UNDERSTANDING TIME DELAY– FOUR MAIN AREAS TO INSPECT

In a process analyzer sampling system, there is always a delay between the moment you grab the sample and the time you obtain a reading. This time delay may be longer than you think. Underestimating it can lead to inferior process control. If you're assuming your time delay is one minute, but in fact it's two hours, your analyzer readings may no longer be relevant or purposeful.

Time delay is cumulative, accounting for the total amount of time it takes for a sample to travel from the tap in the process line to the analyzer and be analyzed. You want to minimize this delay, with a common goal of one minute or less from the tap to the analyzer reading.

You'll find time delay throughout an analytical instrumentation system. Here are four main areas to look at closely (*Figure 1*):

1. Delay in the probe
2. Delay in sample transport (including the field station and transport lines)
3. Delay in sampling conditioning (including stream switching)
4. Delay in the analyzer

Let's explore these areas to understand how each may contribute to increasing the total amount of time it takes to obtain an analysis.

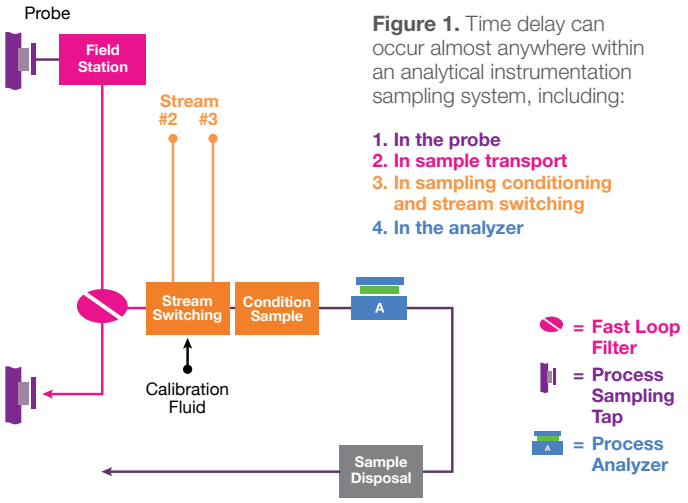

Figure 1. Time delay can occur almost anywhere within an analytical instrumentation sampling system, including:

1. **In the probe**
2. **In sample transport**
3. **In sampling conditioning and stream switching**
4. **In the analyzer**

1. Delay in the Probe

Look out for **large sample probe volumes**. The probe should be long enough to reach to the middle third of the process line diameter, where the stream moves the fastest and provides the cleanest, most representative sample. However, it should not be any longer – or wider – than necessary because the larger the probe's volume, the greater the delay.

Tap location in the process pipe is another, related issue. If you locate the probe near a low-flow section of the process pipe, you will need to wait longer for any change in the process chemicals to show up. For example, new molecules entering a large-volume tank or drum will create a "mixing volume," with both new and old molecules showing up at the exit until the volume is fully purged. Therefore, do not locate the tap downstream of a "mixing volume." Instead, position the tap upstream of such sources of in-process delay, including drums, tanks, dead legs and stagnant lines.

2. Delay in Sample Transport

In the sample transport areas of a sampling system, expect to encounter increased time delay due to:

- **Remote Sample Tap Locations:** The further a sample has to travel for analysis, the longer the time delay. Therefore, locate the tap as close to the analyzer as possible. For longer transport lines, consider using a fast loop to accelerate flow and provide your analyzer with a more recent sample.
- **Line Length and Diameter:** The further the sample has to move and the larger the internal volume of the transport lines, the longer the time delay. Perform the required calculations and adjust these factors if you want to reduce the delay.
- **Low Pressure in a Liquid Sample Transport Line:** For liquid samples, the tap location should provide enough pressure to deliver the sample through the transport lines or fast loop without a pump, which is expensive and introduces another variable.
- **High Pressure in a Gas Sample Transport Line:** With a gas, the higher the pressure, the slower the flow. To speed up flow – and therefore reduce time delay – lower the pressure. For example, at half the pressure, you will get half the time delay.

3. Delay in Sample Conditioning Systems

You'll find delays in the following sample conditioning areas:

- **Unpurged Tee-Pieces Causing Dead Legs:** A dead leg is an unpurged side volume that allows molecules to diffuse into and out of the flowing system media. Any tee or cross in the analyzed sample line is a dead leg unless all its ports are flowing. You'll need to purge these areas before performing sample analyses, with that purging period contributing to time delay. Common dead legs include connection points for pressure and temperature gauges, purge and bleed valves, calibration manifolds, and lab sampling points. Relocating the dead leg (such as a gauge) is sometimes the simplest solution (*Figure 2*).
- **Adsorption of Samples on Tube Walls and Filters:** When a sample touches the walls of tubing, or any other solid surface, a few of its molecules stick to that surface. When you're working on a parts per million analysis, the loss of molecules due to adsorption (or gain from desorption) can be significant. However, the loss is only statistically significant with gas samples. Only worry about adsorption with a liquid sample when you're measuring less than 1 ppm. For gas samples, build in sufficient wait times between switching sources to allow for the previous gas molecules to clear.
- **High Internal Component Volumes:** To ensure a representative sample – and obtain accurate analyzer readings – the entire volume of every device in the flow path needs to be purged. If you have a large volume device, such as a filter or coalescer, you need to allow enough time to purge it thoroughly. A general guide would be to flush it with three times the volume of the device. Minimize the size of these components when possible.

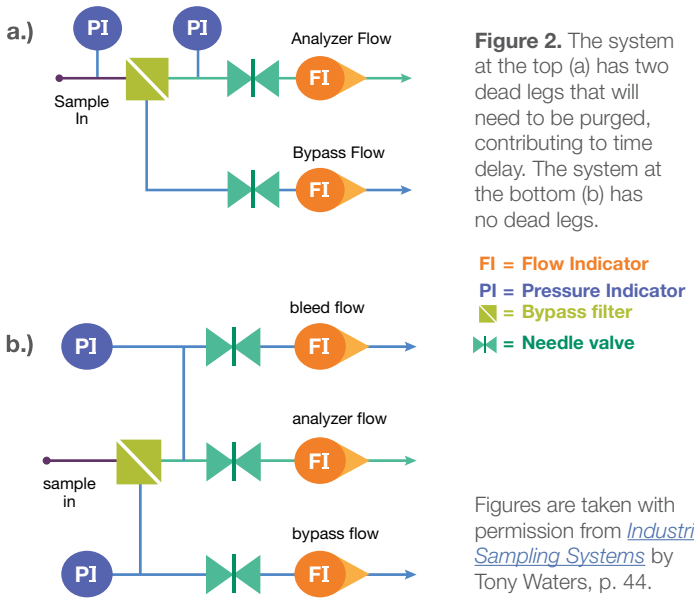

Figure 2. The system at the top (a) has two dead legs that will need to be purged, contributing to time delay. The system at the bottom (b) has no dead legs.

Figures are taken with permission from *Industrial Sampling Systems* by Tony Waters, p. 44.

4. Delay in the Analyzer

Time delay also occurs in the final analysis at the analyzer due to:

- **Discontinuous Analyzer Response Times:** Certain analyzers take more time than others to perform their analyses due to processes that take place within the analyzer. For example, a colorimeter needs to develop its measured color before completing an analysis, and a gas chromatograph needs to separate its measured components before analyzing them.
- **Continuous Analyzer Response Times:** Some analyzers run continuously, but even these do not provide an immediate result, so there is always some delay.
- **Manual System Operator Response Times:** When manually managing the sample analysis process, be sure to factor in the inevitable time delay that occurs for the operator to notice and respond to necessary system adjustments.

Know Your Time Delay to Enable Accurate System Responses

It's important to know how much time has passed between the tap (when the sample is first taken from the process line) and the analyzer (when you receive your analytical result). A wrong assumption about this time lapse means that you no longer understand the relationship between what's in the process line and the analytical result. If you study the four areas of your system covered in this white paper (probe, sample transport, sample conditioning, and analyzer) you will derive some general conclusions about where time delay is occurring in your system. To learn how to precisely calculate time delay and take corrective actions, consider one of Swagelok's sampling systems training courses.

