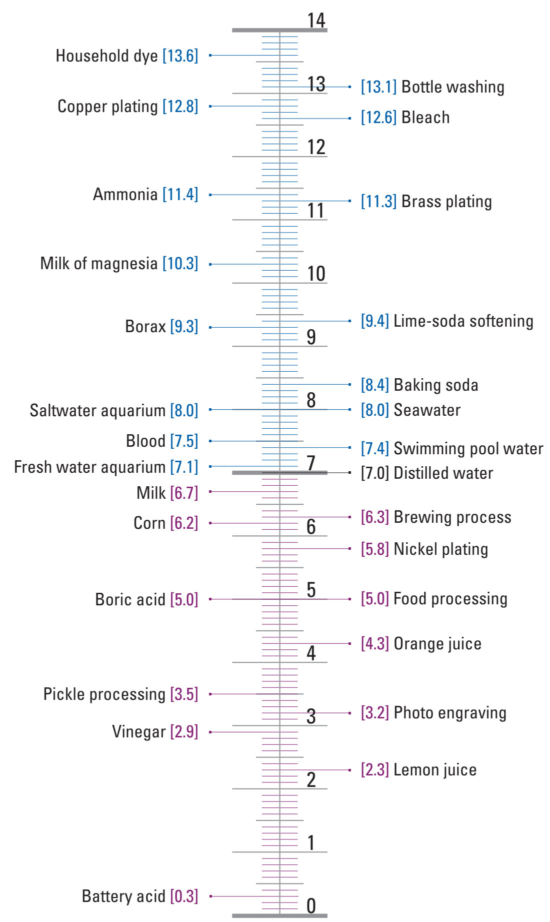
Next to temperature, pH is quite possibly the most common laboratory measurement today. It crosses over many disciplines from water/wastewater, R&D, environmental, chemical & life sciences, and an endless number of industrial applications.

The pH or **p**ower of **H**ydrogen, is the degree of acidity or alkalinity of a solution based on the hydrogen ion activity, represented by the equation:

$$pH = -\log [H+]$$

Stated mathematically, pH is the negative logarithmic value of the Hydrogen ion. As it is based on a log scale, each pH unit represents a factor of 10, so a solution with a pH of 5 is 100 times more acidic than pH of 7.

Here are examples of pH in a few common industrial and household products.



Litmus paper can be used for rough pH measurements, but for highest accuracy a potentiometric system using a pH meter and pH electrode is used. The electrode is sensitive to H+ ions, which create a small voltage potential, which is converted to a pH value by the pH meter. Electrode behavior is described by the Nernst equation:

$$E = E_o + (2.3\ RT/nF) \log aH+$$

E is the measured potential from the sensing electrode, Eo is related to the potential of the reference electrode, (2.3 RT/nF) is the Nernst factor and log aH+ is the pH. The Nernst factor, 2.3 RT/nF, includes the Gas Law constant (R), Faraday's constant (F), the temperature in degrees Kelvin (T) and the charge of the ion (n). For pH, where n = 1, the Nernst factor is 2.3 RT/F. Since R and F are constants, the factor and therefore electrode behavior is dependent on temperature.

The pH electrode system consists of two half cells: a pH indicating electrode, which develops a potential dependent on the pH of a solution; and a reference electrode, which provides a constant potential and completes the electrical circuit. Using separate pH indicating and reference half cells allows you to select each cell without compromise, tailor the system precisely to the sample's nature, and achieve good accuracy. It can mean lower replacement costs too, since usually only one of a pair is broken. For ATC, a third electrode is required. Nevertheless, the combination electrode – an indicating half cell and a reference half cell joined co-axially – is by far the most common choice for the convenience and compactness it offers. Some combined electrodes also offer built-in ATC for added convenience.

» Temperature Compensation

In a perfect pH electrode – one that measures zero mV at exactly pH 7 – there is no temperature effect on the electrode sensitivity at pH 7 regardless of temperature change. While pH electrodes are not perfect, errors related to temperature are negligible near pH 7, and can be disregarded. As a rule however, the further from pH 7 the solution is and the greater the temperature changes, the greater the expected measurement error due to changes in the electrode's sensitivity. For most electrodes, the error is approximately 0.003 pH/°C/pH away from pH 7.

Consider a pH meter that was calibrated at room temperature (25 °C) and measures a sample at pH 4 at 5 °C,

Temperature difference : 25 °C - 5 °C = 20 °C
Number of pH units away from neutral : 7 pH - 4 pH = 3 pH units
Total error : 0.003 x 20 x 3 = 0.18 pH

pH meters that incorporate Automatic Temperature Compensation (ATC) are able to overcome this error.

Q: So why does my pH 10.00 buffer read as 10.06?
A: ATC or not, temperature influences the pH of all solutions. While pH 10.00 buffer is certified to 10.00 at 25 °C / 77 °F, at 20 °C / 68 °F which is often room temperature, it is actually 10.06.

To understand the pH/temperature relationship, we need to look at two main processes; Calibration & Measurement.

Calibration: Meters have a buffer/temperature look-up table stored into memory for every pH buffer that the meter can calibrate to. For example, when calibrating with a pH 10 buffer that is 20 °C, the meter knows to calibrate to a value of 10.06 when calibration is performed. Had the temperature of the buffer been 25 °C, the meter would calibrate instead to 10.00. Using a temperature probe during calibration allows best accuracy as the meter is able to calibrate to the most appropriate pH value.

Measurement: As temperature changes, the pH electrode responds slightly differently. Since this change is predictable, the meter is able to make the appropriate adjustment. The meter senses the temperature and applies the appropriate electrode slope (mV per pH unit) for that temperature. For example, if the temp is 25 °C, the instrument uses 59.16 mV for each pH unit. If the temperature is 20 °C, the meter uses 58.16 mV for each pH unit. Using a temperature probe during measurement allows best accuracy as the meter is able to correct for changes in electrode response due to temperature. Note: Temperature compensation only corrects for the change in the output of the electrode, not for the change in the actual solution pH. As such, the AB15 will always display the actual pH of the solution at the current temperature.

» pH Standardization Buffers

Buffers – solutions of known pH value – allow adjustments to the meter/electrode system to reflect accurate measurements. Certified accurate buffers are available as ready-to-use color coded solutions, concentrated solutions, capsules and prepackaged salts. All have the special characteristic of resisting pH change upon dilution or acid/base contamination. For best accuracy, use a minimum of two-point standardization; first with a buffer value close to the electrode system's zero potential (typically pH 7); and next with an acid or base buffer whose value brackets the expected pH value of the sample. Microprocessor-based meters may permit additional calibrations – up to five points in some models. For best accuracy, perform calibration with ATC at the same temperature as the expected samples.

» ORP Measurement

Oxidation-Reduction Potential (ORP) or "Redox" measurements are used to monitor chemical reactions, to quantify ion activity, or to determine the oxidizing or reducing properties of a solution. ORP is a measurement of the total electrical potential of a solution – a sum of all oxidation and reduction reactions.

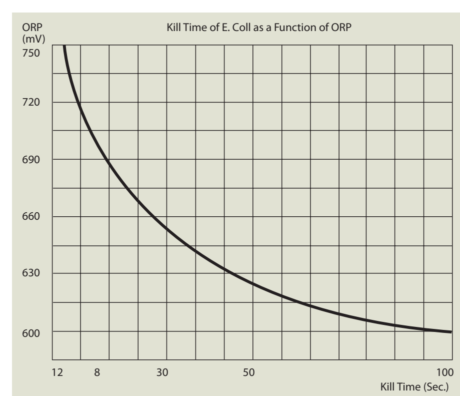
ORP electrodes measure the voltage across a circuit formed by the measuring metal half cell and the reference half cell. When the ORP electrode is placed in the presence of oxidizing or reducing agents, electrons are constantly transferred back and forth on its measuring surface, generating a tiny voltage. ORP is expressed as +/- mV, and can be measured by using the millivolt mode of any pH meter with an ORP electrode.

Like pH, an ORP electrode system consists of a sensing and reference electrodes. For ORP, the indicating electrode is metallic – usually platinum, gold, or silver.

ORP varies with temperature, but unlike pH, it is not completely predictable and therefore, ATC is not used. Constant temperature is best for monitoring ORP.

In principle, ORP measurements should not require standardization; in practice however, it may be necessary to check the system against standards of known potential, as described in ASTM Method D 1498.

ORP is also useful in pool water treatment as an indication of sanitation in relation to free chlorine. ORP technology has gained recognition worldwide and is found to be a reliable indicator of bacteriological water quality. The table below illustrates the Kill Time of E.Coli bacteria as a function of ORP value. With a value of 600 mV, the life of the bacteria is almost 2 minutes; at 650 mV it reduces to 30 seconds. Above 700 mV the bacteria is killed within a few seconds. It is therefore necessary for the water to have an ORP value of at least 700 mV to ensure good water quality.



ORP value also depends on the pH of pool water. The pH of the pool water has to be maintained at the optimum level between 7.2 and 7.6 pH by dosing appropriate chemicals. If the pH of the swimming pool water is acceptable and the ORP value is below 700 mV, hypochlorite or other oxidizing chemicals should be added.

Common ORP applications include the treatment of industrial wastes, study of biological systems, oxidation of cyanide, bleaching of pulp, manufacture of bleach and reduction of chromate wastes.

» ISE Measurement

Ion-Selective Electrodes (ISE) respond to a particular ion in solution because of the characteristics of the electrode's sensing membrane. Ideally, the ISE develops an electrical potential which is proportional to the concentration of the ion for which the membrane is selective. The most widely-used ISE is the glass-membrane pH electrode (selective for hydrogen ion).

When an ISE – the indicator electrode – and a reference electrode are placed in a solution and connected to a pH/ion meter, they form a potentiometric cell. At equilibrium, the meter measures the potential difference between the ISE and the reference electrode. This potential is proportional to the activity of the ion of interest.

The table below gives theoretical slope values at 25 °C:

Species	Slope (mV/Decade)
Monovalent Cation	+59.16
Monovalent Anion	-59.16
Divalent Cation	+29.58
Divalent Anion	-29.58

Although ISE's are most often measured by direct analysis, some sample preparation is required. Normally, an ionic strength adjuster must be added equally to samples and standards. Then, standards must be prepared which are used to calibrate the meter, or to construct a calibration curve (by plotting the electrode's output in mV vs. the log of concentration). Sample concentration can then be read directly from the meter or calibration curve.

Incremental methods can reduce errors caused by temperature variations, complex matrices, and complexation. They're also useful for applications where only occasional samples are analyzed. Incremental methods include: 1) Known Addition; 2) Known Subtraction; 3) Analate Addition; and 4) Analate Subtraction.

Ion-selective electrodes can also be used to detect the endpoint of a titration. The ISE can be selected to monitor either the addition of titrant or the depletion of analate. The electrode potential is plotted vs. the volume of titrant added. The volume corresponding to the equivalence point is determined from the graph, and used to calculate sample concentration.

A number of metallic electrodes are also used in titrations. Dual platinum wire and plate electrodes, are used with pH meters and titration instruments in dead-stop and amperometric titrations; and silver billet electrodes are the choice for silver and halide titrations.

The ion meter/electrode system must be standardized by immersing the electrodes into solutions having a known concentration of the ion of interest. Stock ISE standards are available in a variety of molar, ppm, and percent concentrations. Calibration is typically done using at least two points that are 10 fold apart, such as 1 and 10 ppm. An ionic strength adjuster is required to eliminate interference from other ions. Since some ISE's have a restricted pH range, a pH adjustment solution may also be necessary. Other special reagents and solutions are available for specific applications.

Testing/Care/Troubleshooting

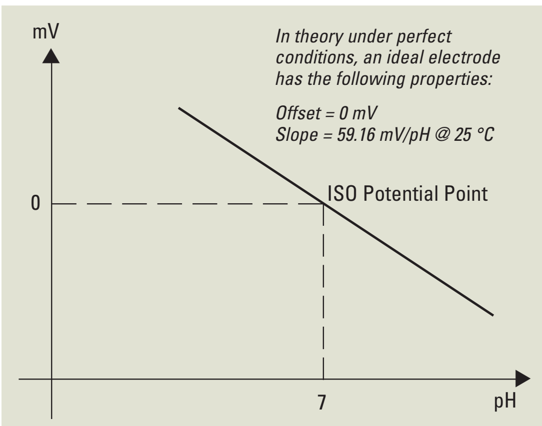
Prevent Problems From Happening And Recognize When It's Too Late

›› pH Electrode Offset

A perfect pH electrode under ideal conditions, when placed in pH 7.00 buffer at 25 °C, will produce 0 mV. The difference between 0 mV and the electrode's actual mV reading is called the offset error, which usually becomes problematic when it is more than ±30 mV or about ½ of a pH unit.

›› pH Electrode Slope

A perfect pH electrode under ideal conditions at 25 °C, produces a slope of 59.16 mV per pH unit. For example, an electrode with 0 mV offset should read mV value of 177.48 mV when placed in a pH 4.01 solution. The slope is calculated as (177.48 mV – 0 mV) / 3 pH = 59.16 mV/pH. The difference between this perfect slope reading and the electrode's actual reading is called the slope error. These theoretical values are not always achieved, even with brand new electrodes. The slope of most new pH electrodes should fall between 92 % and 102 % of 59.16 mV.



›› Normal Aging

As electrodes are used or stored for long periods they can undergo changes in performance. The electrode offset and slope can be monitored to evaluate these changes. Periodic calibration is usually adequate to correct for these changes. If an electrode is able to be calibrated and reads accurately in certified standards, is stable, is responsive and repeatable, it is still considered functional and may be used indefinitely although it no longer meets "new" electrode specifications with regards to offset or slope.

›› How to check your pH electrode – including slope and offset:

1. Clear/reset any existing calibration stored in your meter then select the millivolt (mV) mode of your pH meter
2. Using a pH electrode, obtain mV readings of two fresh calibration buffers (i.e. pH 4.0 and pH 7.0 are best)
3. Determine the net mV change
4. Determine the net mV change per pH unit change and compare using the chart below. For example, at 25 °C: pH 4 = 170.5 mV, pH 7 = -3.4 mV: Net change = 170.5 mV - (-3.4 mV) = 173.9 mV. Since pH 4 and pH 7 are 3 pH units apart, using the chart below, 98 % = Very Good
5. The offset can be determined by observing the mV reading with your pH electrode in pH 7 buffer. The closer to 0 mV the better. A mV more than 30 mV from 0 may be problematic.
6. Also take notice of the electrode response time – the faster, the better. Don't expect an economy gel electrode to respond as fast as a high performance glass refillable electrode, but note that <u>a great slope alone is not meaningful if the electrode takes 2 hours to stabilize.</u>

Slope	At 20 °C		At 25 °C		Status
	1 pH Unit	3 pH Units	1 pH Unit	3 pH Units	
>102	>59.3	>178.0	>60.3	>181.0	Poor
102 %	59.3	178.0	60.3	181.0	Ok
101 %	58.8	176.3	59.8	179.3	Very Good
100 %	58.2	174.5	59.2	177.5	Ideal
99 %	57.6	172.8	58.6	175.7	Very Good
98 %	57.0	171.0	58.0	173.9	Very Good
97 %	56.4	169.3	57.4	172.2	Very Good
96 %	55.8	167.5	56.8	170.4	Very Good
95 %	55.3	165.8	56.2	168.6	Very Good
94 %	57.0	171.0	58.0	173.9	Ok
93 %	54.1	162.3	55.0	165.1	Ok
92 %	53.5	160.5	54.4	163.3	Ok
<92	<53.5	<160.5	<54.4	<163.3	Poor

›› Common Symptoms/Cause (Remedy)

- **No Response, All Buffers Or Samples Read The Same pH – Usually pH 7.00 Or 0 mV**
  Broken sensing bulb or wiring problem (replace electrode), probe not connected to input (verify correct channel selection when using multiple-channel meters), probe is not in contact with sample (remove electrode storage bottle or rubber bulb guard), meter automatically has frozen reading (verify that the hold feature or auto read feature is set to off when using meters with this feature, usually by pressing measure or read.)

- **Slow Response With Excessive Crystallization Inside Probe Of Refillable Electrodes**
  Electrolyte flow clogged from supersaturated electrolyte ("flush & fill" by remove the filling solution through the fill hole with a syringe or by shaking it upside down. Repeatedly flush and rinse the reference cavity with clean, 60-80 °C water to dissolve crystals until removed. Replace filling solution and apply gentle pressure to the filling hole. Re-hydrate electrode in storage solution or pH 4 buffer), (ensure fill hole is in open position). To prevent this in the future, <u>ensure that the re-fill hole is closed when electrode is not in use.</u>

- **Slow Response Due To Clogged Junction-Usually With Single-Junction Electrodes**
  Reaction with silver such as silver sulfide formation or protein deposits which causes a dark spot on the ceramic reference junction (For protein layers prepare a 1 % pepsin solution in 0.1 M of HCl and soak the reference junction for one hour in this solution. Rinse the electrode with distilled water. Alternatively, heat a diluted KCl solution to 60 to 80 °C. Place the sensing part of the electrode into the heated solution for about 10 minutes. Allow the electrode to cool in some unheated KCl solution.

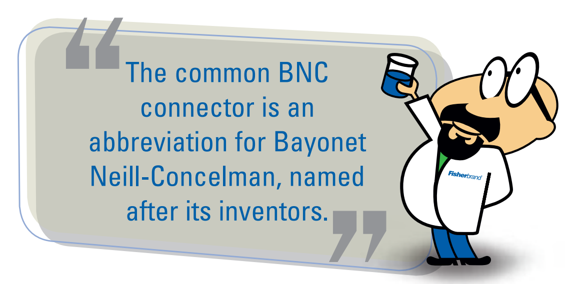
- **Dried Salt Deposits Present**
  Electrolyte residue deposited on electrode surface – often with new electrodes or periods of non-use. (simply dissolve the deposits in warm tap water followed by a brief soak in pH 4 buffer).

- **Slow Response, Noisy, Unstable, Or Erratic Readings**
  Sensing bulb dry or dirty (clean electrode with mild detergent & warm water and re-hydrate electrode), temperature may be changing rapidly or electrode may be thermally shocked (allow electrode to reach sample temperature), sample may be non-aqueous (take 30 second readings and soak in pH buffer for one minute between measurements).

For additional support contact your Fisher Scientific sales or customer service representative, call a electrochemistry specialist at 1-888-358-4706, or send an email to: accumet@fishersci.com

›› General Rules And Tips

- When using refillable electrodes, open the fill hole during calibration and measurement – but remember to close it afterwards when finished!
- The level of electrolyte in the outer cavity of refillable electrodes should be kept above the level of the solution being measured to prevent reverse electrolyte flow.
- The electrode need only be immersed far enough to cover both the glass pH sensing bulb and reference junction to obtain accurate readings.
- Electrodes perform best when they are hydrated. However, if they dry out they can be reconditioned to normal performance again. Soaking in electrode storage solution helps to optimize and re-establish the thin hydration layer on the sensing bulb that is critical to pH measurement.
- Rinsing the electrode with deionized or distilled water between samples is fine, but storage in deionized or distilled can be detrimental as it will rob critical ions from the sensing bulb. Also, avoid wiping or touching the sensing bulb to maintain the hydration layer and producing any electrical charge.
- Moving or touching the electrode cable may result in unstable readings due to the high impedance (resistance) of the pH glass membrane and introduce noise.
- To eliminate temperature errors associated with the electrode, manual or automatic temperature compensation (ATC) should be used for best accuracy. Since temperature changes pH, the sample temperature should always be noted with pH readings. i.e.) Record results as "pH 8.43 @ 23.2 °C", instead of "pH 8.43".
- Always use fresh pH buffers for calibration. Excessive air exposure and sunlight an alter the buffers value – especially pH 10.00 buffers which is particularly susceptible to drift.



About Conductivity Measurement

A Practical Approach To Achieve Best Results

Electrical Conductivity (EC) meters measure the capacity of ions in an aqueous solution to carry electrical current. As the ranges in aqueous solutions are usually small, the basic units of measurements are milliSiemens/cm (mS) and microSiemens/cm (µS).

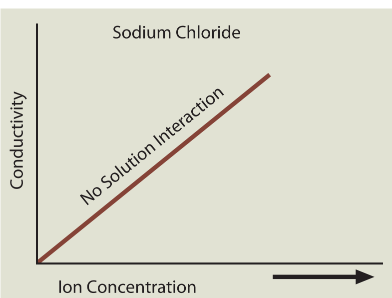
Solution	Conductivity
Absolute Pure Water	0.055 µS
Power Plant Boiler Water	1.0 µS
Good City Water	50 µS
Ocean Water	53 mS
Distilled Water	0.5 µS
Deionized Water	0.1 - 10 µS
Drinking Water	0.1 - 1 mS
Wastewater	0.9 - 9 mS
Seawater	53 mS
10 % NaOH	355 mS
10 % H2SO4	432 mS
31 % HNO3	865 mS

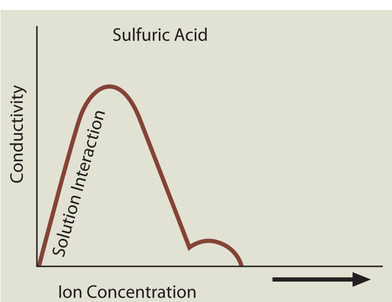
Conductivity Measurement

The principle by which instruments measure conductivity is simple – two plates are placed in the sample, a potential is applied across the plates, and the current is measured. Conductivity (G), the inverse of Resistivity (R) is determined from the voltage and current values according to Ohm's law.

G = I/R = I (amps) / E (volts)

Since the charge on ions in solution facilitates the conductance of electrical current, the conductivity of a solution is proportional to its ion concentration. However, conductivity may not correlate directly to concentration. The graphs below illustrate the relationship between conductivity and ion concentration for two common solutions. Notice that the graph is linear for sodium chloride solution, but not for highly concentrated sulfuric acid.

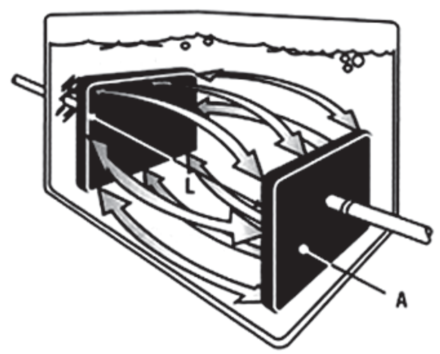




Resistivity, Conductivity, and Salinity Units

The basic unit of conductivity is the Siemens (S), formerly called the mho. Since cell geometry affects conductivity values, standardized measurements are expressed in specific conductivity units (S/cm) to compensate for variations in electrode dimensions. Specific conductivity (C) is simply the product of measured conductivity (G) and the electrode cell constant (L/A), where L is the length of the column of liquid between the electrode and A is the area of the electrodes.

Figure 1



C = G x (L/A)

Resistivity is simply the reciprocal of conductivity: conductivity = 1/resistivity. In practice, resistivity units are used when describing ultra pure water such as deionized or reverse-osmosis water. Conductivity units are used for water ranging from drinking water to brackish water. Salinity units are reserved for the highest concentrations expressed as parts per thousand (ppt) or more commonly % concentrations of salt, such as 3.5 % sea water.

Conductivity	Resistivity
0.01 µS	100 MΩ
0.055 µS	18.0 MΩ
0.1 µS	10 MΩ
1 µS	1 MΩ
10 µS	0.1 MΩ
100 µS	0.01 MΩ
1 mS	1 kΩ

Total Suspended Solids (TSS) and Total Dissolved Solids (TDS)

Suspended Solids measurements are traditionally determined by filtering a measured volume of water – usually 1 liter. Solids captured by a filter are deemed "suspended solids". The water that passes thru (filtrate) is oven dried and the residue that remains is called "dissolved solids". Both are usually measured as mg/L or ppm. Unfortunately, drying of the filtrate to complete evaporation is a long process and requires heating. TDS (conductivity multiplied by a TDS factor) can be used as a quick, inexpensive alternative method. TDS as measured with a conductivity meter will correspond to the dissolved ionic content that is often a useful approximation for the total dissolved material.

There are limitations when using TDS. First, a TDS factor used is salt specific so if there are multiple or unknown salts in solution, it's nearly impossible to determine the ideal factor to use. Second, since ionic concentrations are not linear, the TDS factor changes with concentration. Also, TDS is not preferred for low measurements.

Temperature Compensation and Coefficient

Conductivity is greatly influenced by temperature. Most fluids increase in conductivity as temperature increases. Most ionic solutions will increase about 2 % for each 1 °C increase. Unfortunately, this temperature coefficient (TC) is not always. In the case of high resistance water it can be closer to 5 % or so per °C.

Many instruments adjust the conductivity value based on a TC and display a value that is said to be corrected or normalized to 25 °C. The meter will automatically make corrections to the reading and display a value as if the sample was 25 °C, no matter what the actual temperature is. Some instruments use a fixed TC of 2.0 % per °C. Let us consider a meter that uses 2.0 % TC to measure a 1413 µS standard at 25 °C (77 °F). If the standard is warmed to 30 °C (86 °F), the meter applies a correction of 5 degrees x 0.02 % x 1413 µS = 141.3. Without correction (0.0 % TC) the actual value of a 1413 µS standard of KCl at 30 °C (86 °F) is 1548 µS. As the meter corrects for temperature, it displays a value of 1548 µS minus 141.3 µS = 1407 µS. When the sample cools to 25 °C, it will again read 1413 µS as no correction is applied. Although conductivity cell response is immediate, temperature corrected values will fluctuate as the temperature measurement stabilizes. Advanced meters offer adjustable TC's, usually from 0.0 % to as much as 10 % per °C.

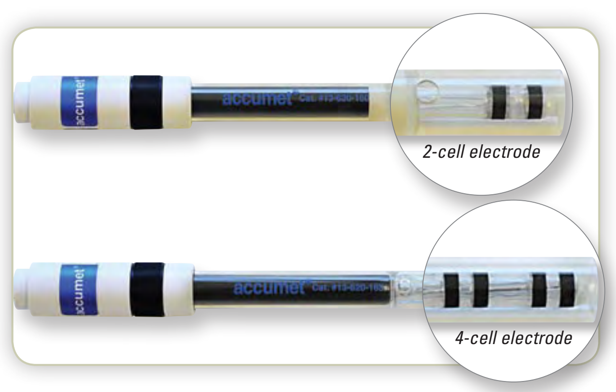
Calibration and Maintenance

Conductivity systems should be calibrated to certified solution standards before using. When selecting a standard, choose one that has the approximate conductivity of the solution to be measured. Unlike pH, conductivity cells generally change less over time and therefore do not require as frequent calibration.

A polarized or fouled electrode must be cleaned to renew the active surface of the cell. In most situations, hot water with a mild liquid detergent is an effective cleanser. Alcohol easily cleans most organic matter, and chlorine solutions will remove algae, bacteria or molds. To prevent cell damage, abrasives or sharp objects should not be used to clean an electrode. A cotton swab works well for cleaning but care must be taken not to widen the distance of cell.

2-Cell Vs. 4-Cell

Most conductivity meters use a 2-cell electrode. The electrode surface is usually platinum, titanium, gold-plated nickel, or graphite. The 4-cell electrode is more expensive and uses a reference voltage to compensate for any polarization or fouling of the electrode plates. The reference voltage ensures that measurements indicate actual conductivity independent of electrode condition, resulting in higher accuracy.



Advanced Meter Features To Consider

- **Adjustable TDS Conversion Factor**
  When a solution does not have a similar ionic content to natural water, the ability to adjust the TDS conversion factor will enable improved accuracy.

- **Adjustable Temperature Coefficients**
  Allows for the precise manipulation of the temperature compensation levels for improved results at various temperatures.

- **Multiple Cell Constants**
  Allows use of additional electrodes for best results – usually low or high ranges.

"Both table salt and sugar dissolve easily in water. However, since sugar molecules don't dissociate there is no charge and they can't be detected with an electrical conductivity/TDS meter."

About Dissolved Oxygen Measurement

A Practical Approach To Achieve Best Results

Dissolved Oxygen

» What is Dissolved Oxygen?

Dissolved Oxygen (DO) is a measure of the amount of dissolved gaseous oxygen in a solution. Some gases, such as ammonia, carbon dioxide and hydrogen chloride, react chemically with water to form new compounds. However, gases such as nitrogen and oxygen merely dissolve in water without chemically reacting with it, and exist as microscopic bubbles between water molecules.

There are two main ways in which dissolved oxygen occurs naturally in water: From the surrounding atmosphere, where oxygen in the surrounding air dissolves readily when mixed into water, up to saturation, during water movements; Via photosynthesis when oxygen is produced by aquatic plants and algae as a by-product of photosynthesis. The amount of oxygen dissolved in water is usually measured in percent saturation, or expressed as a concentration in milligrams per litre water. Accurate measurement of dissolved oxygen is essential in processes where oxygen content affects reaction rates, process efficiency or environmental conditions, such as biological wastewater treatment, wine production, bio-reactions, environmental water testing.

» Basic Principle in DO Measurement

In theory, the amount of DO in a solution is dependent on three factors, namely temperature, salinity and atmospheric pressure.

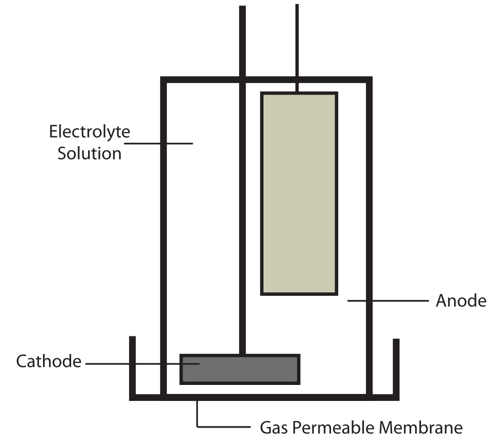
1. **Water Temperature**
   Solubility of oxygen reduces as temperature increases. Hence, the colder the water, the more dissolved oxygen it contains. Since temperature affects both the solubility and diffusion rate of oxygen, temperature compensation is necessary for any standardized DO measurements.

2. **Salinity**
   The amount of dissolved oxygen increases as salinity level decreases. In other words, freshwater holds more oxygen than saltwater. Since the presence of dissolved salts limits the amount of oxygen that can dissolve in water, the relationship between the partial pressure and concentration of oxygen varies with the salinity of the sample.

3. **Atmospheric Pressure**
   There is a direct proportional relationship between the solubility of dissolved oxygen and the surrounding atmospheric pressure. As pressure decreases with increase in altitude, the amount of dissolved oxygen found in water reduces.

   To ensure that your dissolved oxygen is not affected by atmospheric pressure, most instruments include barometric pressure compensation. Advanced meters include a built in barometer that measures and adjusts automatically. However, basic meters will make adjustments only after the user inputs the appropriate pressure manually. Atmospheric pressure correction charts included in with certain instrument manuals are also a helpful reference.

» DO Electrodes



The measurement of DO requires a special DO electrode that is made up of an anode, a cathode, electrolyte solution and a gas permeable membrane. The material of the membrane is specially selected to permit oxygen to pass through. Oxygen is consumed by the cathode which will create a partial pressure across the membrane. Oxygen then diffuses into the electrolyte solution. In short, a DO meter actually measures the pressure caused by movements of oxygen molecules in water or any other medium. The higher the partial pressure of the oxygen in solution, the higher the oxygen concentration. Currently, galvanic and polarographic electrodes are the predominant methods for measuring dissolved oxygen.

The Galvanic Cell consists of two metals, the positive anode and the negative cathode, connected by a salt bridge between the individual half-cells. As the metal electrodes leave electrons behind as they dissolve in the electrolyte. The different properties of the two metals causes them to dissolve at different rates, hence a potential is created when the number of electrons in either side of the cell differs. The potential is translated into an electric current proportion to the oxygen concentration in the electrolyte if an electrical circuit is created between the two electrodes. The galvanic electrode does not need polarising time and is able to assume operation immediately.

During this process, ions of the more active anode are transferred through the electrolyte to the less active cathode, and deposited there as a plating. In this way the anode is corroded. When the anode material eventually corrodes away, the potential drops and the current halts.

The Polarographic Cell consists of two electrodes placed in the electrolyte: One with fixed potential called the reference electrode, and the other with a variable potential called the polarizable electrode. As voltage is applied to the polarizable electrode, a redox reaction occurs, where electrons break away from the electrode to bond with oxygen in the electrolyte. The rate at which the electrons break away from the polarizable electrode is linearly proportionate to the amount of oxygen available in the electrolyte, hence this movement of electrons is representative of the amount of dissolved oxygen left in the electrolyte.

The advantage of a polarographic cell is that the cathode remains intact. The current flow of the polarographic cell is also linearly proportional to the amount of oxygen present in the electrolyte, enabling the cell to provide highly accurate measurements at low oxygen levels.

» BOD & COD

The BOD test measures the molecular oxygen utilized in the biodegradation of organic material and the oxidation of inorganic material. By measuring the amount of oxygen dissolved in samples at the beginning and end of a specified incubation period, the relative oxygen requirements of wastewaters, effluents, and polluted waters can be determined.

$$BODt\ (mg/L) = \frac{D1 - D2}{P}$$

BODt = Oxygen uptake during incubation period t

D1 = DO of diluted sample immediately after preparation (mg/L)

D2 = DO of diluted sample after incubation period t (mg/L)

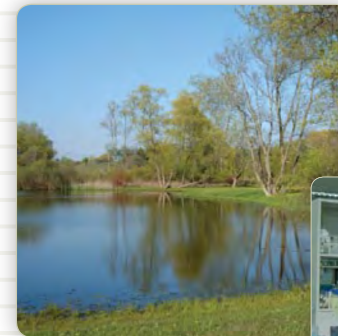
P = Decimal volumetric fraction of sample used

BOD is similar to the Chemical Oxygen Demand (COD), which also measures relative oxygen-depletion. However, the possible presence of non-biologically oxidizable may render the COD test to be less accurate.

The COD test is often used to measure the amount of organic compounds in water by measuring the amount of oxygen required to oxidize and break down an organic compound into carbon dioxide, ammonia and water. The basis of the COD test is to determine what can be oxidized into carbon dioxide using a strong oxidizing agent in acidic environments. A blank sample, created by adding all reagents to distilled water is usually used as a control in COD measurements.

Both the BOD and COD tests are means to measure the relative oxygen-depletion effect of a waste contaminant, and are widely used to monitor pollution levels. The BOD test measures the oxygen demand of biodegradable pollutants whereas the COD test measures the oxygen demand of biogradable pollutants plus the oxygen demand of non-biodegradable oxidizable pollutants.

COD measures everything that can be chemically oxidized and not just the level of biologically active matter that BOD measures. This is especially important to keep in mind when understanding and comparing COD and BOD results that may contain non-biological oxidizable components.



Dissolved Oxygen

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