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Equipment – Guide to Choosing a Meter

A REAGECON GUIDE

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1.0 Equipment – Guide to Choosing a Meter

1.1 Measuring Instruments

Choosing a pH or Conductivity meter to meet your requirements
With over 100 brands of pH & Conductivity meter available on the market today choosing a pH meter that is suitable for your application has never been more difficult. Each brand of meter may have at least 8 models to choose from with varying degrees of specification and features, leaving you the unenviable task of choosing the correct type of meter for your particular application.

In order to simplify the task of choosing a meter for your application the first thing to consider is where exactly are you going to take the majority of your measurements? The following are some common scenarios of where pH & Conductivity are measured.

Some examples of places where pH is measured

- By a river side
- A lakeshore measurement
- In an effluent stream
- A quick reading in a food process vessel
- On a boat offshore at a specific depth
- At site in a chemical plant from a reaction vessel that has had a sample removed
- A sample above ambient temperature
- A sample below ambient temperature
- Pharmaceutical raw material samples
- Food samples that are semisolid
- A waste stream from a plant containing highly alkaline constituents
- Ultra pure water in a plant that produces semiconductor material
- Online in a wastewater stream
- In situ in a process vessel
- A HPLC vial prior to injection
- A micro-titre plate where 0.2 of a millilitre of sample is available
- On line in an effluent treatment plant where neutralisation is required
- In an laboratory with FDA or ILAB accreditation
- A low ionic water sample from a power station

1.2 Fitness for Purpose

The environment determines the type of meter that is suitable a particular application
From the examples given above we can clearly begin to see that the whereabouts of the measurement is by far the most important factor in choosing a meter for your application. The type of sample being measured will to a great extent determine the type of sensor you should attach to the meter. Sensors for measurement are covered in another section of this document.

Different requirements of users
People with little knowledge of chemistry or laboratory instrumentation often do measurements of pH & Conductivity. The requirement for these people is not to know the exact reading to three decimal places,

rather they need to know quickly and easily how their process is doing. The advantage of process people taking measurements is that they can very quickly get a reading and react much quicker to changes in the process. The length of time required to take a sample, bring it to the laboratory, log it in, carry out a detailed instrument calibration and subsequently to report a result is prohibitive for many process personnel.

Ease of use is tantamount to such personnel. A meter with the minimum level of functionality is required. The ability to calibrate outside the typical laboratory environment with standards that are portable is ideal. The meter used has to be lightweight and may even fit into a breast pocket. Measurements may be taken near extremes of temperature so a robust system is essential. The operator may be taking a measurement in a large vat or process vessel so the meter may need to be waterproof or indeed if it is dropped into a vessel it should float rather than sink to the bottom. Often the process person is measuring at non-ambient temperatures so the facility of automatic temperature compensation (ATC) is desireable.

The traditional distinction between portable meters and laboratory bench-top meters has become blurred. The performance of a hand held instrument if used in a way that adheres to good laboratory practice could be as good as any measurement made in the laboratory.

As with any sector of industry, laboratory apparatus in general is getting smaller. Microchips and the boards onto which they are mounted are only a fraction of the size they were only a few years ago. In general meters have become smaller in dimension and lighter in weight. The functions contained in a hand held meter can now match a laboratory bench-top meter.

It is now possible for an operator, engineer or chemist to make a measurement away from the laboratory that is both accurate and precise. To have all testing centralised in the laboratory is no longer always a necessity. To have every sample tested in a central laboratory with expensive bench-top apparatus and highly trained personnel is no longer required. The advantages of this shift in work practice are obvious. Readings can be taken immediately on site and the results acted upon immediately if necessary. No time delay is incurred for process or field personnel waiting for the laboratory to report results. No change or deterioration can occur in the sample if tested immediately after sampling. The laboratory bench space and the time of the laboratory based analyst can be used for analysis of a more sophisticated nature that truly requires a laboratory environment. It is now common practice to measure many parameters outside of the laboratory such as:

- Conductivity
- Ammonia
- pH
- TOC
- Sulphate
- Chloride
- Fluoride
- Nitrate
- Heavy metals
- Turbidity

Conversely many instruments that are now used in the field are found in the laboratory. The quality and functionality of this new portable breed of apparatus is such that it can meet all of the requirements of traditional laboratory based instruments.

The specification of portable meters is now equivalent in many respects to that of bench-top meters

The following table compares the specification of a modern hand held meter to that of a modern GLP compliant bench-top meter

Specification	***Eutech Hand Held Cyberscan pH 300 Meter***	***Schott GLP Compliant CG 843 Bench-top meter***
pH range	-2.00 to 16.00	-2.00 to 16.00
Resolution	0.01 pH	0.001 pH
Accuracy	± 0.01 pH	± 0.005 pH
Temperature range	0.0 °C to 100 °C	-5.0 °C to 100 °C
Temperature resolution	0.1 °C	0.1 °C
Temperature accuracy	± 0.3 °C	± 0.1 °C
Millivolt range	- 2000 to + 2000	- 2000 to + 2000
Millivolt resolution	1.0 mV	0.1 mV
Millivolt accuracy	± 2 mV	± 0.4 mV
No. of buffer values	Up to 6	Up to 3
Date & time	Yes	Yes
Dimensions	199 X 100 X 60 mm	285 X 240 X 85 mm
Weight	320 grams	1300 grams

As bench top meters represent a greater capital outlay it is important to think not only of your current requirements but also of requirements you may have in the future. By way of example you may choose a bench top meter without an RS 232 port and discover at a later date that you need to print your results or down load them to a laboratory information management system. The cost of retro fitting this RS 232 function may be more than the initial purchase price. Fitness for purpose for today's requirements is normally easy to identify. Future requirements however are not so easy to predict. As a general rule of thumb you can assume in the future that the demand for GLP compliance will be greater. The presence of more GLP functions however should not make an instrument difficult to use. It is important to choose a meter that is both GLP compliant for your application and also easy to operate for everyone in your laboratory.

1.3 Selection Of The Most Appropriate Model

When choosing a bench top pH meter what features are of interest? The following are a list of features available on bench top pH meters with a brief description of the benefit this feature represents

Resolution 0.01 pH This resolution is adequate for more than 99% of applications

Accuracy ± 0.01 pH — carried out in the laboratory

Resolution 0.001 pH
Accuracy ± 0.005 pH

While many meters offer three decimal place resolution it is worth bearing in mind that in order to measure to 3 decimal places you need to be able to read the temperature of your sample and your buffer standards to a accuracy of greater than 0.1 °C. In practice thermosetting your buffer standards to a specific temperature perhaps 20°C or 25°C is the most accurate way of achieving a three decimal place calibration. On a day to day basis this methodology is highly in practical. Only research or development analysts normally require this kind of accuracy.

Temperature Range
-5.0°C to 100.0°C
Accuracy ± 0.1°C

This temperature range covers most laboratory applications from low temperature through ambient and up to high temperature measurements. The accuracy of greater than ± 0.1°C is adequate for pH measurements of accuracy to three decimal places. If you are measuring at the extremes of this temperature range bear in mind that not every electrode is capable of measuring pH at these extremes.

Drift Control

In order to ensure that you achieve reproducible readings some meters have drift control. When the electrode is measuring the meter will indicate on the display that the drift is OK. Drift is expressed as mV per minute and reflects the stability of your reading. Normally when the reading of pH is drifting less than 2 mV per minute the meter indicates that it is OK to report the reading when measuring a sample or accept the standard while calibrating with a buffer. A meter that takes a long time to accept a sample or buffer reading normally has a problem with its electrode. In this respect drift control can be a good indicator of electrode response time. A good working electrode should settle down in less than 15 seconds for a stable sample or buffer standard.

Two or three point calibration

You need to consider if the meter can perform a two or three point buffer calibration.
If all of your samples are within the pH range of 5.10 to 6.80 then buffers 4.00 ± 0.01 and 7.00 ± 0.01 at 20°C or 25°C are fine. This is known as a "2 buffer calibration" or a "two point calibration".

If your samples vary in pH from 4.20 to 9.50 then you can consider a "three point calibration" using buffers 4.00 ± 0.01, 7.00 ± 0.01 and 10.00 ± 0.01 at 25°C or 20°C.

Perhaps all your samples are acidic e.g. pH range 2.50 to 3.10, then consider using a two point calibration using buffers 3.00 ± 0.01 and 7.00 ± 0.01 at 25°C or 20°C.

For alkaline samples of the range pH 8.50 to 9.80 use buffers 10.00 ±0.01 and 7.00 ± 0.01 at 25°C or 20°C
In each case above you are using buffers that bracket the range of the samples you are measuring.

Buffer recognition

All bench top pH meters have buffer sets pre programmed into the system memory. These can be buffers according to DIN, NIST or buffers prepared by the pH meter manufacturer. In addition you may have the option of telling the pH meter which buffer standard you are using. You need to know

1. What buffers values the meter recognises?
   (4.00, 4.01, 7.00, 9.18, 10.00 etc) or any nominal value
2. What temperature are these buffer standards quoted at?
   (normally 20 °C or 25°C)

Automatic buffer recognition

Once a buffer set has been programmed (see previous point) the meter may have a function which automatically recognises buffers know as "automatic buffer recognition". Some meters will in addition accept the buffers in any order. This can reduce operator error.

Date and time stamping

If you intend to export data from the meter to a printer or PC it is essential that the meter has a real time clock. Some meters have what is known as a "non volatile memory". This means the clock function is powered by an independently powered battery source within the meter to give you the correct date and time whether the meter is connected to the mains or not.

Electrode inputs

Normally BNC or DIN, these inputs are ideal for combined electrode systems. If you are using a separate sensing and reference system of electrodes you will require a separate reference input on the metre.

Temperature sensor

These can be PT 1000 or 30K NTC. Both these types of sensor inputs have a wide measurement range (0-100°C) and high resolution (0.1°C)

RS232

This is a bi-directional port to send and receive data to a printer or PC

Recorder output

Normally any x, y recorder is compatible.

Electrode stand

Essential for mounting the electrode and temperature sensor

Calibration protocol

This is a sequence the meter enters in to when the "calibration" button is pressed. Ideally the meter should prompt the user to

1. place the electrode in first buffer
2. record the temperature of the buffer
3. indicate that the buffer reading has been accepted
4. place the electrode in the 2nd buffer etc
5. automatically display and or output a value of slope & pH asymmetry
6. automatically store the calibration data in the meter memory

Calibration recall

At any time it should be possible to view the calibration data form the last calibration on the display or as an output to a printer. Calibration printouts can be entered into the instrument logbook.

Results printout

A meter can print results with a date and time stamp

Measurement memory

Results can be stored in the meter memory for viewing or printed at a later stage.
This function prompts the user every day to re-calibrate the attached electrode. This ensures that the instrument logbook is kept up to date at all times with respect to calibration.