What is time constant and why is it important?

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Time Constant is the period of time over which the values measured by a detector are averaged. On most applications the time constant is 30 to 60 seconds.

Why is Time Constant Important?

It is necessary to minimize noise.

The output signal from a detector is not the process value at that instant. It is an exponentially weighted average of the values recorded over the time constant. All measurements have noise – or statistical fluctuations. This noise is generated from the inconsistency of radioactive decay, but can be minimized when the values are averaged. The greater number of values (longer time constant), the less impact noise has on the measurement.

It is a common term used in process measurement – represented in equations by the Greek letter 'τ' (tau).

When a change in density or level occurs, the number of counts at the detector will also adjust. If the change is a higher density in a pipe, or higher level in a vessel, the detector will see fewer counts. For the opposite, the detector will see more counts. The instrument will detect the change immediately as the output process value is updated every second; however, the newest value is averaged with the values recorded over the time constant.

Here is an example. If you find math disconcerting, continue with the paragraph following the box.

> The level of the process inside a vessel changes from 10% to 40% of the measuring range. The detector is configured with a 60-second time constant.
>
> After 60 seconds (or 1τ) the detector will indicate 29.0. This can be calculated with the following equation:
>
> $L_f = L_o + (\Delta L \times [1-(\frac{1}{1}e)])$
>
> Where: L_f = level final e = natural log or 2.72.
> L_o = level original, or 10 for this application
> ΔL = change in level, or 30 for this application (40% - 10%)
>
> Inserting the values into the equation results with:
>
> $L_f = 10 + (30 \times [1-(\frac{1}{1}e)]) = 28.97 \approx 29.0$
>
> After another 60 seconds, for a total of 120 (or 2τ), the equation is now:
>
> $L_f = 10 + (30 \times [1-(\frac{1}{2}e)]) = 34.49 \approx 34.5$

It takes 5 Time Constants (or 5τ) before the detector output matches the process level inside the vessel. This amounts to 300 seconds with a 60-second time constant. The time constant is not the amount of time it takes for the detector output to match the process. For applications where the level or density changes quickly, the time constant should be reduced. This is seen on small-diameter vessels and pipes that switch between grades (cuts) of crude oil.

"If the time constant is set to 1 second, won't the detector match the process immediately?"

Yes and No. If a person is given 6 darts and instructed to aim for the bullseye, the thrower will perform better if given 60 seconds to perform the task rather than 10 seconds. Accuracy (or resolution) is sacrificed for the faster response as more noise is introduced. If the measurement requires a fast response, some options include a more-sensitive detector (larger bullseye) or a larger source (more experienced thrower). When comparing our sizing to the competition ensure the time constants for both are identical.

Many factors are weighed into selecting the source for an application. For some customers the time constant is important. Understanding some basics about time constant, and being able to explain them, helps familiarize the customer with nuclear measurements.