Top 10 things to consider when installing a new pH loop

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This paper is written to help those who are looking to engineer the installation of a new pH loop, have a new loop ready for installation or are re-doing an existing loop. Whether a novice to the world of pH or a seasoned veteran, this is intended to be a helpful roadmap to a successful journey. It is not an end all be all, but rather a primer to get you past the most common road blocks.

Maybe you have heard past pH horror stories throughout chemical, food and water treatment plants. And yes, the stories are mostly true. If you haven't heard any of these stories, maybe this list will keep you from adding your own story to the already toppling heap. If you are at all familiar with pH measurement, you probably know the horror stories, and maybe even have had your own experiences.

When we conduct pH seminars or schools, one question we ask the group is, "How many of you have worked with pH?, raise your hands. Now keep them up. How many of you have had bad experiences with pH?, keep your hands up". How many hands do you think went down? You guessed it, the majority of hands remained high and somewhat shy.

Below is our top 10 list for things to do, watch out for, or not do, (not necessarily in any order).

1. Watch your flow rate, pressure and temperature

When it comes to pH measurement, there are many factors to take into consideration aside from the zero and slope variables that are derived from a quality calibration. Three of the most critical are listed above. These physical constraints have been known to kill many a field sensor if not taken into account.

For typical applications, it is recommended that the linear flow velocity across your measure sensor does not exceed 10 feet per second. It has been the case among even benign field applications where higher velocity solutions can have drastic effects on sensors – the case of cooling tower water taking out otherwise good sensors! As media flows past the pH probe at these elevated rates, metal salts are leached from the glass turning your once 'magical' pH sensor membrane into ordinary high impedance glass that does not like to exchange ions as originally intended.

Pressure and temperature are also silent killers that can greatly affect the overall life of an otherwise good sensor. While it is important to follow manufacturer's recommendations per specification data, beware of some real world applications. It has been noted that sensors are often rated for process levels that should not necessarily be sustained. A good example of this phenomenon could be described by your car engine. Just because it is designed to hit 400 hp at 7,500 rpm doesn't mean it should be run in that fashion regularly if you want to get any life out if it. pH sensors are the same way. In regards to temperature, one could expect the typical sensor life to be cut drastically as process temps rise above 176°F (80°C) for prolonged periods with caution being taken when such processes hit 149°F (65°C). Newer types of glass and flowing references seem to help but this rule of thumb is a good one to adhere to.

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Figure 1: Make sure line pressure and temperature are within manufacturer's specifications.

2. Clean the sensor

How often would you recommend throwing something away simply because it got dirty? The answer is typically 'not often' but this doesn't always seem to be the case with pH sensors that get exposed to coating or fouling process streams. The first indication that such a cleaning is needed is the dreaded calibration failure or extreme degradation in such calibration data following removal from the process medium. pH sensors should be cleaned regularly with soap and water. By performing this practice before every calibration, much variability is removed and your quality assurance manager will thank you for following standard operating procedures.

Whenever standard soap and water is not enough to do the job, a weak acid can be used (4-5% W/V HCl) to remove scale from the measuring glass. Upon doing such a cleaning, be sure to let the cleaned sensor sit in a bath of 50% 3.0 molar KCl / 50% 4-buffer to recondition said sensor and bring the junction potential back to a neutral state. One hour is typically more than enough time.

3. Watch the temperature - why won't my online reading match the lab reading?

In the history of pH measurements, there is no greater battle than the one historically fought between the field and lab technician. Both march into the fight armed with what they believe to be 100% accurate data, but who is actually correct? I'd wager that on any given day, both parties could very well have valid readings but the question is – with respect to what temperature? It must be understood that pH readings are only as relevant as the temperature to which they are referenced. Asking a technician what pH they are reading without regards to temperature is like asking a pilot what their altitude is with no idea where the ground is underneath.

It should also be noted that pH sensors and transmitters are often equipped with temperature compensation routines. These software tools are designed to compensate for the effect of temperature on the sensor glass, not the typically assumed effect of temperature on a process solution. Each process behaves differently and the effects of temperature on the pH measurement should be examined independently for each solution.

4. Keep it wet, and accessible

If one thing can be said of all pH sensors regardless of type – they like to remain wet at all times. It doesn't really matter how you do it, individual plastic boots for the sensor tips or one large tub for communal soaking, it is imperative that the sensors remain wet when being stored for service. To take it a step further, one should ensure that the sensors also remain wet while installed in process lines.

The occurrence of walking out to various sample points only to find pH sensors left to dry out in empty lines is all too common during process unit startups and shutdowns. Only through engineered piping design (wet leg) and/or excellent communication with your counterparts in unit operations can we achieve the desired result.

In order to keep all of the ions from rapidly trying to escape from within your sensor, do NOT store in de-ionized water. Ideally, a nice mixture of 3.0 molar KCl and 4-buffer should be utilized to maintain balance within the universe and help your sensors to last much longer when they are not actively in use.

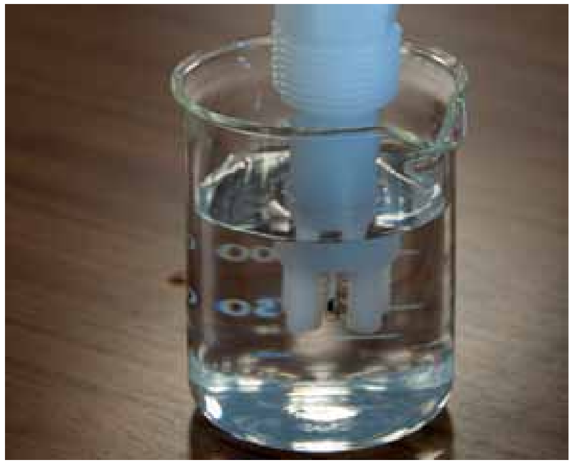

Figure 2: pH sensor being kept wet in tap water.

5. Consider redundancy

In the world of analytical measurements, no reading is better suited for a redundant confirmation than that of pH. This is true in the sense that not too many other calibration efforts incorporate so many variables, the largest of which is the human factor. To have a quality standard operating procedure, things such as the following need to be taken into consideration: which operator calibrated the sensor, did they allow for temperature stabilization, is the sensor nearing end of life, are all sensors of the same model code, etc.

With all of these things patiently waiting to show up after the fact and make your day more interesting, a reliable redundant measurement is a nice way to gain confidence in the online reading. Where possible, triple redundancy is the best bet when coupled with a DCS enabled 2 out of 3 voting control scheme. Who knows, you may even avoid having to take a grab sample or two.

6. Monitor sensor life

Often the question gets asked, “How long will my pH sensor last?” This is analogous to asking how long will my tires last. It will depend on how fast you are driving, road conditions, are you always turning left, how many burn outs do you do, etc.
A pH sensor in a drinking water plant measuring effluent water at 77°F (25°C) and about 7 pH should last a year or more. Yes, we have seen this type of application many times and in one case, the sensor performed well for over six years. We have also seen applications where the sensors only last a day or two and are exhausted and must be tossed out.

The best answer and the truest answer is, “it depends”. Sensor life will depend on pressure, temperature and flow as well as the pH and chemistry of the process itself. Are there any solids present, if so how much?

A new sensor, properly stored with its protective shipping cap, full of the solution it came with (usually 3.0 molar KCl) should be able to sit on the shelf for approximately a year and still provide a standard lifetime of service in your process. Left unattended and dry, the sensor will have to be regenerated in a 3.0 molar KCL solution for one to three days and it should recover.

Figure 3: Store pH sensors with manufacturer's supplied boot/shipping cap or in beakers with storage solution.

7. Establish and follow QA/QC procedures

When the pH is being controlled and the process is running properly, everyone is happy. That's whether it is the production process or the wastewater process (maintaining proper pH outfall to receiving bodies). But what happens when the process fails due to pH irregularities? Is the process allowed to run until it doesn't?

The implementation of an ongoing and self-correcting quality assurance or control procedure is essential for the maximum up time of a process. The implementation of this process is best described as test and learn. The frequency of pulling a pH sensor for cleaning can only be determined by the operator for a particular process location. This frequency is best adjusted by checking the sensor after an initial operating time in the process, perhaps 12, 24 or even 48 hours – again experience is the key. Keep an eye on the pH value the sensor is providing and how this value relates to what the theoretical pH is supposed to be.

Remove the sensor from the process and rinse it in warm tap water. Check the sensor in calibration buffers and determine whether the values are consistent with the initial calibration or your company's standards and guidelines for good manufacturing practices. If the readings are within acceptable limits, re-install the sensor and repeat these steps in another 12

Figure 4: pH sensor being readied for calibration.

or 24 hours. Once you have found a time base which relates to the shift in the calibration numbers that deviate from your standards and guidelines, you have set your cleaning/maintenance frequency.

8. Handle sensors carefully

The pH sensor is a delicate instrument. It should not be handled in a gruff manner. As the title infers, yes, we have seen sensors used by some as steps or hand holds for gaining access to other systems in the plant.

As most pH sensors are made of glass, or plastic bodies with glass measuring ends, care must be taken so that the glass is not broken by mis-handling. Proper care must be made in the installation as well, such as mounting general pH sensors at an angle of 12 degrees to the horizontal plane. That is to say that the back end of the sensor be at least 12 degrees more than the glass end to insure any air bubbles in the glass electrode are driven to the back end of the sensor so as to not form in the glass bulb.

Cleaning of the sensors could cover another few pages, but in a nut shell, don't use knife blades or wire brushes to clean off deposits left on the glass bulb. Doing so could scratch the glass or break off the bulb at the neck. Proper cleaning of pH glass usually involves a soap or other cleaning agent and the possible use of a soft bristle brush to facilitate cleaning.

9. Use only as directed - use where it will work or provide a meaningful reading

Many times pH measurements are asked for in impossible locations or in areas that are not accessible. Also, they might be asked for in processes or applications where they will not provide a meaningful reading.

Think about where the pH sensor will make its measurement in relationship to how the sensor will be maintained. The sensor will require cleaning or calibration at some point (most likely multiple times) during its lifetime. Make sure the sensor is accessible and easy to remove and re-install. Will special tools, man lifts or other departments, electrical/mechanical, be required to do a cleaning or calibration? Will it be outdoors, what about winter freezing or summer heating conditions – will that impact the sensor's function, how about the operator's ability to perform a useful calibration – think of a cold environment/warm buffers etc. Try and place the sensor away from rain or snow conditions if possible.

Figure 5: An example of a pH sensor installation in a convenient location for maintenance by plant personnel.

Don’t install a pH sensor in a tank without the correct insertion and retraction hardware. Will that be more expensive than just threading a sensor into the tank through a nipple ? Yes, but less expensive than having to drain the tank to be able to remove it.

Make sure the pH measurement is measurable. For instance, products that have no water won’t likely provide meaningful pH readings. Think oils or hydrocarbons such as gasoline. If in a tank, mount the sensor far enough away from the reagent addition so that proper mixing has occurred. Otherwise you are simply measuring the pH value of the reagent. If in-line, verify proper mixing has occurred between the process and reagent through the use of an inline mixer. Sometimes it is a matter of time (pH reaction of various chemistries) and not direct mix.

10. Select the correct sensor for the process

pH sensors are manufactured in pH bandwidth targeted to their specific use. Sensors can be made for use in low value pH solutions, high value pH solutions (ignoring the effects of sodium ion error) and most commonly, middle band pH solutions (pH values between 2-10). Some sensors claim a range of the full bandwidth, 0-14 pH. Specific sensors are also engineered for low ionic strength solutions like those found in boiler feed, condensate, WIFI water, high purity and reverse osmosis applications. The use of pH sensors incorporating flowing junction reference electrodes are useful in both low ionic strength solutions and media that has a high fouling potential.

Specific pH sensors are made to withstand hi/low temperatures and or pressures and the effects of different types of media that will tend to coat, plug or otherwise contaminate the reference electrode.

It is important to work the manufacturer to select the pH sensor that will be best suited for your application. This is a case where one size does not fit all. Many manufacturers have their go-to sensor, a sensor that 80% of the time will cover most of the applications. That might be the sensor for you, or it might not.

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