

Leak Detection with pH

BACKGROUND

Virtually all industries from food and beverage to chemical processing use heat exchangers, condensers, or jacketed vessels.

Leakage of the process into the cooling water represents a loss of product and can be a source of fouling or corrosion in the cooling water system.

Conversely, leakage of the cooling water into the process can be a source of contamination. An example is the leakage of cooling water into steam condensate, which is a source of contamination in the steam-water circuit.

PRINCIPLE OF LEAK DETECTION USING pH

For a leak to be detected by pH, a small amount of contaminant must cause a measurable change in the pH of the sample being monitored. In general, when the sample pH is near neutral (pH 7.0), the pH response is greater, resulting in increased sensitivity to detect leaks.

SENSITIVITY OF LEAK DETECTION

However, exactly how the pH of the sample will respond to a small amount of contaminant, depends upon the pH and the composition of both.

SAMPLES WITHOUT BUFFERING

In dilute samples or in samples without buffering action, the pH response can be easily predicted.

Table 1 shows the best sensitivity of leak detection possible for various sample and contaminant pH values. The sensitivities are given in terms of the volume fraction of the leak detectable, expressed from percent (%) through parts per billion (ppb), by volume.

For estimating sensitivity, the normal pH range of the sample and the contaminant must be considered. The maximum and minimum pH of each should be checked against one another and the poorest sensitivity should be used for estimation.

SAMPLES WITH BUFFERING

Samples containing weak acids and bases have weak pH response, which reduces the sensitivity of leak detection. This is due to buffering action, which is the tendency of a solution to resist pH changes. The degree to which this occurs depends on the concentration of the acids, bases, or salts and the sample pH range. Examples include acetic acid (CH_3COOH), hydrofluoric acid (HF), ammonia (NH_3), sodium carbonate (Na_2CO_3), and sodium sulfate (Na_2SO_4).

It is often difficult to predict just how the sample pH will respond in such mixtures, so a volume of the sample should be titrated with the contaminant. The volume of contaminant required to cause a ± 1.0 pH or other reliably measured pH change, divided by the volume of sample titrated, will be the sensitivity.

As an initial check, Table 1 can be consulted to see if there is the possibility of acceptable sensitivity before titration.

LEAK DETECTION WITH ONE pH ANALYZER

For a leak to be reliably detected, the pH used as a set point must be significantly larger or smaller than the sample's maximum or minimum without a leak. The sensitivities in Table 1 were based on ± 1.0 pH above or below maximum or minimum pH as a reliably measurable change. Using the poorest sensitivity based on the maximum and minimum sample pH of the sample and contaminant ensures that the actual sensitivity will be equal to it or better.

DIFFERENTIAL pH

Differential pH involves using two pH sensors, one before the potential leak source and one after. The difference in pH is measured and used to detect the leak (Figure 1).

The reason for using differential pH is to cancel out variations in the sample pH. By cancelling out these variations differential pH has the potential for detecting leaks at better sensitivity than with a single pH sensor.

Ideally, when no leak is occurring the differential pH would read zero.

In the real world two factors must be taken into account before applying differential pH. The first is the rate at which sample pH changes, and the second is the transit time, which is the time it takes the sample to pass through the potential leak source.

BEST CASE FOR DIFFERENTIAL pH

If normal pH changes are slow relative to the transit time, both pH sensors are seeing essentially the same sample. Except for small variations due to measurement errors, differential pH can be applied successfully. The sensitivity will depend on the pH of the sample and contaminant at the time the leak occurs. Sensitivity should be estimated using the value of contaminant pH that is closest to the normal pH (see Table 1).

FAST SAMPLE pH CHANGES/LONG TRANSIT TIME

When normal pH changes in the process are much faster than the transit time through the leak source, the differential pH can vary widely both positively and negatively.

If the process can change over its full pH range in less time than the sample transit time, using two sensors can actually be worse than using a single sensor, due to the variability of the pH before the leak.

The best course of action in cases of wide and fast sample pH swings is to use a single sensor and alarm after the leak source only.

RULES FOR LEAK DETECTION WITH pH

1. The process and contaminant pH range and composition must be known, as well as the rate of pH changes in the sample and the transit time.
2. When both the process and contaminant are unbuffered the sensitivity of leak detection can be estimated from Table 1.
3. When there is the possibility of buffering action in the process, it should be titrated with the contaminant to determine sensitivity.
4. When normal process pH changes are slow relative to the transit time through the leak source, leak detection with differential pH can improve the sensitivity.
5. When the process pH can change faster than the transit time, a single pH sensor after the leak source provides the best leak detection.

INSTRUMENTATION

The usual considerations of temperature, pressure, and material compatibility should be taken into account.

For pH measurements that will exceed 10 pH, a high pH glass electrode should be used.

For measurements in samples with conductivity below 5 $\mu\text{s}/\text{cm}$, the Model 3200 HP high purity pH sensor should be used. In other clean applications, the Model 3900 insertion/submersion sensor is a sound economical choice.

INSTRUMENTATION

Model 1056 Analyzer

- MULTI-PARAMETER INSTRUMENT – single or dual input. Any combination of pH/ORP/ISE, Resistivity/Conductivity, Chlorine, Oxygen, Ozone, Turbidity, Flow.
- LARGE DISPLAY – easy-to-read process measurements.
- SEVEN LANGUAGES: English, French, German, Italian, Spanish, Portuguese, and Chinese.
- HART AND PROFIBUS DP Digital Communications.



Model 3200 HP High Purity pH Sensor

- Rugged combination electrode with VP connector
- Integral solution ground for measurement stability and complete diagnostic functionality
- Exposed stainless steel thermowell for rapid temperature response



Model 3900 General Purpose pH/ORP Sensor

- Extended sensor life provided by double junction reference.
- Rugged polyphenylene sulfide body, completely sealed to eliminate sensor leakage.
- Multiple mounting options, including 3/4" and 1" insertion and 1" submersion.



**Table 1. Estimated Sensitivity for Unbuffered
Samples and Contaminants at Various pH Values**

Sensitivity at a pH change of ± 1.0

Sample pH

Contaminant pH ↓	1	2	3	4	5	6	7	8	9	10	11	12	13
10 Molar Acid		9.0 ppT	900 ppm	90 ppm	9.0 ppm	0.9ppm	1.0 ppb	90 ppb	0.9 ppm	9.0 ppm	90 ppm	900 ppm	9.0 ppT
1 Molar Acid			9.0 ppT	900 ppm	90 ppm	9.0 ppm	10 ppb	0.9 ppm	9.0 ppm	90 ppm	900 ppm	9.0 ppT	9.0 %
1				9.0 ppT	900 ppm	90 ppm	0.1 ppm	9.0 ppm	90 ppm	900 ppm	9.0 ppT	9.0 %	
2					9.0 ppT	900 ppm	1.0 ppm	90 ppm	900 ppm	9.0 ppT	9.0 %		
3						9.0 ppT	10 ppm	900 ppm	9.0 ppT	9.0 %			
4							100 ppm	9.0 ppT	9.0 %				
5							1.0 ppT	9.0 %					
6							N/A						
7							N/A						
8							N/A						
9							1.0 ppT						
10					9.0 %	9.0 ppT	100 ppm						
11				9.0 %	9.0 ppT	900 ppm	10 ppm	9.0 ppT					
12			9.0 %	9.0 ppT	900 ppm	90 ppm	1.0 ppm	900 ppm	9.0 ppT				
13		9.0 %	9.0 ppT	900 ppm	90 ppm	9.0 ppm	0.1 ppm	90 ppm	900 ppm	9.0 ppT			
1 Molar Base	9.0 %	9.0 ppT	900 ppm	90 ppm	9.0 ppm	0.9 ppm	10 ppb	9.0 ppm	90 ppm	900 ppm	9.0 ppT		
10 Molar Base	9.0 ppT	900 ppm	90 ppm	9.0 ppm	0.9 ppm	90 ppb	1.0 ppb	0.9 ppm	9.0 ppm	90 ppm	900 ppm	9.0 ppT	

% = percent

ppT= parts per Thousand

ppm = parts per Million

ppb = parts per Billion

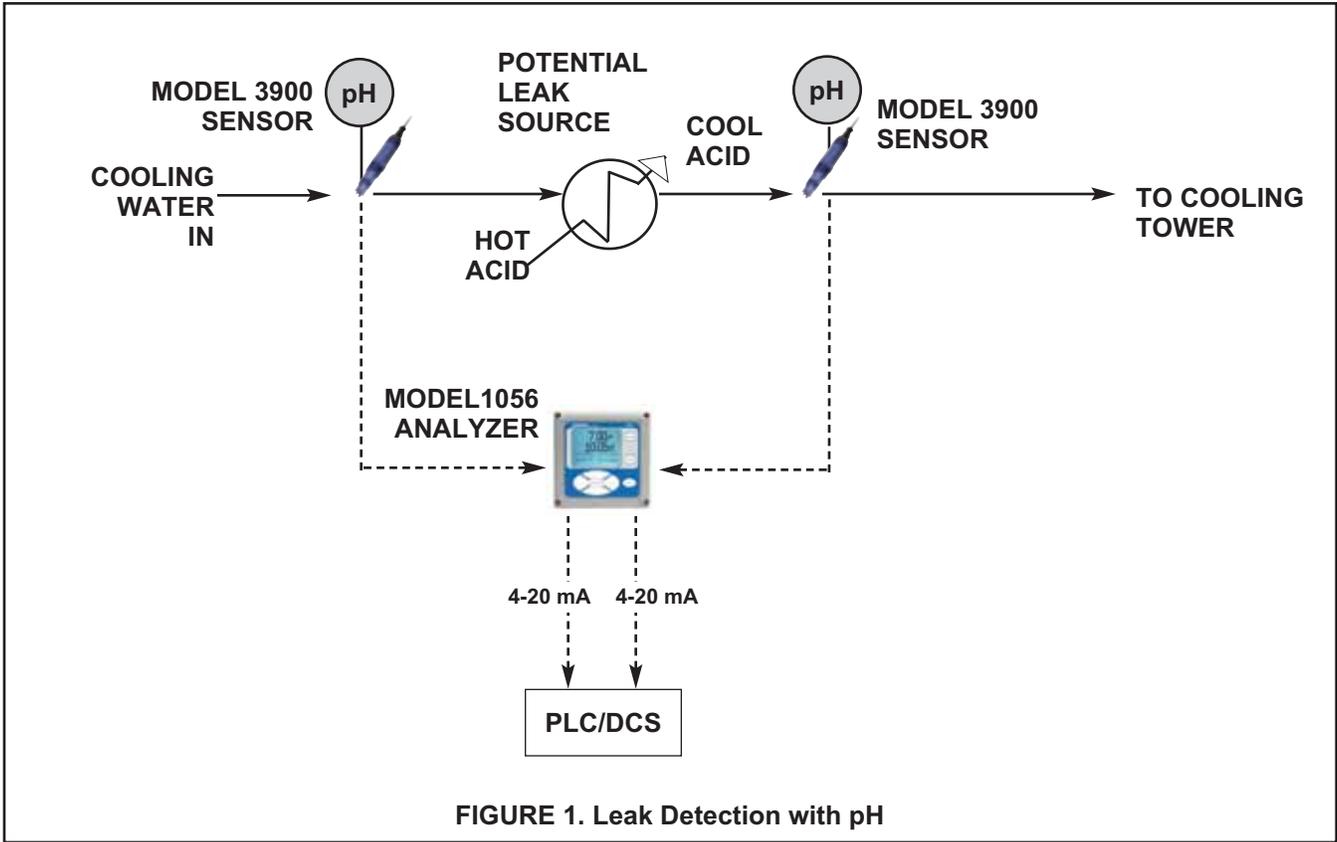


FIGURE 1. Leak Detection with pH



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