



## Top Revelations from 50 Years of Sampling System Training

by **Tony Waters**

Engineer, Teacher, and Lifelong Student

A process analyzer sampling system is one of the most challenging systems in your plant. It's challenging to design, and it's challenging to operate accurately. Make a minor adjustment here, and you may have to make a major one elsewhere. No wonder Swagelok gets so many good questions during our sampling system training courses, as well as such attentive trainees. Over the 50 years I have been teaching, I have observed participants experiencing many epiphanies. Here are some of those "aha" moments:

### **"Time Delay Is Often Longer Than I Expected"**

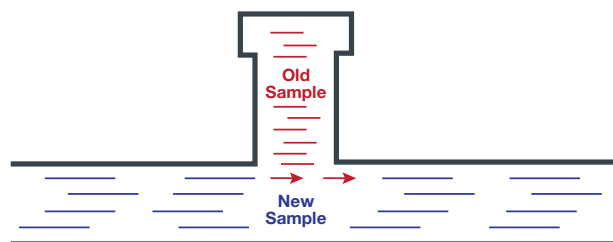
Most trainees haven't considered the importance of addressing time delay in a sampling system and are often amazed at how late some analyzer measurements can be. The industry standard is a one-minute response time from pulling a sample to obtaining a reading. This short time frame provides near real-time readings of process conditions, so you can make immediate adjustments and minimize wasted product. However, the time to obtain a reading could be extraordinary, even with the analyzer mounted a few feet away from the process tap.

The only way to reduce time delay is by adjusting your system design. We do a fun, practical exercise in our training courses in which we calculate the time delay in a typical sampling system. Our initial design has an enormous delay of more than five hours. After making some quick system modifications, we bring that delay down to the one-minute industry standard. Trainees are amazed and can't wait to try the exercise at their own facilities.

### **"My Sample May Not Be Representative of the Process Conditions"**

Time delay is such a critical issue to correct because it affects the "representativeness" of your sample reading (i.e., how "representative" the sample is of the fluid in the process line at the time you obtain your analyzer reading). Say, for example, a system has a more than five-hour delay like the training course exercise. If a bad reading shows up, the system operator will quickly correct the quality issue, thinking the problem is fixed. However, the operator likely doesn't know the reading was delayed more than five hours. During that time, a lot of inferior product went through the system that may have been shipped to a customer.

Even when you take a proper sample and limit time delay, it may still become unrepresentative due to the system's design. For example, deadlegs (Figure 1) or dead spaces in the sampling system may trap old samples that can bleed into the new sample, creating a mixed sample that isn't true to real-time process conditions.



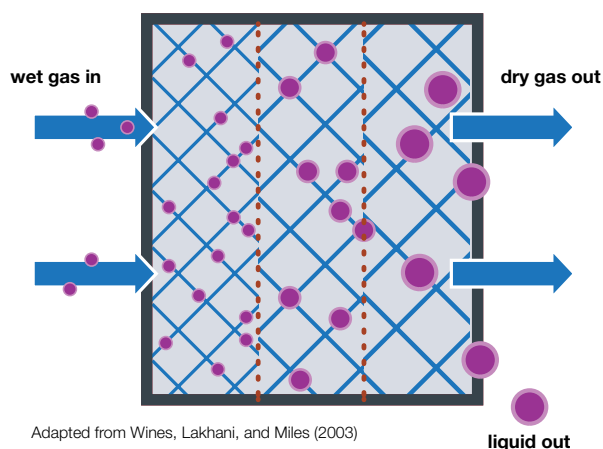
**Figure 1.** In this deadleg configuration, old sample trapped in the tee formation leaks into the main fluid stream, contaminating the new sample.



Or, to take another example, your sample may become contaminated because of leaks – not leaks *from* the sampling system but leaks *into* the sampling system from the ambient air around it. For instance, oxygen can leak into a system containing 100 percent nitrogen at 100 psia because the partial pressure of oxygen outside the system is greater than its partial pressure inside the system.

### “I Need to Pay More Attention to My Coalescers”

In sample conditioning training, most attendees think a coalescer is a device used to separate and remove liquids from a gas sample. That’s partly true, but only for liquids suspended in aerosol form. Aerosol is present in many gas samples because acceleration devices like cyclones or gravity separators are unable to separate the tiny droplets. A coalescer installed in the sampling system will allow small liquid droplets to come together and combine into large drops that more easily separate by gravity (Figure 2).

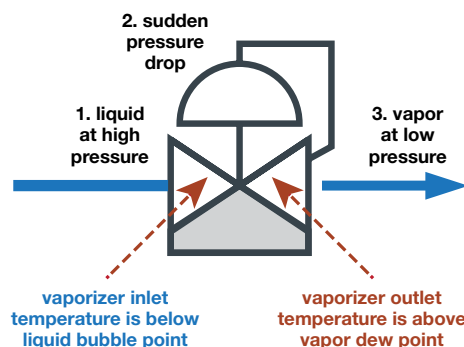


**Figure 2.** Inside a coalescer, droplets from aerosol in a wet gas sample cling to elements inside the coalescer, and then form into large drops that fall out due to gravity. The gas on the downstream side is then dry.

Trainees are surprised to learn two conditions will typically render a coalescer useless. First, free liquid (i.e., liquid that is not aerosol) will flow right through a coalescer with hardly any separation due to the large size of the liquid droplets. In addition, when the flow rate through a coalescer is too high, the fine aerosol droplets get pushed past the coalescer elements and don’t drip out of the flow path. Both scenarios increase the potential of aerosol droplets – the very element you were attempting to remove – reaching the analyzer and reducing the reliability of your readings.

### “Vaporizing a Liquid Can Be Very Difficult”

Many trainees think vaporizing a liquid sample is easy – but a lot can go wrong. The goal is to convert the liquid to all vapor instantly by dropping the liquid’s pressure rapidly (Figure 3). However, instead of flashing the whole sample into a vapor, you could unintentionally create a fractionated sample through a combination of vaporization and evaporation. In this case, lighter gas molecules that evaporate first move downstream to the analyzer, while heavier liquid molecules remain behind. As a result, the sample reaching the analyzer no longer accurately represents the product taken from the process line. Once a sample fractionates, it is no longer of the same chemical composition. By understanding what occurs during vaporization and learning how to adjust settings for temperature, pressure, and flow, you can prevent this scenario.



**Figure 3.** During the three-stage vaporization process, high-pressure liquid vaporizes to low-pressure gas following a sudden pressure drop.

### “Condensation Is Tricky – But Fixing It Is Easy”

Condensation is perhaps the most common issue experienced with gas samples. Trainees are surprised to learn how quickly gases cool down (and how slowly liquids do). However, they’re also happy to learn that it’s easy to predict when condensation will occur, as well as what temperature is required to stop it.

Consider a system that reduces the pressure of a gas sample in a field station, which should be located as close to the tap as possible. Remember, almost all gases lose heat when their pressure drops (a phenomenon known as the Joule-Thomson effect). If your pressure drop is small, you can likely use a simple pressure-reducing regulator without worry of producing condensation. However, a significant gas pressure drop will cause condensation due to the significant heat loss. This is even more likely when the gas is close to its dew point temperature.



In such cases, you may need to use a heated regulator to keep the gas temperature above its dew point. To optimize your energy consumption, you can calculate the number of watts required from the heater cartridge based on the Joule-Thomson coefficient of the gas, as well as the pressure drop and flow rate in the system.

### **Continuing Your Journey of Discovery**

Analytical sampling system design is a lifelong journey of discovery. You'll never have everything figured out. After 50 years of experience with sampling systems, I'm still learning myself – and even achieve an aha moment of my own now and then. Training is key to enhancing your skills and discovering what you don't know. Then, when you're out in the field, you'll likely experience some aha moments at your own plant that can lead to more accurate and reliable sampling system readings.

### **ABOUT THE AUTHOR**

Tony Waters is an industry expert and consultant for Swagelok. With more than 50 years of experience with process analyzers and their sampling systems, he has worked in engineering and marketing roles for an analyzer manufacturer, an end user, and a systems integrator. He founded three companies to provide specialized analyzer services to the process industries and is an expert in the application of process analyzers in refineries and chemical plants.



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