

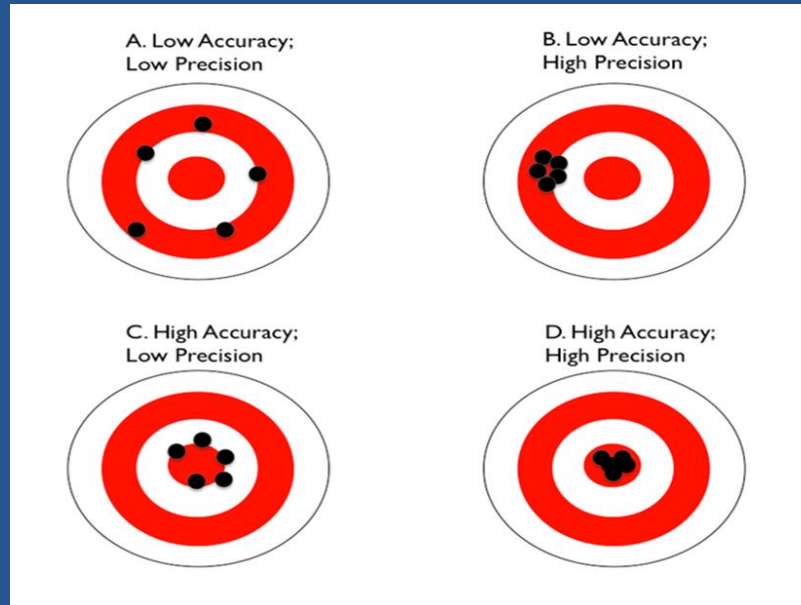


Measuring Variation

in the Laboratory

Let's Define Variation

- **Analytical Variation (Error):** The collection of factors causing drift from the true value of a measurement.



Systematic Variation

- Systematic Variation: Variation caused by a component that is (ideally) controllable.
- Corrections for systematic variations are accounted for after the measurement is taken.
- Example: A thermometer reading 99 degrees C when placed in water at 100 degrees C.

Random Variation

- Random Variation - Non-repeatable inaccuracy caused by unknown or uncontrollable influences.
- Random Variations can have varying magnitudes of influence over multiple measurements.
- For any “stable” system, random variations in measurement will cause a cluster of observed values.

Random Variation

- Larger sample sizes tend toward normal distribution (Gaussian).
- Random Variation allows us to ideally establish the limits for a measurement, but not the accuracy of a measurement.

Blunders

- This would be considered an outright mistake and not factored in for variation.
- Transcription errors, dilution errors, or dropping samples would be examples of blunders.
- Usually not frequent or are one-time mistakes.

Sources of Variation

- Environmental – Conditions within and surrounding a test system.
- Test Methods and Method Validation –Sensitivity, Selectivity, and Matrix applicability.
- Equipment – Calibrations and Inherent Difference between instruments, Reagents, and Standards.
- Measurement Traceability – Weighing and volumetric determinations
- Sampling – Sample Homogenization, Sample Weight, and Sample Matrix.
- Handling of Test Items – Sample integrity.
- Human Factors – Training, Experience, Technique.

Environmental Conditions

- Each of the following factors can add uncertainty:
 - Humidity
 - Temperature
 - Contaminants
 - Lighting
 - Elevation
 - Vibration
 - Gravity
 - Pressure
 - Static Electricity

Test Methods and Method Validation

- **Method Sensitivity** – The capacity of a method to detect the desired analyte.
- **Method Selectivity** – Ability of method to find a particular analyte in a complex mixture without interference.
- Scope of matrices applicable to method.

Equipment

- Equipment not having regular calibration or maintenance.
- Not all lab instruments are created equal.
- Reagents and Standards used in the testing.
- Correction Factors

Measurement Traceability

- Level of Measurement.
- Classes of glassware or calibration of equipment.
- Environmental factors
- Damage to glassware or equipment

Handling of Test Items

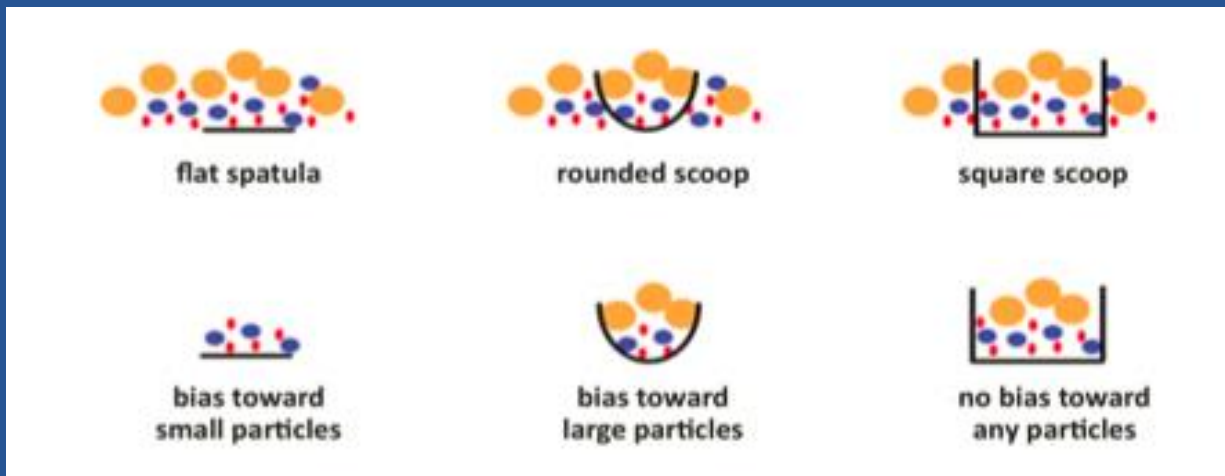
- Conditions of sample during initial packaging.
- Sample travel conditions.
- Sample prepped for testing incorrectly.
- Sample stored incorrectly.

Sampling

- Samples are not always homogenous upon arrival to a lab.
- Sampling of these compositions can lead to variable results.
- Sample size can affect how particles in the composition are represented.

AAFCO Sampling Example

- The type of spatula used for sampling can affect how composition is represented. (AAFCO, 2018)



Thiex Laboratory Solutions, N. T., Canadian Food Inspection Agency, A. P., APHL and AFDO, Y. S., Dept of Agric and Consumer Services, J. C., MT
Dept of Agric, H. H., SD State Univ, L. N., . . . Univ of KY, S. W. (2018). Good Test Portions [PPT]. Champaign, IL: AAFCO.

The Human Factor

“Knowledge and error flow from the same mental sources; only success can tell one from the other.” - Ernst Mach

The Human Factor

- Training between analysts is almost never the same quality.
- New analysts begin with different levels of experience.
- Analysts develop different techniques and skills (i.e., pipetting, weighing, performing steps in the method).

Measurement of Uncertainty

- Have to quantify expected variance as an interval from the expected true value.
- A Measurement of Uncertainty shows the analytical variance of a method as it relates to a specific result.
- Can be calculated using a confidence interval to provide a range of expected variation for a result.

Simple Uncertainty Calculation

- Calculate Relative Standard Deviation for a minimum of 20 data points: (Use a T Table if at least 20 data points are not available)

$$\text{rsd} = (\text{standard deviation} / \text{average})$$

- Calculate $\text{MU}(\text{Relative}) = k * \text{rsd}$ (k is based on confidence interval)
- Calculate absolute measurement uncertainty:

$$\text{MU}(\text{Absolute}) = \text{MU}(\text{Relative}) * \text{Test Result}$$

Claims of Accuracy

- Measurements of Uncertainty help us determine the maximum bounds of variation.
- Ex: If x is accurate to within 3 (units), then the maximum expected value of $|x_{\text{measured}} - x_{\text{true}}|$ is $|x_{\text{true}}| \pm 3$ (units).
- When calculating an MU, remember that the number of significant figures is dependent on the precision of the measurement.

Summary

- A major goal of any analysis process is to identify and minimize variation as to provide the most accurate result possible.
- What variation is still present in a process or method can be quantified and reported.
- Understanding what variation is present can help with improving processes or methods.

References

- Recktenwald, G. (2012, September 11). Uncertainty Estimation and Calculation. Portland State University.
- Abernethy, R. B., Benedict, R. P., & Dowdell, R. B. (1985). ASME Measurement Uncertainty. Journal of Fluids Engineering, 107(2), 161. doi:10.1115/1.3242450
- Vessman, J., Stefan, R. I., Van Staden, J. F., Danzer, K., Linder, W., Burns, D. T., . . . Müller, H. (2001, July). "Smith, John. "Sensitivity and Social Media." Jan. 2016. PowerPoint presentation."
- G104 - Guide for Estimation of Measurement Uncertainty In Testing [PDF]. (2014, December). A2LA.
- Schenkelberg, F. (2017, May 31). Sources of Variation. Retrieved from <https://accendoreliability.com/sources-of-variation/>
- A.Wright, D. (n.d.). How_does_the_environment_affect_weighing. Retrieved from http://www.standardscale.com/UsefulLinks/How_does_the_environment_affect_weighing.html
- Weaver, L. (2012, December 19). Good Weighing Practices for the Food Industry - Page 3 of 5. Retrieved from <https://www.foodqualityandsafety.com/article/good-weighing-practices-for-the-food-industry/3/?singlepage=1>
- Thiex Laboratory Solutions, N. T., Canadian Food Inspection Agency, A. P., APHL and AFDO, Y. S., Dept of Agric and Consumer Services, J. C., MT Dept of Agric, H. H., SD State Univ, L. N., . . . Univ of KY, S. W. (2018). Good Test Portions [PPT]. Champaign, IL: AAFCO.
- Types of Experimental Errors. (n.d.). Retrieved from http://writeonline.ca/media/documents/LabReport_TypesOfExperimentalErrors.pdf
- Weitzel, M. L. (2013). Application of iso/iec 17025 technical requirements in industrial laboratories. Canada: Friesenpress.
- Reason, J. (2009). Human Error. Cambridge, UK: Cambridge University Press
- ISO/IEC 17025:2005 <https://www.iso.org/standard/39883.html>