Artel Lab Report 4

This publication provides technical information regarding the use, application, and metrology related to liquid handling instrumentation.

"I welcome new words, or old words used in new ways, provided the result is more precision, added color or greater expressiveness."

William Safire

Defining Accuracy, Precision & Trueness

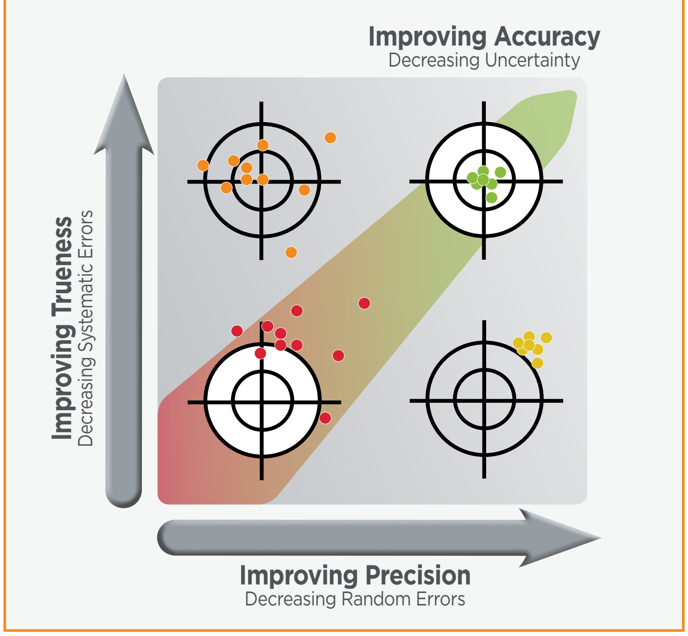
Language influences thinking

and careful use of words when evaluating data allows us to understand how best to improve laboratory accuracy. Accuracy is a particularly important concept because it is foundational to the quality of laboratory measurements. Accuracy invokes an image of something that is correct, reliable and trustworthy. As a conceptual goal, accuracy is universally sought after.

However, what exactly do we mean when we speak of accuracy? Try this experiment: The next time someone uses the word "accuracy", engage in a conversation and try to understand as clearly as possible what they mean by the term. These are some possibilities:

- Highly consistent results (e.g., a low standard deviation, or small CV).
- An average which is very close to the true value.
- Knowing that each measurement correctly represents what is present in the sample.

Figure 1. Accurate results are achieved by improving both precision and trueness.



Removing ambiguity

Historically, there have been two different ways that the word "accuracy" is used in the context of liquid handling. We can use this word to describe a single liquid delivery, and also how the average value of a group of dispenses can be evaluated for accuracy. This "double usage" of the term is still common today, but recent work in developing definitions for ISO IWA 15[1] (based on the vocabulary of metrology[2)]) has provided more precise explanations which help to clarify our thinking, and allow us to be more exact in what we are talking about.

Defining 6 key terms

Six terms related to accuracy are: Precision, Trueness, Accuracy, Random Error, Systematic Error and Uncertainty. There is a logical relationship between these six terms, as shown in Figure 1 and Table 1.

Accuracy

is a combination of trueness and precision. Good accuracy requires good trueness and good precision. Accuracy is measured and reported as an uncertainty. Thanks to the growing popularity of laboratory requirements standards such as ISO 17025[3], much has been written about uncertainty and the detailed procedures to how

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to calculate or estimate uncertainty. Uncertainty is frequently presented in a very mathematical way, with lots of equations. The mathematical expressions in authoritative documents such as the guide to the expression of uncertainty in measurement[4], can create the impression that uncertainty is a mysterious and difficult concept. It is helpful to remember that uncertainty is simply a quantitative expression that tells us the accuracy of a measurement.

Precision

is a concept meaning that results are tightly clustered. Precision can be achieved regardless of where the cluster falls on the target. The degree of precision can be measured by quantifying the overall effect of all ***random errors*** using descriptive statistics such as standard deviation, relative standard deviation (RSD) or coefficient of variation (CV). Precision is necessary for achieving good accuracy, but it is not sufficient. Good accuracy requires both precision and trueness.

Trueness

is labeled on the vertical axis of Figure 1, and like precision is a concept. The measure of trueness is ***systematic error***. The idea is that a measurement is true when it is aimed squarely at the center of the target. A pipette or automated liquid handler which is true, will deliver on average a result which is close to the center. As shown in the upper left target in Figure 1, it is possible to be true, while also having poor precision. Trueness and precision are independent of one another. Each can be increased or decreased without changing the other.

Table 1. Relationships between error concepts and the way they are quantified.

CONCEPT	QUANTITATIVE MEASUREMENT
Accuracy	Uncertainty
Precision	Random Error
Trueness	Systematic Error

For the mathematically inclined:

To determine systematic error (%SE)

$$\bar{V} = \frac{1}{N} \sum_{i=1}^{N} V_i \qquad \%SE = \frac{\bar{V} - V_T}{V_T} \times 100\%$$

$\bar{V}$ **is the average of all measured volumes;**

N **is the number of replicate deliveries;**

V_i **is a single measured volume;**

V_T **is the target volume, the volume intended to be delivered.**

To determine random error (%CV)

$$\%CV = \frac{100\%}{\bar{V}} \sqrt{\frac{\sum_{i=1}^{N} (V_i - \bar{V})^2}{N - 1}}$$

Q&A

Q: When can a liquid handling device be considered reliable?
A: liquid handling device is reliable if it maintains accuracy over a period of time. The reliability can only be established by checking the method, using appropriate primary standards and control specimens[3].

Q: What is an outlier?
A: Outliers are extreme values which are outside of the expected range of values. They can occur by chance, but also may indicate an experimental error. Outliers should be investigated in an attempt to find a root cause. There are a many different tests to identify outliers[5].

Q: How many data points should I collect when testing for precision and trueness?
A: The number of data points will vary depending upon your laboratory's needs, and whether you are testing for trueness, precision or both. Please see **Artel Lab Report, Issue 1, *How Many Data Points*[6].**

References:

1. ISO IWA 15:2015, Specification and method for the determination of performance of automated liquid handling systems. **www.iwa15.org**
2. JCGM 200:2013 International vocabulary of metrology – Basic and general concepts and associated terms (VIM 3rd edition). **www.bipm.org/en/publications/guides/**
3. General requirements for the competence of testing and calibration laboratories. ISO/IEC 17025:2005.
4. JCGM 100:2008 Evaluation of measurement data – Guide to the expression of uncertainty in measurement **www.bipm.org/en/publications/guides/**
5. NIST Engineering statistics Handbook, What are outliers in the data? **www.itl.nist.gov/div898/handbook/prc/section1/prc16.htm**
6. Artel Lab Report 1, How Many Data Points: **www.artel-usa.com/resource-library/how-many-data-points/**

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