

# Calibration: Repeatability vs. Accuracy

## Introduction

Your Drainac has been designed to measure the drainage time of your furnish with a high degree of repeatability. This drain time measurement is the native measurement of the Drainac analyzer and is linear with respect to freeness. Many mills, however, prefer that the freeness measurement be reported in other units, most popularly Canadian Standard Freeness (CSF) though some mills prefer industry-specific units such as Williams-Slowness or Schopper-Riegler. The Drainac has the ability to be programmed to convert the drain time measurement into any unit of interest. This process, called calibration, is the means by which a mathematical relationship is defined between the native measurement of the instrument, drain time, and the desired unit of measure.

## What's in a Relationship?

Analytical instruments typically function by responding to some changing physical phenomenon. The interpretation of that response is indicative of the change in the phenomenon. Temperature, for example, has a very specific effect on the volumetric expansion of mercury or on the resistance of an RTD. Since these relationships are well understood, it is easy for us to accurately and repeatedly measure changes in temperature by referring to the changes in these phenomenon.

In the case of the Drainac, the relationship between drain time and specific units of freeness is defined by relating the Drainac's response to laboratory measurements of the same stock. The development of this relationship is important and requires care to produce the best results.

## Accuracy & Repeatability

When developing a calibration, it is important to appreciate the difference between accuracy and repeatability. Repeatability is a measure of how close a particular result is relative to other measurements by the same device when the same conditions are applied. Accuracy is measure of how close a particular result is relative to an independent evaluation of the same condition

The Drainac is a highly repeatable device. It has been designed to produce far less than 1% variation given the same stock conditions. The same, however, can not be said for the independent evaluation of CSF, the TAPPI 227 laboratory test. The theoretical repeatability of that test is  $\pm 20$  CSF points and is, in practice, often worse.

Thus, for any particular stock sample, the drain time measurement would not be expected to vary significantly, but the lab CSF evaluation could vary substantially.

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Thompson Equipment Company  
125 Industrial Avenue  
New Orleans, LA 70121

Phone: 504-833-6381  
Fax: 504-831-4664  
[www.teco-inc.com](http://www.teco-inc.com)



**24 Hour Technical Support**

**call: TECO Customer Service 800-528-8997 or [support@teco-inc.com](mailto:support@teco-inc.com)**

## The Concept of Statistical Volume

So what do we do with this situation? First, it is important to know that a data point is not really a point at all, but rather a volume, within which, any point is statistically the same as any other. Figure 1 illustrates what this means for a particular measurement.

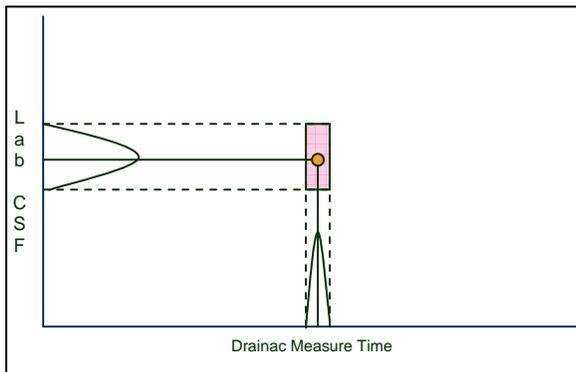


Figure 1: Statistical Volume

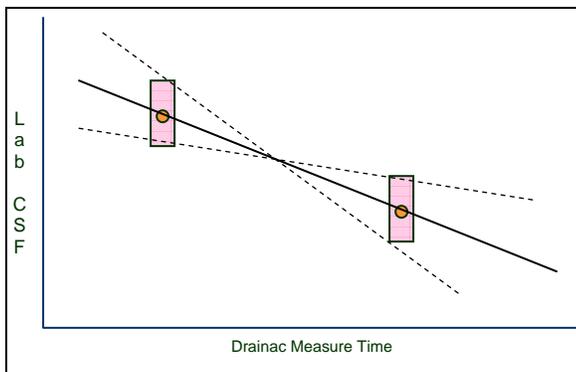


Figure 2: Possible relationships

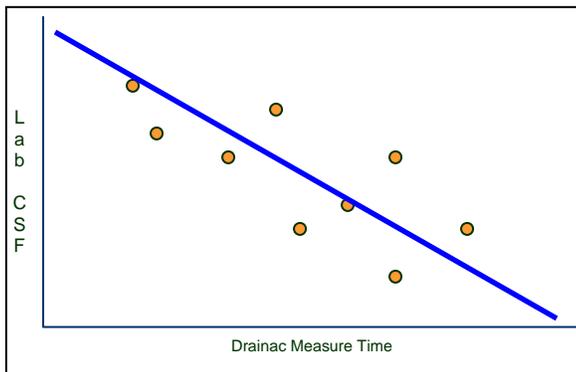


Figure 3: Develop Best Fit Line

The pink box around the data point represents the statistical measurement variation that you could expect to see for this stock. Any value within the box is statistically identical.

This becomes significant when we attempt to take data points and derive a relationship. In figure 2, we see a line drawn between two data points. Also drawn are dashed lines, illustrating the range of relationships possible when the statistical volume for those data points are taken into consideration.

As you can see, there are any number of lines which might be drawn through the two boxes in Figure 2.

But which of these is the correct one?

### Best Fit Lines

The easiest way to deal with the statistical uncertainty associated with laboratory measurement is to develop a line that gives the “Best Fit” to the data at hand. There are many statistical methods available to derive best fits to data, but for our purposes, the least mean square (LMS) routines for linear regression are very good. These routines are universal and are found in many inexpensive software applications, such as Microsoft Excel. Modern DCS packages often include this and other, more powerful, statistical analytical tools as part of their data analysis toolsets.

Figure 3 illustrates a line which has been fitted to the data presented. As expected, there is some variation from the data, but the relationship defined by the blue line is statistically the most robust available. It is this line that we would then use to calibrate the Drainac.

### Extract Operational Parameters from the Best Fit Line

Once the best fit line has been derived from the data, it is straightforward to select an operating region from the data and extract the appropriate operational parameters from the equation for the line to program the calibration into the Drainac. This calibration, based on the best fit to laboratory data, will provide you with both the high repeatability of the Drainac and a statistically sound measurement by which to base production and machine operation decisions.