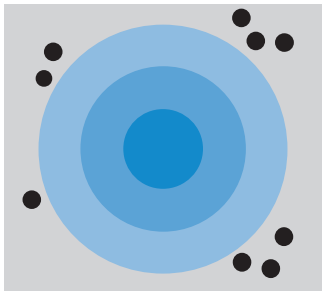
Precision

What do "Error Limit, Accuracy, Coefficient of Variation and Precision" mean in volumetric measuring?

An illustration of Precision and Accuracy

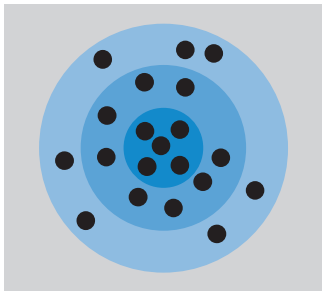
The dart board simulates the volume range around the centered specified value, the black dots simulate the different measured values of a specified volume.



Poor accuracy:
Hits far off center.

Poor reproducibility:
Hits widely scattered.

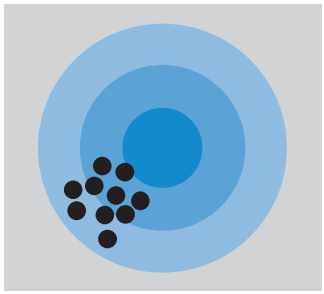
Result:
These volumetric instruments are of inferior quality.



Good accuracy:
On average, hits are evenly distributed around center.

Poor reproducibility:
No gross errors, but hits widely scattered.

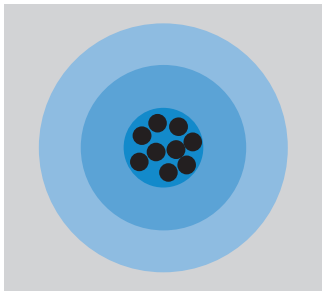
Result:
All deviations are "equally probable".
Instruments exceeding the permissible limit should be removed from service.



Poor accuracy:
Although all hits are close together, the center (true volume) is still missed.

Good reproducibility:
All hits are close together

Result:
Improperly controlled production, with systematic variation.
Instruments exceeding the permissible limit should be removed from service.



Good accuracy:
All hits are near the center, i.e., the specified value.

Good reproducibility:
All hits are close together.

Result:
The volumetric instruments have minute systematic errors, narrow scatter; the permissible limit is not exhausted. These instruments should remain in service.

To describe accuracy, the term "Error limit" is used for glass volumetric devices, while for liquid handling devices the statistical terms "Accuracy [%]" and "Coefficient of Variation [%]" have become established.

❶ Error limit

The term "Error limit" (EL) in the corresponding standards defines the maximum permissible deviation from the specified value.

❷ Accuracy (A)

Accuracy (A) indicates the closeness of measured mean volume to the specified value, i.e., systematic measurement variation. Accuracy is defined as the difference between the measured mean volume ($\overline{V}$) and the specified value ($V_{spec.}$), related to the specified value in percent.

❸ Coefficient of Variation (CV)

Coefficient of variation (CV) indicates the closeness of values of repeated measurements, i.e., random measurement variation. Coefficient of variation is defined as standard deviation in percent, related to the mean volume.

❹ Partial volumes

Generally A and CV are related to the nominal volume ($V_{nominal}$). These values are in % and have to be converted for partial volumes ($V_{part.}$). In contrast, there is no conversion for partial volumes, if A and CV are stated in volume units (e.g., ml).

❺ Error limit of A and CV

A good estimate for the error limit (EL) of the instrument, e.g., for the nominal volume ($V_{nominal}$), can be calculated using the values for accuracy and coefficient of variation.

❻ Precision (reproducibility)

It describes the closeness in volume units between the different values in a set of measurements.

❶ $$EL \geq \left| V_{measured} - V_{spec.} \right|$$

❷ $$A\,[\%] = \frac{\overline{V} - V_{spec.}}{V_{spec.}} \cdot 100$$

❸ $$CV\,[\%] = \frac{s \cdot 100}{\overline{V}}$$

❹ $$A_{part.}\,[\%] = \frac{V_{nominal}}{V_{part.}} \cdot A_{nominal}\,\%$$

(analog $CV_{part.}$ [%])

❺ $$EL \geq \frac{|A\%| + 2CV\%}{100\%} \cdot V_{nominal}$$