

Definitions

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Accuracy:

The closeness of agreement between a test result and the accepted reference value. Accuracy of a test method is described by the terms trueness and precision.

Trueness:

The closeness of agreement between the average value μ of a large number of test results and the true or accepted reference value.

Precision:

The variability between repeated test results. There are two conditions of precision; repeatability and reproducibility.

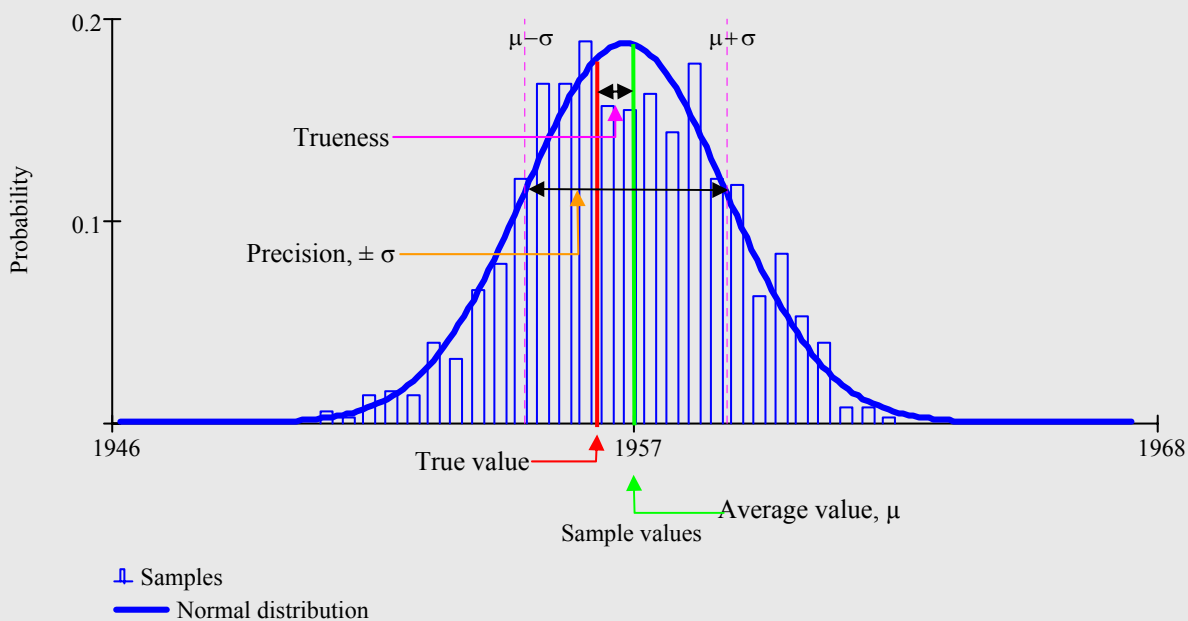
Repeatability:

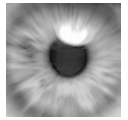
Precision of repeated test results on the same specimen, where the operator, the equipment and the environment does not vary. No calibration is done between measurements and the measurements are performed within a limited time interval. Repeatability is the minimum limit of variability in test results.

Reproducibility:

Precision of repeated test results on identical specimen, where the operator, the equipment and the environment does vary, calibrations are performed and the measurements are done during a longer period of time. Reproducibility is the maximum limit of variability in test results.

See figure below.





Instrument reading and precision

Both the reading of an instrument and the result of a measurement should always be supplied with an estimate of the precision. It is normal to use a coverage factor $k=2$, meaning that the precision used is $\pm 2 \times \sigma$. A reading $\pm 2 \times \sigma$ provides a level of confidence of approximately 95%. See formula (1).

The precision of an instrument is often given as $\pm k \times CV$ [%]. With $k=2$ this corresponds to state that any reading will be in the range $[\mu - 2 \times \sigma ; \mu + 2 \times \sigma]$ with a probability of 95%.

Instrument reading and trueness

The trueness of an instrument is found by calibration. With a device capable of generating a known measurable quality (with a given trueness and precision) and measuring this quality a large number of times to establish an average value, the trueness of the instrument is found as the difference between the known quality and the average value.

The trueness value should be part of the documentation of an instrument together with the repeatability and reproducibly

Statistical parameters and formulas

Average value, μ , of N test results ($x_1, x_2 \dots x_N$):

$$\mu = \frac{\sum_{i=1}^N x_i}{N}$$

Standard deviation, σ , of N test results ($x_1, x_2 \dots x_N$):

$$\sigma = \sqrt{\frac{\sum_{i=1}^N (x_i - \mu)^2}{N - 1}}$$

Signal to Noise ratio, SN: $SN = \frac{\mu}{\sigma}$

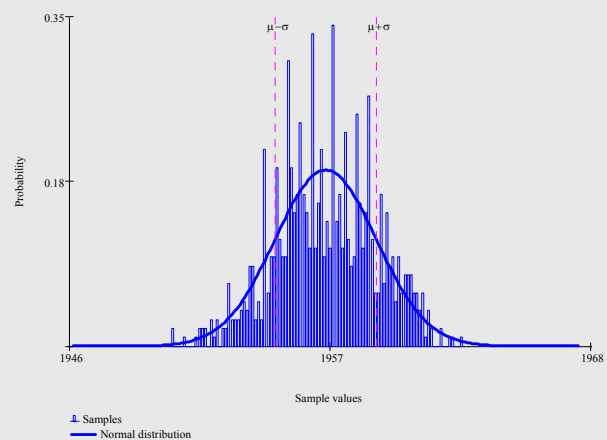
Coefficient of Variation, CV: $CV = \frac{\sigma}{\mu} \cdot 100\%$

Normal distribution: $y(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$

Calculating the probability of a sample value between $\mu - 2 \times \sigma$ and $\mu + 2 \times \sigma$:

$$\int_{\mu-2\sigma}^{\mu+2\sigma} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} dx \approx 0.954 \quad (1)$$

Normal distributed samples.



Graf of a normal distribution. $\mu = 1957$ and $\sigma = 2.13$. $SN = 919$ and $CV = 0.109\%$.

Bibliography

5725 – 1:1994, Accuracy (trueness and precision) of measurement methods and results. Part 1: General ISO principles and definitions.