pH Buffer Solutions, Selection, Use, Application and Metrology

Author: John Barron, Technical Director, Reagecon Diagnostics Ltd., Shannon Free Zone, Shannon, County Clare, Ireland.

Abstract

Accurate and fit for purpose pH measurement is dependant on a number of factors. The quality of the pH buffers or calibrants is one such factor. Up to now this critical area has received poor attention in the technical and scientific literature. This paper explains in detail what pH buffers are, provides a full best practice calibration procedure using pH buffers and then details exactly, the effects of temperature on the buffers and how to correct the serious impacts of temperature coefficient of variation of the buffers on the overall pH result. However, calibration of the instrument is not the only function of high-quality pH buffers. Such buffers have a role in quality control, method validation and instrument qualification. The detail of a lot of this functionality is outside the scope of this paper, but references are made to relevant publications produced by this author, relating to these areas. However, the role of pH buffers in pH electrode fault identification is covered in some detail and the information provided is based on original work carried out in our laboratory. The characteristics of what constitutes a high-quality pH buffer selection is presented, with particular emphasis on the metrological aspects. This includes traceability, stability, accreditation and certification. This paper concludes with many practical aspects of pH buffer selection, packaging options, specifications and brief information as to how the pH buffers, currently available, have evolved. This paper emphasises that there are many good producers of pH buffers, but because of the involvement of the author with Reagecon and his familiarity with Reagecon's products, these are referenced in some parts of this publication for example purposes and also, to illustrate some of the concepts presented.

What Are pH Buffer Solutions?

pH Buffer Solutions are chemical mixtures, with a known stable hydrogen ion activity, expressed as a pH value. This activity, ideally, should be barely affected by dilution or contamination, but in practice pH values in alkaline buffers can be affected to a significant extent by Carbon Dioxide in the atmosphere. The buffer solutions of the American National Institute of Standards and Technology (NIST) are the basis for the practical pH scale. These are available as calibration standards for precise measurement from Reagecon and all of the buffers from Reagecon are calibrated against NIST Primary Standards. Reagecon buffers typically have a pH accuracy of ± 0.005 pH units up to ± 0.05 depending on value or accuracy required and in nearly all cases, have a shelf life of at least 2 years. Buffer solutions which are colour coded or in capsule (powder) format are also available as are special buffers for low ionic strength pH measurement, and where antimony electrodes are used. These solutions have a number of applications. Principally they are used for the calibration of pH measuring systems, but should also be used for quality control purposes, method validation, instrument qualification, proficiency testing and analyst qualification. Apart from their application in pH measuring systems in laboratories, they can be used in industrial on-line pH measurement or control systems and for calibrating electrodes used in acid/base titrations. In the context of pH measurement, buffers also play another important role, the performance of fault diagnosis of pH electrodes. This is covered later in this paper and in greater detail in another publication from this author[(1)].

Calibration Procedures

For proper calibration the use of two buffer solutions of good accuracy and suitable pH range is an imperative. The first buffer solution should have a pH as close as possible to the electrode zero point which is generally pH 7 and the second solution should have a pH value within the anticipated measuring range. This means if measurements are to be carried out in the acid region the second buffer should have a value of 4 whereas for measurements in the alkaline regions the second buffer should have a value of pH 9 or 10. What is particularly important is that the difference between the two calibration buffers should be at least 2 pH units. Of course, if measurements of extreme pH value are being taken in either the acid or alkaline region then calibration buffers close to these extreme values should be used. A full range of NIST traceable even integer values are available from Reagecon for pH 1 to pH 13 in ready to use format at both 20°C and 25°C. By performing a two-point calibration both zero point and slope are calibrated at the same time. When performing a calibration regime close attention should be paid to the manufacturer's instructions for the particular pH meter, however, the following hints should prove useful:

- Stirring of the solutions gives quicker response. However, it is critical that if stirring is applied, the following rules are observed:
  - If the sample is being stirred, then both the calibration buffers and the control material must be stirred and vice versa.
  - All solutions should be stirred gently and at the same speed. This stirring speed should be written in to procedure for the purpose of comparability.
  - The optimal measurement volume for pH measurement in a laboratory setting is 100mls. A 100ml duran flask, or equivalent, is the optimal container. This is the volume of both calibrant and sample that should be used.
  - In a homogenous sample, the measurement sensor and diaphragm should be immersed about half way down the liquid. The motion of the stirring flea should be gentle, smooth, slow and always in the same direction. The optimal set up for accuracy and precision is to use a temperature-controlled water bath with a submersible stirrer.

The above information relating to stirring applies to homogenous materials, and for such materials, stirring brings significant advantages, is an option and is straightforward. In a laboratory environment however, for accurate measurement, stirring may be mandatory for certain types of samples, such as colloidal materials or where a portion of the sample is insoluble and in suspension. For such samples, stirring is mandatory for accurate measurement, because if the suspension is allowed to settle, the pH value of the supernatant and the settled material may be different, giving rise to erroneous and confusing results. In addition, there may be a very large measurement error at the interface between

the settled material and supernatant, known as a suspension effect. More information on these effects and their significance is presented in a separate paper[2].

- Electrodes should never be rubbed dry, but rinsed with a wash bottle and only dried by gently dabbing with paper, or tissue. Drying will create static charges on the glass membrane resulting in a sluggish response.
- For very accurate work it is recommended to repeat the zero point calibration after slope adjustment.
- For accurate work it is also recommended that the sensor be rinsed with a portion of buffer before immersion into that particular buffer. The same procedure should be carried out with the sample.
- Buffer solutions should be thrown away immediately after use and never poured back into the original bottle, or allowed to lie on the bench, because of the risk of contamination with other liquids, carbon dioxide or vapours from the atmosphere.
- The importance of the effects of temperature on pH measurement has been dealt with in detail elsewhere by this author[3]. However, the actual procedure to minimise the effects of temperature is covered in the next section as it effects buffers. By way of general information though, depending on what temperature the measurement material was at prior to immersion, a longer incubation period may be necessary if a water bath is being used. Ideally, prior to measurement a fully calibrated thermometer should be inserted into the liquid, to ensure that the temperature at the sensing point within the liquid is at the desired temperature. However, this degree of control can only be achieved in a laboratory environment. In any other situation, the regime outlined in the next section, must be adhered to.
- Zero-point and slope stability depend entirely on the nature of the sample solution, its temperature and the required degree of accuracy. No hard and fast rule can be given as to how often one should recalibrate the electrode. In practice, the frequency of recalibration should depend on a history built up by the user on the degree of drift over a period of time. If the solution has never been tried before then it is advisable to recalibrate frequently at the beginning and less frequently if minimal or no variation in pH value is found.
- The meter's drift control function should be enabled, alternatively, the time for the pH value to stabilise should be standardised.
- Keep the electrical parts of the electrode (the cable and connector) dry at all times.
- After the measurement has been completed, remove the electrode from the sample. For short-term storage, suspend the electrode in a pH 4 buffer or for longer term (e.g. overnight) in specially

formulated electrode storage solution - this will ensure the electrode is kept in an optimum condition for rapid response times and to prolong its lifespan.

Effects of Temperature coefficient variation on the calibration buffer or sample

The importance of temperature measurement, when performing pH measurements, has already been mentioned in reference to slope correction. Temperature also has an effect of both pH buffers and samples, as the hydrogen ion activity will increase with increasing temperature. The relationship between buffer value and temperature is described, as the temperature coefficient of variation.

Temperature coefficient of variation of pH buffers

Although, the temperature coefficient of variation of pH buffers may vary only minimally over a wide span of temperatures in the acid region, it may be quite dramatic in the alkaline region. If not corrected for, the consequential error can be substantial in the alkaline region (see Table 1). There are three mechanisms to overcome this temperature coefficient variation:

- The correct pH at a particular temperature may be checked on "lookup" tables on the pH buffer label and the correct value manually inserted into the pH meter at calibration. This approach suffers from the drawback of requiring knowledge of the correct ambient temperature, which can vary quite substantially in a field situation.
- Most modern pH meters have an auto buffer recognition facility, whereby values of pH buffers at various temperatures are stored in memory. Meter standardisation and temperature coefficient of variation correction is therefore automatically done if the correct buffer is used. Meter manufacturers generally specify specific pH buffer types to be used for calibration - for example some pH meters can be calibrated using technical pH buffers or DIN/NIST buffers (values specified at 25°C). Use of the incorrect buffer type can lead to inaccurate calibration and hence incorrect pH measurements.
- The measurement of the sample and the buffers can be done under controlled temperature conditions in a water bath, for example at 20°C or 25°C as detailed earlier. Such an option is generally only available or feasible for very accurate laboratory work.

Temperature effects on the value of pH buffers

Temperature °C	pH 4.00 ± 0.01 @ 25°C	pH 7.00 ± 0.01 @ 25°C	pH 10.00 ± 0.01 @ 25°C
10	4.00	7.07	10.18
15	4.00	7.04	10.14
20	4.00	7.02	10.06
25	4.00	7.00	10.00
30	4.01	6.99	9.95
35	4.02	6.98	9.91
40	4.03	6.97	9.85
50	4.05	6.96	9.78
60	4.08	6.96	9.75

Table 1

The Use of pH Buffers in Electrode Fault Identification

Following extensive original published work carried out in Reagecon, a simple but highly effective fault identification regime for pH electrodes was developed. This has been published elsewhere[(1)], but in the context of pH buffers, a section of the publication is presented here in abbreviated form. This is

done to illustrate an additional use of pH buffers, but also to assist the analyst to improve pH measurement technique. In addition to presenting the fault diagnosis regime as repeated here, the original publication also provides a set of remedial actions[1].

Before beginning any investigation work, always check the following:

- The electrode is connected to the meter and the meter is switched on.
- The electrode connector is plugged into the correct channel on the meter (for multiple input meters)
- The electrode cable and connectors are clean, dry and corrosion free
- The temperature probe is properly connected or the correct temperature is entered manually

To determine if the electrode is the source of the fault, proceed as follows:

- Switch the meter to the millivolt mode (mV) and place the electrode in fresh pH 7 buffer. Allow the electrode to stabilise and note the potential in millivolts.
- Remove the electrode from pH 7 buffer, rinse with purified water and then with pH 4 buffer. Place in fresh pH 4 buffer, allow the electrode to stabilise and observe the potential after one minute and after two minutes.
- From the above readings calculate the Fault Diagnosis Parameters outlined in Table 2.
- Compare the values obtained against those in Table 3 to identify the cause of the fault.

Fault Diagnosis Parameters

Parameter	Calculation	Optimum value
Asymmetry potential (Eo)	mV reading in pH 7.00 buffer	± 25 mV
Slope	mV reading in pH 7.00 buffer - mV reading in pH 4.00 buffer	160 – 180 mV
Drift	mV reading in pH 4.00 buffer (1 min) – mV reading in pH 4.00 buffer (2 min)	± 1.5 mV

Table 2

Identification of common pH electrode faults

Fault Class	Cause	Eo (mV)	Slope (mV)	Drift (mV)
Electrode OK	Electrode and meter OK, problem with sample	± 25	160 - 180	± 1.5
Terminal Electrode Fault	Glass membrane cracked	55-65	<10	± 1.5
	Reference element poisoned	>±25	160 – 180	>±1.5
	Cable/electrical damage: short circuit	± 25	<10	± 1.5
	Aged membrane/old electrode	± 25	50-150	± 1.5
	Cable/electrical damage: open circuit	>±25	<10	>±1.5
Electrolyte Problem	Wrong or contaminated electrolyte	>±25	160 – 180	± 1.5
Soiled Electrode	Membrane/diaphragm coated with sample deposits	>±25	50-150	>±1.5
	Diaphragm blocked	± 25	160 - 180	>±1.5

Table 3

Characteristics of High-Quality pH Buffers

Like almost all analytical measurement techniques, pH measurement is a comparison between known and unknown values. In the case of pH, the known is the buffer or set of buffers (one point or two-point calibration) and unknown, is the sample. Like all analytical techniques the quality and fitness for purpose of the unknown is entirely dependent on the calibrant or known. For the calibrant to be deemed fit for purpose and of appropriate quality, it must be subjected to metrological due diligence. Generally, in metrology particular scrutiny is paid to traceability, stability, accreditation and measurement uncertainty. Broadly, all of these are connected and all are dealt with in great detail in another of this authors publications[4]. Arising out of this metrological scrutiny, specifications, accuracy and shelf life can be assigned and certified. These are the principal metrological parameters of interest in the context of pH measurement.

There are many high-quality producers of pH buffers around the world that score well, in some or all of these parameters. However, for the purpose of expediency and for demonstration purposes, we continue to use the range of products produced by Reagecon, in this publication for example purposes. All of these products were developed by this author, all have been marketed globally for over 30 years and the characteristics, features and benefits are well known to the author. So, the following pages, present in shortened form, some key metrological features of Reagecon's buffers, that include traceability, stability, accreditation and specification. Advice is also offered on packaging options, product options, temperature options and details of some specialty products.

Traceability

Reagecon's pH buffer standards are directly traceable to the IUPAC pH scale by an unbroken chain of traceability. Reagecon achieve this traceability through a series of comparisons, the key reference materials being Standard Reference Materials (SRMs) manufactured by NIST. (See Table 4.)

Traceability of Reagecon's pH Buffers

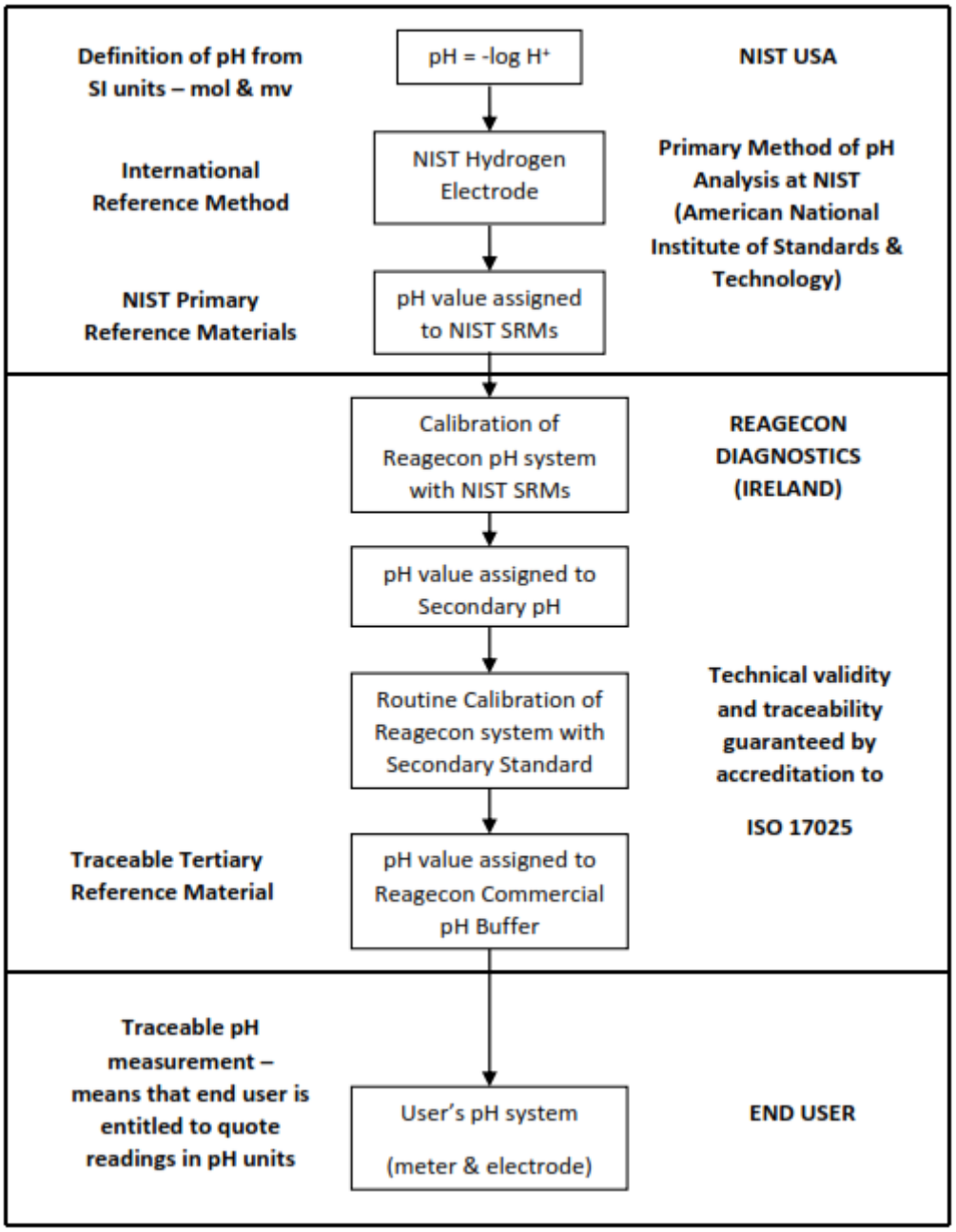


Table 4

For proof of traceability, all of these comparisons must be made in a technically - valid manner and the accuracy of each step must be quantified by calculating the associated Uncertainty of Measurement. Reagecon's pH buffer standards meet the ISO definition of traceability: "The ability to relate measurements back to a stated reference (usually an international standard) through an unbroken chain of comparisons, each having stated uncertainties of measurement." Reagecon's traceability claims are guaranteed by our accreditation to ISO/IEC 17025 (INAB Ref:264T).

Why use traceable pH buffers?

Your pH measurements can only be as good as the pH buffers that you use. If your pH calibration is made using traceable pH buffers then you have a direct link to the International pH scale for your measurements. Without this link, you are not entitled to report your measurements in pH units so the number displayed on your pH meter is just that - a number and is not a pH value. The common link that is achieved by traceability allows comparability of results regardless of:

- When the measurements were made
- Where the measurements were made
- What instrumentation was used to make the measurements

Traceable analysis is necessary for consistency and universal acceptance of your pH results - including acceptance by regulatory bodies.

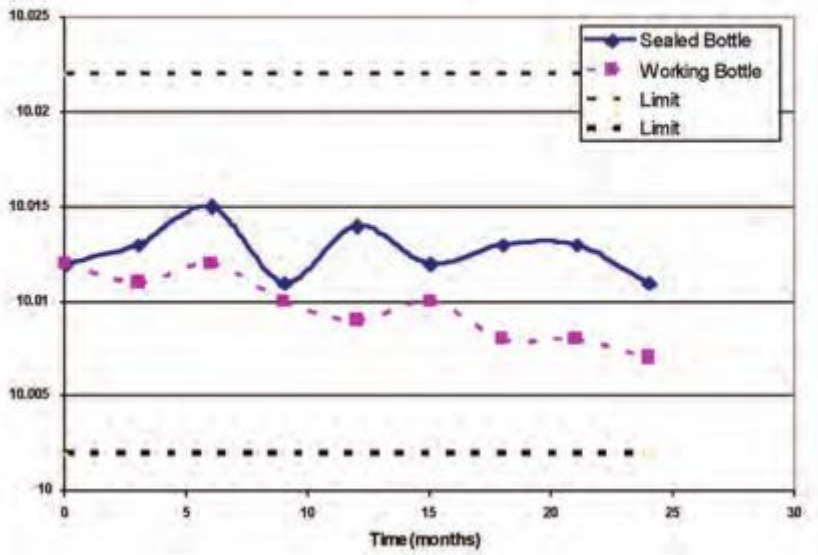
Stability

Reagecon's pH buffers have been specially formulated, to ensure their stability. The packaging bottles that we use have also been selected and tested to provide maximum stability. We have conducted stability trials on both freshly-opened and part-full bottles of our pH buffers to validate their shelf-life - an example is given in Graphic 1. This demonstrates that Reagecon's pH buffers will stay within their specification limits up to the stated expiry date regardless of when the bottle was first opened (provided that the pH buffer is stored and used in accordance with good laboratory practice). Most of Reagecon's pH buffers have an expiry date of either 2 years or 3 years from the date of manufacture.

This means that our pH buffers' expiry dates are an absolute value and they have a long "Active Life". We do not quote a short usage period after opening the bottle and there is no need to record by hand an "Opened on date" and a "Use by date". With Reagecon's pH buffers you just open the bottle and use the contents - with other manufacturers' pH buffers you need to record these extra dates and may need to dispose of most of the contents of the bottle at the end of its short "Active Life".

Reagecon manufacture the most comprehensive range of pH reagents in the world; these are designed to suit all end user requirements. All are supplied with a detailed Certificate of Analysis (see the next section) which outlines traceability to N.I.S.T (the N.I.S.T SRM(s) Lot No. is stated on the certificate). Temperature dependence data is printed on the label as are lot numbers and expiry dates.

Stability Data for Reagecon pH 10.012 @ 25°C



Graphic 1

Accreditation

Reagecon's pH analysis is accredited to ISO/IEC 17025 (INAB Ref:264T) "General requirements for the competence of testing and calibration laboratories". Reagecon's accreditation to ISO/IEC 17025 (INAB Ref:264T) gives independent proof of three key areas:

- Our pH analysis is technically valid and is carried out in a thoroughly controlled manner by highly - qualified staff.
- Our claims over the accuracy of our pH analysis are valid and we have properly quantified our accuracy in our Uncertainty of Measurement calculations.
- Our pH analysis is traceable to NIST SRMs. It is important to note that NIST do not police claims of traceability to their SRMs.

Reagecon's accreditation is indicated by the Irish National Accreditation Board (INAB) accreditation symbol on our Certificates of Analysis for pH Buffers. Accreditation by INAB and all other accreditation boards validated to accredit ISO/IED 17025 (INAB Ref: 264T) are mutually recognised as being directly equivalent.

Why take chances with your pH buffer supplier's traceability? By using buffers from a manufacturer that holds ISO/IEC 17025 (INAB Ref:264T) accreditation you have a guarantee of traceability.

Reagecon

Certificate of Analysis

pH Buffer Solution

Buffer Solution pH 4.00 ± 0.01 @ 20°C

Product No:	1040
Lot No:	M419J1
Expiry date:	28/09/2022
Mean pH value:	4.01 @ 20°C
Date of measurement:	14/11/2019

Specification:
3.99 - 4.01 @20°C

pH Measurement:
The result reported above was determined by analysis of a sample of this lot taken at time of manufacture. Test Method used was TPPHB. Measured with a combination glass electrode after multiple point calibration with reference materials. It is certified traceable to the following National Institute of Standards and Technology (USA). SRM 185i Potassium Hydrogen Phthalate, SRM 186-I-g Potassium Dihydrogen Phosphate and SRM 186-II-g Disodium Hydrogen Phosphate.This certificate relates solely to the lot number given above. The uncertainty of measurement has been calculated not to exceed ± 0.01pH at 95% confidence level, i.e. coverage factor k =2.

Buffer Substance:
Potassium Hydrogen Phthalate.

Accreditation:
Reagecon Diagnostics Ltd. is accredited by the Irish National Accreditation Board, under scope 264T, for the test method, TPPHB, used to generate the above result. This accreditation is intended only to certify that Reagecon has the Quality Management Systems in place to ensure that each individual test result generated using TPPHB is technically valid and is supported by appropriate uncertainty measurements.

Products are manufactured under an NSAI registered I.S EN ISO9001:2015 Quality System, registration no: IE-2758

Date of issue of the certificate: 14/11/2019

QC Technician Orla Sheehan

Complementary information relative to this product is available at www.reagecon.com
Page 1 of 1.This Certificate must not be reproduced except in full. Rev-19L28

Reagecon Diagnostics Ltd.
Shannon Free Zone, Shannon, Co. Clare, Ireland.
Tel +353 01 472022, Fax: +353 01 472042
Email: sales@reagecon.ie, www.reagecon.com

Extensive Range of pH Values

Reagecon manufacture the most comprehensive range of pH reagents in the world; these are designed to suit all end user requirements[5]. These include laboratory grade buffers, the Professional Range (buffer standards as per N.I.S.T/DIN and high-resolution buffers), low ionic strength buffers and pH buffer capsules. We are delighted to have added several new offerings that include buffers to calibrate Antimony electrodes, Sterile Buffers and colour coded pH buffers with a three decimal place specification. All are manufactured to exacting specifications with an extended shelf life and cover the pH range of pH 1.00 to pH 13.00 inclusive. All are supplied with a detailed Certificate of Analysis which outlines traceability to N.I.S.T (the N.I.S.T SRM(s) Lot No. is stated on the certificate). Temperature dependence data is printed on the label as are lot numbers and expiry dates.

Primary and Secondary pH Standards

The buffer solutions of the National Institute of Standards form the basis of the currently used pH scale. These products serve as the primary standards for high precision measurements and all commercially available buffers (secondary standards), including those available from Reagecon are traceable to these primary standards. Various types of buffers have been developed since the initial work carried out by Roger Bates in NIST, which was subsequently adopted by DIN in the German Standard DN 19266. These include but are not exclusive to the following:

- Even integer buffers at values of pH 1.00 to pH 13 and temperatures of 20°C and 25°C. (These are available in many packaging options and some are colour coded for easy recognition.)
- Buffers that are certified at the same values as the NIST primary standards at 20°C.
- Buffers that are certified at the same values as the DIN 19266 buffers which are at 25°C.
- Buffers that are certified in accordance with DIN 19267 at 25°C.
- Even integer buffers that are certified to three decimal places at either 20°C or 25°C.
- Buffers certified at 25°C which are described in the literature, (particularly by countries that follow DIN) as Technical Buffers.
- Low ionic strength buffers, particularly suitable for calibrating the pH measurement system, where low ionic strength samples are being tested.
- Buffers suitable for calibrating antimony pH electrodes.
- Several other options, including pH buffer capsules in solid powder form.

There are several other formats and buffer families described in more detail in the remainder of this document. Buffers for pH calibration as described in the pharmacopoeias are also available from Reagecon, as are several families of buffers, applicable to pH control in such areas as elution in chromatography. Reagecon pH Buffers are pre-programmed into the instruments of most major manufacturers.

Control Buffers

For increased confidence in their test measurements, analysts should regularly measure the pH of a Control Standard. If an acceptable value is obtained from the Control Standard measurement then the analysts, can have improved confidence that their test measurements will be correct. Reagecon's extensive range of pH buffers means that there will be a Reagecon pH buffer which can be used as a control buffer for all pH applications.

The Reagecon Range[5]

pH Buffers @ 20°C

Clear, Colourless pH Buffer Solutions. Tested at 20°C and certified by Reagecon's ISO 17025 (INAB Ref:264T) Accredited Test Method. NIST traceable and presented in various pack sizes.

Description	Product No. 500ml	Product No. 1L	Product No. 5L
pH 1.00 ± 0.02 @20°C	10105	1010	5010
pH 1.20 ± 0.02 @20°C	10125	1012	5012
pH 2.00 ± 0.02 @20°C	10205	1020	5020
pH 3.00 ± 0.02 @20°C	10305	1030	5030
pH 4.00 ± 0.01 @20°C	10405	1040	5040
pH 4.00 ± 0.01 @20°C (Phthalate Free)	CC10405	CC1040	CC5040
pH 5.00 ± 0.01 @20°C	10505	1050	5050
pH 6.00 ± 0.01 @20°C	10605	1060	5060
pH 6.80 ± 0.01 @20°C	10685	1068	5068
pH 7.00 ± 0.01 @20°C	10705	1070	5070
pH 8.00 ± 0.01 @20°C	10805	1080	5080
pH 9.00 ± 0.01 @20°C	10905	1090	5090
pH 9.20 ± 0.01 @20°C	10925	10920	50920
pH 9.22 ± 0.01 @20°C	109220	10922	50922
pH 10.00 ± 0.01 @20°C	11005	1100	5100
pH 11.00 ± 0.05 @20°C	11105	1110	5110
pH 12.00 ± 0.05 @20°C	11205	1120	5120
pH 13.00 ± 0.05 @20°C	11305	1130	5130

pH Buffers @ 25°C

Clear, Colourless pH Buffer Solutions. Tested at 25°C and certified by Reagecon's ISO 17025 (INAB Ref:264T) Accredited Test Method. NIST traceable and presented in various pack sizes.

Description	Product No. 500ml	Product No. 1L	Product No. 5L
pH 1.00 ± 0.02 @25°C	1010525	101025	501025
pH 1.68 ± 0.02@25°C	10168	1016825	5016825
pH 2.00 ± 0.02 @25°C	1020525	102025	502025
pH 2.00 ± 0.02@25°C (Mercury Free)	1020255MF	102025MF	502025MF
pH 3.00 ± 0.02 @25°C	1030525	103025	503025
pH 4.00 ± 0.01 @25°C	1040525	104025	504025
pH 4.00 ± 0.01 @25°C (Phthalate Free)	CC1040525	CC104025	CC504025
pH 5.00 ± 0.01 @25°C	1050525	105025	505025
pH 5.00 ± 0.01 @25°C (Mercury Free)	1050525MF	105025MF	505025MF
pH 6.00 ± 0.01 @25°C	1060525	106025	506025
pH 6.00 ± 0.01 @25°C (Mercury Free)	1060525MF	106025MF	506025MF
pH 6.80 ± 0.01 @25°C	1068525	106825	506825
pH 7.00 ± 0.01 @25°C (Mercury Free)	1070525MF	107025MF	507025MF
pH 7.00 ± 0.01 @25°C	1070525	107025	507025
pH 8.00 ± 0.01 @25°C	1080525	108025	508025
pH 8.00 ± 0.01 @25°C (Mercury Free)	1080525MF	108025MF	5080525MF
pH 9.00 ± 0.01 @25°C	1090525	109025	509025
pH 9.40 ± 0.01 @25°C	1094025	10940251	5094025
pH 10.00 ± 0.01 @25°C	1100525	110025	510025
pH 11.00 ± 0.05 @25°C	1110525	111025	511025
pH 12.00 ± 0.05 @25°C	1120525	112025	512025
pH 13.00 ± 0.05 @25°C	1130525	113025	513025

Colour Coded Buffers @ 20°C

Coloured pH Buffer Solutions. Tested at 20°C and certified by Reagecon's ISO 17025 (INAB Ref:264T) Accredited Test Method. NIST traceable and presented in various pack sizes.

Description	Product No. 30ml	Product No. 100ml	Product No. 250ml	Product No. 500ml	Product No. 1L	Product No. 5L
pH 4.00 ± 0.01 @20°C (Red)	1040C030	1040C100	10402C	10405C	1040C	5040C
pH 7.00 ± 0.01 @20°C (Yellow)	1070C030	1070C100	10702C	10705C	1070C	5070C
pH 9.00 ± 0.01 @ 20°C (Blue)	1090C030	1090C100	10902C	10905C	1090C	5090C
pH 10.00 ± 0.01 @20°C (Blue)	1100C030	1100C100	11002C	11005C	1100C	5100C

Colour Coded Buffers @ 25°C

Coloured pH Buffer Solutions. Tested at 25°C and certified by Reagecon's ISO 17025 (INAB Ref:264T) Accredited Test Method. NIST traceable and presented in various pack sizes.

Description	Product No. 500ml	Product No. 1L	Product No. 5L
pH 4.00 ± 0.01 @25°C (Red)	1040525C	104025C	504025C
pH 4.00 ± 0.01@ 25°C (Red) (Mercury Free)	1040525CMF	104025CMF	504025CMF
pH 7.00 ± 0.01 @25°C (Yellow)	1070525C	107025C	507025C
pH 7.00 ± 0.01@25°C (Yellow)(Mercury Free)	1070525CMF	107025CMF	507025CMF
pH 10.00 ± 0.01 @25°C (Blue)	1100525C	110025C	510025C
pH 10.00 ± 0.01@ 25°C (Blue) (Mercury Free)	1100255CMF	110025CMF	510025CMF

Twin Neck Bottle Format

pH Buffers are available in an attractive and innovative twin neck bottle.

The main advantages of this packaging are:

- No possibility of contamination
- No need for separate measuring container for use in the calibration of the Electrode
- Correct quantity of buffer required for calibration is dispensed into the calibrating chamber giving rise to no waste
- Ideally suited for field work
- Easy to carry
- 250ml, 500ml and 1L sizes available

Twin Neck Bottle Format @ 20°C

Coloured pH Buffer solutions in twin-neck containers with integrated calibrating chamber. Tested at 20°C and certified by Reagecon's ISO/IEC 17025 (INAB Ref:264T) Accredited Test Method. NIST traceable and presented in various pack sizes.

Description	Product No. 250ml	Product No. 500ml	Product No. 1L
pH 4.00 ± 0.01 @20°C (Red)	10402CTT	10405CTT	1040CTT
pH 7.00 ± 0.01 @20°C (Yellow)	10702CTT	10705CTT	1070CTT
pH 9.00 ± 0.01 @ 20°C (Blue)	10902CTT	10905CTT	1090CTT
pH 9.22 ± 0.01 @20°C	1092202TT	1092205TT	10922CTT
pH 10.00 ± 0.01 @20°C (Blue)	11002CTT	11005CTT	1100CTT

Twin Neck Bottle Format @ 25°C

Coloured pH Buffer solutions in Twin-neck containers with integrated calibrating chamber. Tested at 25°C and certified by Reagecon's ISO/IEC 17025 (INAB Ref: 264T) Accredited Test Method. NIST traceable and presented in various pack sizes.

Description	Product No. 500ml
pH 1.00 ± 0.02 @25°C	1010525TT
pH 2.00 ± 0.02 @ 25°C	1020525TT
pH 4.00 ± 0.01 @25°C (Red)	1040525CTT
pH 6.86 ± 0.01 @25°C (Yellow)	1068805CTT
pH 6.865 ± 0.01 @25°C	106865TT
pH 7.00 ± 0.01 @25°C (Yellow)	1070525CTT
pH 9.00 ± 0.01 @25°C	1090525TT
pH 9.18 ± 0.01@25°C (Blue)	109180CTT
pH 9.18 ± 0.01 @25°C	109180TT
pH 9.21 ± 0.01 @ 25°C (Blue)	1092125CTT
pH 9.21 ± 0.01 @ 25°C	1092125TT
pH 10.00 ± 0.01 @25°C (Blue)	1100525CTT
pH 12.00 ± 0.05 @25°C	1120525TT

pH Buffer Standards NIST Values @ 20°C

Clear, Colourless NIST Value pH Buffer Solutions. Tested at 20°C and certified by Reagecon's ISO/IEC 17025 (INAB Ref:264T) Accredited Test Method. NIST traceable and presented in 500ml bottles. Other pack sizes available upon request.

Description	Product No.500ml
pH 1.675 ± 0.010 @20°C	101675
pH 1.677 ± 0.010 @20°C	101677
pH 3.788 ± 0.010 @20°C	103788
pH 4.001 ± 0.010 @20°C	104001
pH 6.881 ± 0.010 @20°C	106881
pH 7.429 ± 0.010 @20°C	107429
pH 9.225 ± 0.010 @20°C	109225
pH 10.062 ± 0.010 @20°C	110062
pH 12.627 ± 0.050 @20°C	112627

pH Buffer Standards DIN 19266 Values @ 25°C

Clear, Colourless DIN Value pH Buffer Solutions. Tested at 25°C and certified by Reagecon's ISO/IEC 17025 (INAB Ref:264T) Accredited Test Method. NIST traceable and presented in 500ml bottles. Other pack sizes available upon request.

Description	Product No. 500ml
pH 1.679 ± 0.010 @25°C	101679
pH 3.776 ± 0.010 @25°C	103776
pH 4.005 ± 0.010 @25°C	104005
pH 6.865 ± 0.010 @25°C	10687
pH 7.413 ± 0.010 @25°C	107413
pH 9.180 ± 0.010 @25°C	109180
pH 10.012 ± 0.010 @25°C	110012
pH 12.454 ± 0.050 @25°C	112454

pH Buffer Standards DIN 19267 @ 25°C

Description	Product No. 500ml
pH 1.09 @25°C	101095
pH 3.06 @25°C	103065
pH 4.65 @25°C	104655
pH 6.79 @25°C	106795
pH 9.23 @25°C	109235
pH 12.75 @25°C	112755

High Resolution Buffers

Coloured High-Resolution pH Buffer solutions. Tested at 20°C or 25°C and certified by Reagecon's ISO/IEC 17025 (INAB Ref:264T) Accredited Test Method. NIST traceable and presented in 500ml bottles. Other pack sizes available upon request.

Description	Product No. 500ml
pH 4.000 ± 0.010 @20°C (Red)	104000C
pH 4.000 ± 0.010 @25°C (Red)	H40525C
pH 4.000 ± 0.010 @25°C	H40525
pH 7.000 ± 0.010 @20°C (Yellow)	107000C
pH 7.000 ± 0.010 @25°C (Yellow)	H70525C
pH 7.000 ± 0.010 @25°C	H70525
pH 10.000 ± 0.010 @20°C (Blue)	110000C
pH 10.000 ± 0.010 @25°C (Blue)	H100525C

Antimony Buffers

Description	Product No. 250ml	Product No. 500ml
pH 1.07 @25°C - Colourless	10725025	10725050
pH 4.00 ± 0.05 @25°C - Light Red	401025P	40102550
pH 7.01 at 25°C - Yellow	70125025	70125050

Technical pH Buffer Solutions @ 25°C

Coloured Technical pH Buffer solutions. Tested at 25°C and certified by Reagecon's ISO/IEC 17025 (INAB Ref:264T) Accredited Test Method. NIST traceable and presented in various pack sizes.

Description	Product No. 250ml	Product No. 500ml	Product No. 1L
pH 2.00 ± 0.02 @25°C (Coloured)	TB2002	TB200	TB2001
pH 4.01 ± 0.02 @25°C (Coloured)	TB4012	TB401	TB4011
pH 4.60 ± 0.02 @25°C (Coloured)	TB4602	TB460	TB46001
pH 7.00 ± 0.02 @25°C (Coloured)	TB7002	TB700	TB7001
pH 9.21 ± 0.02 @25°C (Coloured)	TB9212	TB921	TB9211
pH 10.00 ± 0.02 @25°C (Coloured)	TB1002	TB100	TB1001

Low Ionic Strength Buffers

Low Ionic Strength pH Buffer Solutions. Special buffers suitable for accurate measurement of low ionic strength samples. Tested at 20°C and certified by Reagecon's ISO/IEC 17025 (INAB Ref:264T) Accredited Test Method. NIST traceable and presented in various pack sizes.

Description	Product No. 500ml	Product No. 5L
pH 4.10 ± 0.04 @20°C	LS41	LS415
pH 6.96 ± 0.04 @20°C	LS69	LS695

Bag in Box – Colour Coded @ 20°C

Coloured, Bag in Box pH Buffer solutions supplied in cubitainers with tap. Tested at 20°C and certified by Reagecon's ISO/IEC 17025 (INAB Ref: 264T) Accredited Test Method. NIST traceable and presented in various pack sizes.

Description	Product No. 5L	Product No.10L
pH 4.00 ± 0.01 @20°C (Red)	BPH01	BPH02
pH 6.00 ± 0.01 @20°C (Clear)	BPH34	BPH35
pH 7.00 ± 0.01 @20°C (Yellow)	BPH03	BPH04
pH 10.00 ± 0.01 @20°C (Blue)	BPH05	BPH06

Bag in Box – Colour Coded @ 25°C

Coloured, Bag in Box pH Buffer solutions supplied in cubitainers with tap. Tested at 25°C and certified by Reagecon's ISO/IEC 17025 (INAB Ref:264T) Accredited Test Method. NIST traceable and presented in various pack sizes

Description	Product No. 5L	Product No. 10L
pH 4.00 ± 0.01 @25°C (Red)	BPH07	BPH08
pH 7.00 ± 0.01 @25°C (Yellow)	BPH09	BPH10
pH 10.00 ± 0.01 @25°C (Blue)	BPH11	BPH12

pH Buffer @ 20°C – Bag in Box (Colourless)

Description	Product No. 5L
pH 1.675 ± 0.01 @20°C	BPH97
pH 4.00 ± 0.01 @20°C	BPH43
pH 4.66 ± 0.01 @20°C	BPH113
pH 5.00 ± 0.01 @20°C	BPH105
pH 6.881± 0.01 @20°C	BPH99
pH 7.00 ± 0.01 @20°C	BPH22
pH 8.00 ± 0.01 @20°C	BPH48
pH 9.00 ± 0.01 @20°C	BPH32
pH 9.225 ± 0.01 @20°C	BPH100
pH 10.00 ± 0.01 @20°C	BPH44
pH 11.00 ± 0.05 @20°C	BPH63

pH Buffer @ 25°C – Bag in Box (Colourless)

Description	Product No. 5L
pH 1.00 ± 0.02 @25°C	BPH27
pH 1.679 ± 0.01 @25°C	BPH90
pH 2.00 ± 0.02 @25°C	BPH13
pH 3.776 @25°C	BPH91
pH 4.00 ± 0.01 @25°C	BPH21

Sterile Buffers

pH Buffer Solutions sterilised by gamma irradiation.

Description	Product No. 500ml
pH 4.00 ± 0.01 @20°C (Sterile)	104005S
pH 6.00 ± 0.01 @20°C (Sterile)	106005S
pH 7.00 ± 0.01 @20°C (Sterile)	107005S
pH 8.00 ± 0.01 @20°C (Sterile)	108005S

pH Buffers @ 38°C

Description	Product No. 1L
pH 4.00 ± 0.01 @ 38°C	104038
pH 6.00 ± 0.01@38°C	106038
pH 7.00 ± 0.01@ 38°C	107038
pH 8.00 ± 0.01 @ 38°C	108038

pH Buffer Capsules

The presentation of pH buffers in capsule format is an innovative concept developed by Reagecon. Tested at 25°C, NIST Traceable. These capsules offer the following advantages:

- Colour coded for ease of identification
- Easy to use
- Dissolve quickly
- Accuracy ±0.02 pH units
- Preservative free
- Economical
- Easy to store and transport
- Extended shelf life

To use: Empty contents of one capsule into 100ml of distilled water.

Description	Product No. Pack of 50 Capsules
pH Buffer Capsules pH 4.01 ± 0.02 @25°C (Red)	CP1040
pH Buffer Capsules pH 7.00 ± 0.02 @25°C (Green)	CP1070
pH Buffer Capsules pH 9.00 ± 0.02 @25°C (Purple)	CP1090
pH Buffer Capsules pH 10.00 ± 0.02 @25°C (Blue)	CP1100
pH Buffer Capsule Kit (10 x pH 4.01, 20 x pH 7.00, 10 x pH 9.00, 10 x pH 10.00 @25°C)	CPMX47910
pH Buffer Capsule Kit (10 x pH 4.01, 20 x pH 7.00, 10 x pH 9.00 & 10 x pH 10.00)	CPMX
pH Buffer Capsule Kit (10 x pH 4, 10x pH 7, 10x pH 10 & 2 x Universal Indicator)	CPMX4710-UNI
pH Buffer Capsule Kit (3 x pH 4, 3x pH 7, 3x pH 10 & 1 Universal Indicator)	CPMX4710-UNI/1
pH Buffer Capsule Kit (20 x pH 4.01, 20 x pH 7.00, 10 x pH 9.00)	CPMX479

RECAL – Single Use Calibration Buffers (Colour Coded)

RECAL is a range of pH Buffers in a wide mouth disposable container which can be used for direct calibration of the electrode and then discarded after use. We offer a range tested at both 20°C and 25°C. RECAL offers the following advantages:

- Tested and Certified by Reagecon's ISO 17025 (INAB Ref:264T) Accredited Test Method.
- Convenience - saves time, more efficient calibration, avoids waste and spillage.
- Mobility - These are easy to store and transport, allowing calibration in the field or directly in the plant.
- Economical - No waste buffer, beaker not required.
- Accuracy - the possibility of contamination is eliminated giving increased confidence in the results.
- Traceability - Each container is labelled with lot number and expiry date and buffers are directly traceable to N.I.S.T. Standards

Description	Product No. 6 x 90ml @ 20'C	Product No. 6 x 90ml @ 25'C
pH 4.00 (Red) ± 0.01	04C60	04C65
pH 7.00 (Yellow) ± 0.01	07C60	07C65
pH 9.00 (Clear) ± 0.01	09C60	09C65
pH 10.00 (Blue) ± 0.01	10C60	10C65
Recal mixed pack of 2xpH 4, 7 & 10 ± 0.01	MXC60	MXC65
Recal mixed pack of 2xpH 4, 7 & 9 ± 0.01	MX09C60	MX09C65

Conclusion

Ultimately, the measurement of pH that is fit for purpose, depends on four key factors: the instrument, electrode, environment and the pH buffers. In the literature in general, less attention has been paid to either the correct use, selection, or metrology of the pH buffers. In fact, in some cases these elements have been taken for granted. It is hoped that the various elements that contribute to the production, use and selection of pH buffers and how pH buffers impact the whole measurement experience has been covered in this publication. It is hoped, therefore, that by using, or being aware of the impacts these elements of pH buffers, will lead to an easier and fit for purpose pH measurement experience.

Bibliography

1. Barron, J., Ashton, C., Geary, L., 2006. “Care, Maintenance and Fault Diagnosis of pH Electrodes”. 57th Annual Meeting of the International Society of Electrochemistry, Edinburgh. Available from Reagecon’s ecommerce facility and knowledge centre www.reagecon.com

2. Barron, J., 2020. “The Measurement of pH: Reference Electrode, Sensing Electrode and Sample – A Review”. Reagecon Technical Paper, Self-published.

3. Barron, J., Ashton, C., Geary, L., 2006. “The Effects of Temperature on pH Measurement”. 57th Annual Meeting of the International Society of Electrochemistry, Edinburgh. Available from Reagecon’s ecommerce facility and knowledge centre www.reagecon.com

4. Barron. J., 1999. “A Guide to Method Validation”. Self-published, Reagecon Technical Paper. Available from Reagecon’s ecommerce facility and knowledge centre www.reagecon.com

5. Barron, J., 2016. “Physical and Chemical Standards Compendium”. Reagecon Technical Publication, Self-published. Available from Reagecon’s ecommerce facility and knowledge centre www.reagecon.com