

Temperature Compensation for pH Instruments

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Although it is widely advertised, the need for temperature compensated pH measurements is not always explained except in technical books and articles. This Tech-Tip will give a brief explanation of the major characteristics of temperature compensation in pH instruments.

1. The Solution Temperature Effect

When temperature changes, the actual pH of the solution being measured can change. This change is not an error caused by the change in temperature. It is the true pH of the solution at the new temperature. Since this is not an error, there is no need to correct or compensate for this temperature effect.

2. The pH Electrode Temperature Effect

There is only one major temperature effect in pH measurement that can cause errors in readings. This is the change in the electrode's response (or sensitivity) to pH that results from change in temperature. It is the only reasonably predictable error due to changes in temperature, and is the only temperature related factor that pH instruments with temperature compensation can correct.

This temperature error is very close to 0.003 pH/°C/pH unit away from pH 7. In a perfect pH electrode—one that is zeroed at exactly pH 7—there is no temperature effect on the electrode sensitivity at pH 7 no matter how much temperature changes. (Remember though, the temperature of the solution may actually change the pH of the solution to be different from pH 7 at the new temperature). Most pH electrodes are not perfect, but the errors from changes in temperature are still very minute when near pH 7, plus or minus one or two tenths of a pH, and can be be disregarded. However, the further from pH 7 the solution is and the greater the temperature change, the greater the measurement error due to changes in the electrode's sensitivity.

The errors from changes in electrode sensitivity due to changes in temperature are the only errors that can be corrected by meters with temperature compensation. In both cases a correction factor based on 0.003 pH/°C/pH unit away from pH 7 is applied to the final reading you see on your meter.

There are two variations for temperature compensation:

Automatic: where a temperature sensor signals the meter what the solution temperature is, and the meter automatically corrects the pH readings for changes in the electrode sensitivity.

Manual: where the user must dial or key in the solution temperature, and the meter then corrects the pH readings for changes in the electrode sensitivity.

Temperature compensation eliminates most of the temperature dependent measurement error from the electrode. Further minimization of this error in both temperature compensating and non-temperature compensating pH instruments can be achieved by calibrating the instrument and

electrode in pH buffers that are close to the expected measurement values for pH and at (or near) the same temperature as the solution to be measured. This technique also minimizes other temperature related errors which occur in all electrodes but which cannot be predicted or compensated for when temperatures change.

These unpredictable pH measurement errors due to temperature changes are somewhat complex in nature and vary from electrode to electrode. They can result in small but noticeable pH measurement errors. Unfortunately, there is not much that can be done about these in a manner that is economical or practical for most users of pH instruments. Therefore, as a practical matter they are mostly ignored in everyday pH applications.