Random error and systematic error of the Eppendorf Reference® 2

The quality of the dispensing results of pipettes is defined by two error concepts:

- random error and
- systematic error

The Eppendorf Reference 2 specifications for these errors are listed in the user manual and the catalogue.

Content

First this paper will explain the two concepts

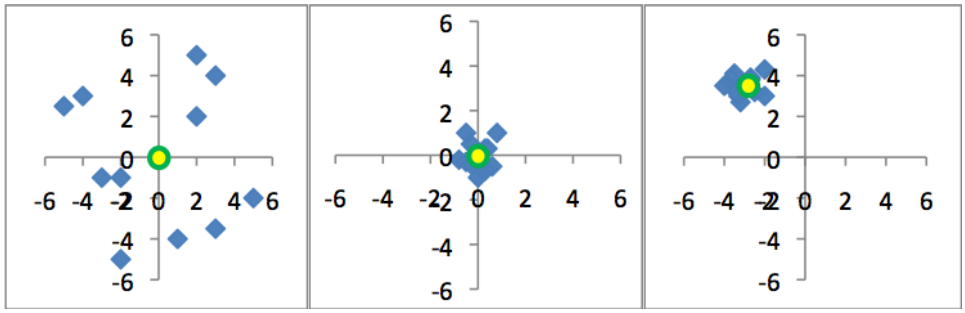
- random error and
- systematic error

Then the performance of the Reference 2 will be shown in an example.

A figurative approach to random and systematic errors

The random error is the reproducibility of a dispensed volume.
The systematic error is the proximity to the desired volume.

As an example



Mean Volume

Random error:	Bad	Good	Good
Systematic error:	Good	Good	Bad

Fig. 1: Examples for measurements with variing random and systematic errors

Random error

The measured volumes of a pipette follow a Gaussian distribution around a mean value.

The Gaussian distribution is characterized by a statistical range. The range contains 68,27 % of the measured volumes. In statistics this characteristics is called standard deviation or sigma (σ).

In the context of pipette specifications σ is named random error.

Hence 68,27% of the measured volumes are in the range of the random error specification and 31,73% are outside.

Gaussian distribution

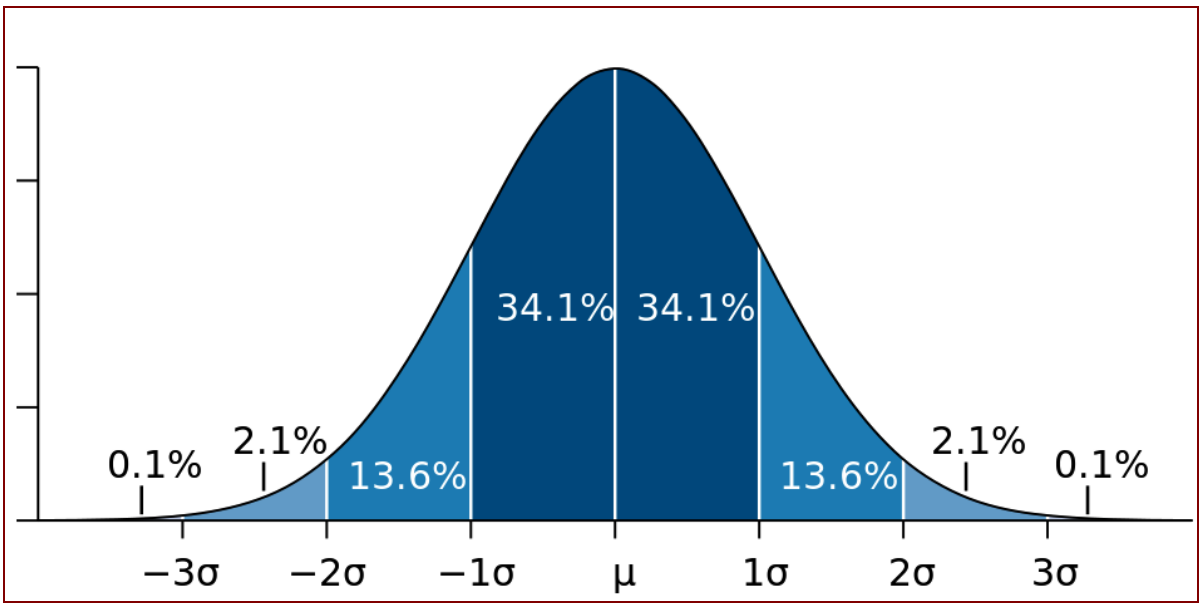


Fig. 2: Gaussian distribution with standard deviation

The following three examples show how the random error values change the Gaussian distribution.

The larger the random error values the wider the range where a significant amount of volume measurements are possible.

As you can see in Fig. 3 nearly 1 out of 20 volume measurements is 1,2 % or further away from the mean volume.

Fig. 4 shows, that this boundary is closer to the mean value, while Fig. 5 with a random error of 0,1% shows a very narrow Gaussian distribution.

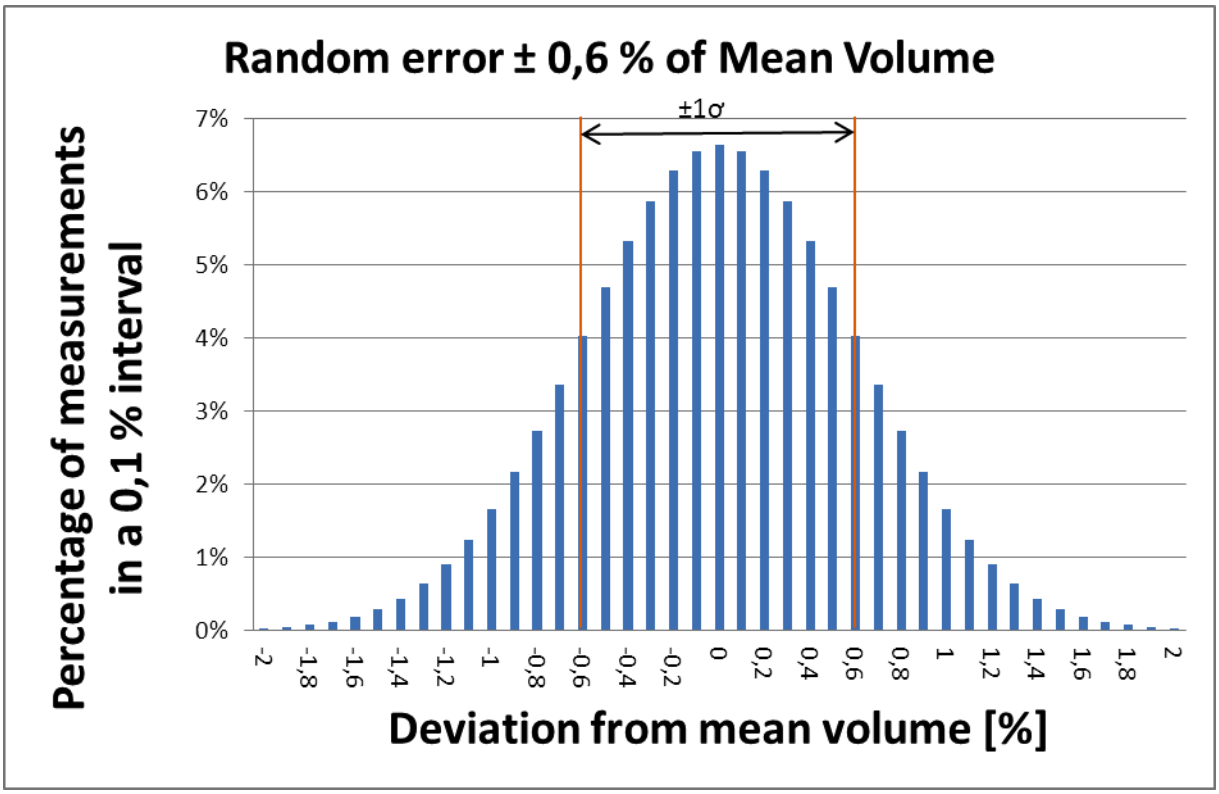


Fig. 3: Measurement distribution for a random error of ± 0,6 %

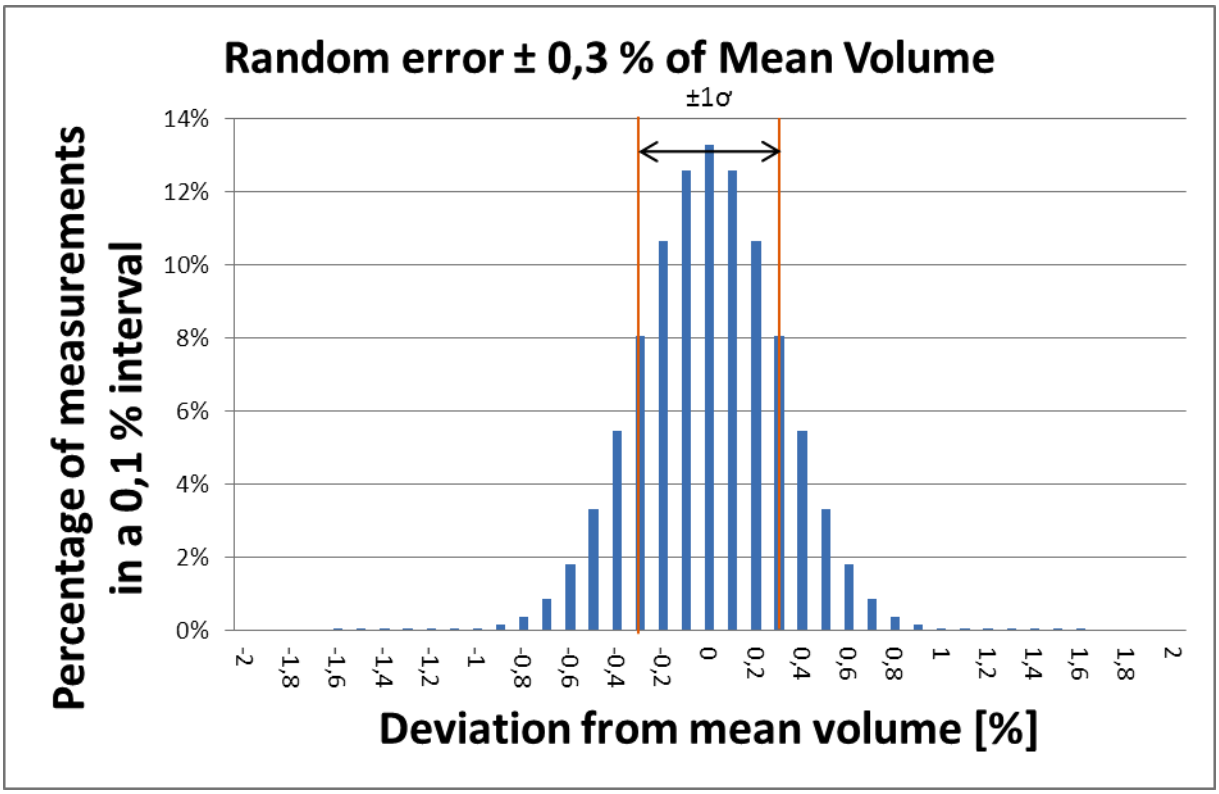


Fig. 4: Measurement distribution for a random error of ± 0,3 %

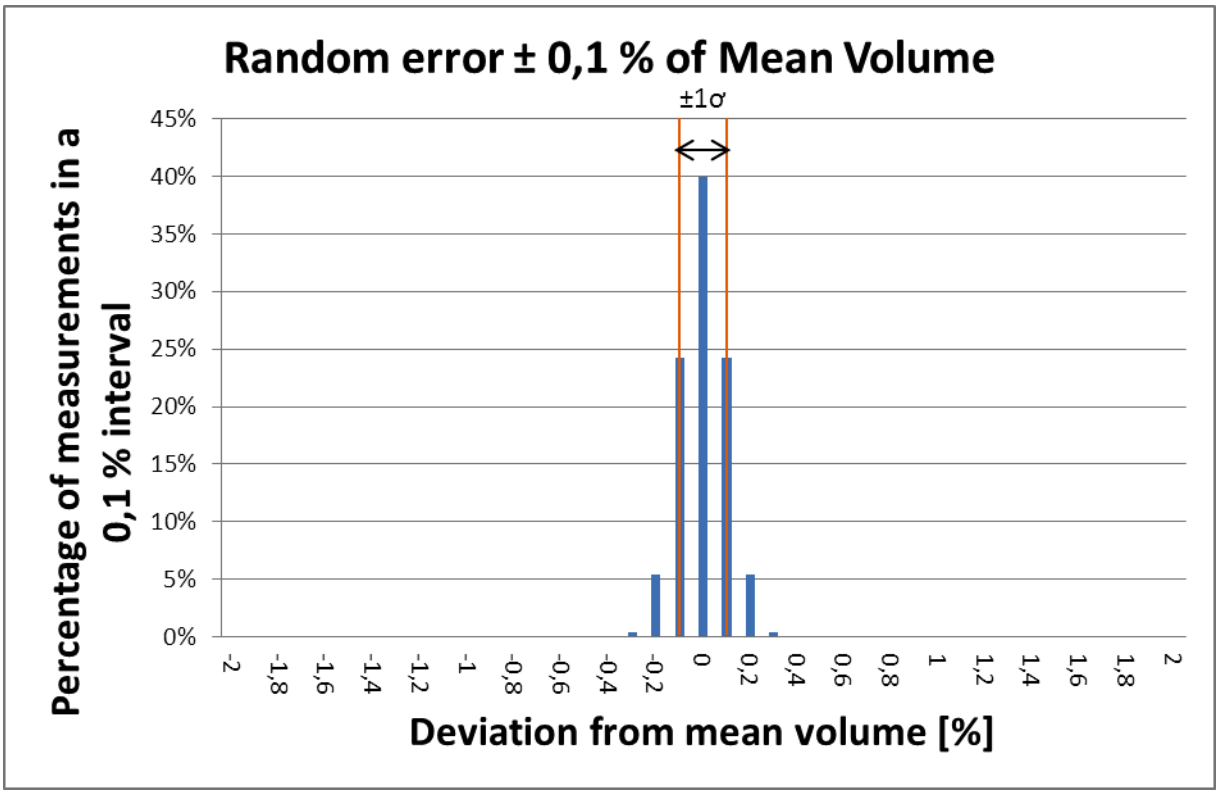


Fig. 5: Measurement distribution for a random error of ± 0,1 %

Systematic error

The systematic error is the deviation of the mean volume measured for a pipette from the volume set on the pipette counter.

The systematic error specification is a fixed range outside of which measured mean volumes are not allowed. I.e. a pipette with a mean volume outside the systematic error boundaries will not pass the calibration criteria.

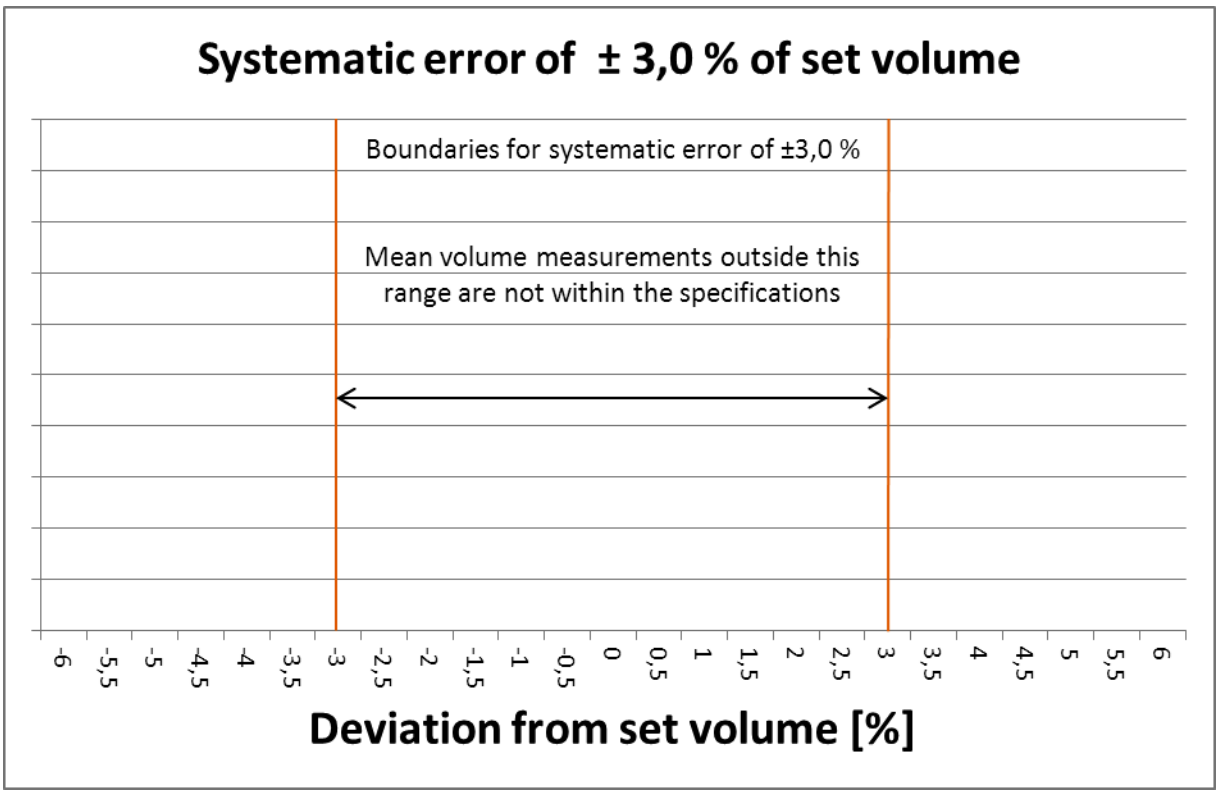


Fig. 6: Systematic error boundaries

Eppendorf Reference 2 Production Calibration Measurements
Example 1000 µL Reference 2 at 100 µL

The Eppendorf error specifications for the 100 µL measurement of the 1000 µL Reference 2 pipette are:

- Random error: ± 0,6 %
- Systematic error: ± 3,0 %

Fig. 7 shows the measurement distribution for 180 pipette calibrations. The results were summed up in intervalls of 0,25 µL.

The pipettes were 1000 µL Reference 2. The volume was set to 100 µL.

These measurements include random error and systematic error.

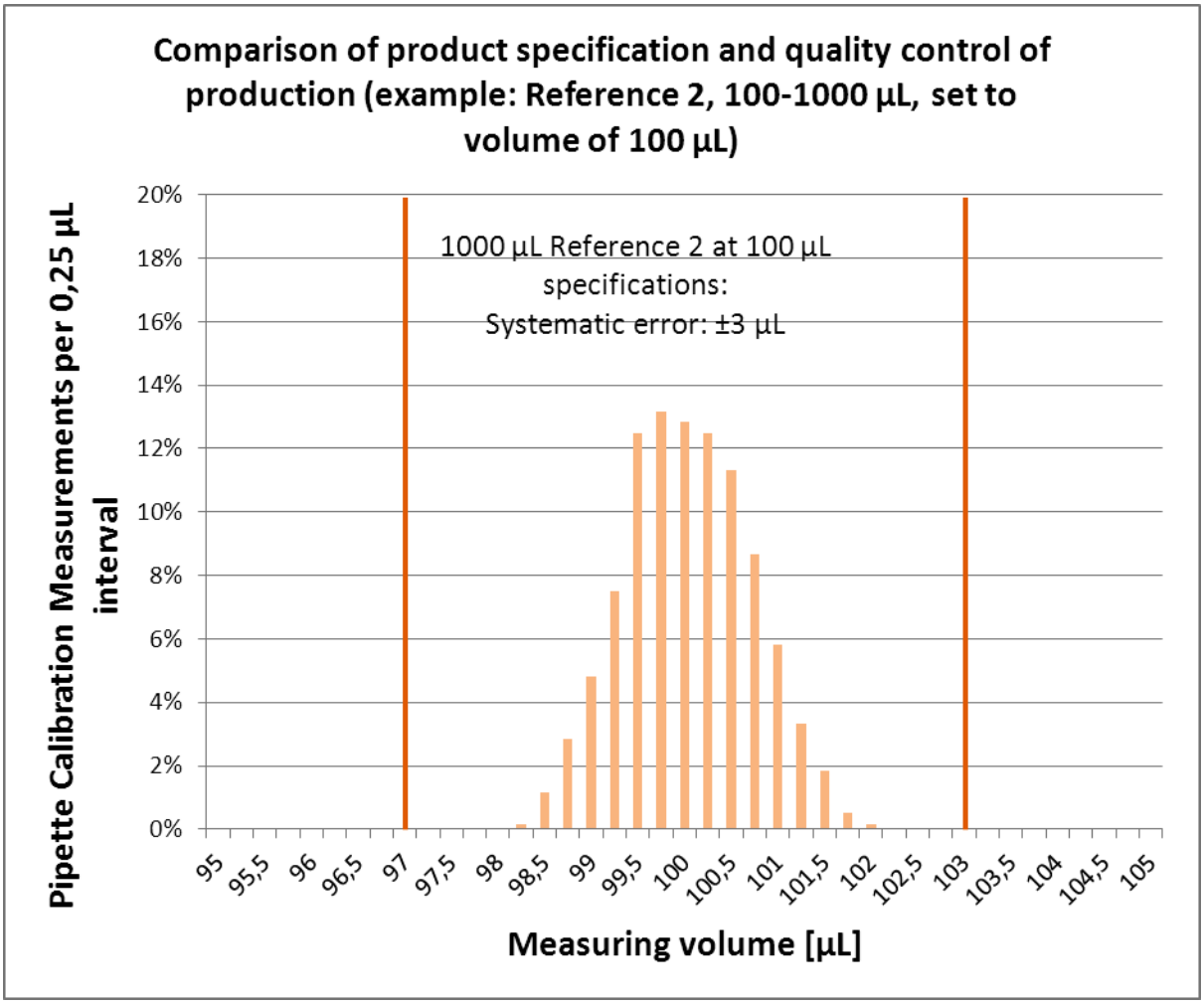


Fig. 7: Distribution of Reference 2 volume measurements (180 individual calibrations)

Conclusion

As shown in Fig. 7 calibration measurements in production of the Reference 2 show much smaller systematic and random errors as displayed by it`s technical data.

Benefit for the customer:

> The instrument is much better than stated. This means the instrument gives the user a room for errors. With Reference 2 it is easy to pipette correctly!

For customers working under regulations:

> When doing a calibration E.g. within a calibration the probability to be outside technical data is smaller than with a pipette whose accuracy only is as good as it`s technical data.

Why not displaying smaller systematic and random errors?

> In quality control of production perfect environmental conditions exist and the calibration is done by very trained personnel.
>
> Most customers use the “manufacturer specifications” as barriers for calibration results (evaluation of “pipette ok” or “pipette not ok”).
>
> To give customers without excellent conditions the possibility to meet these specifications, broader error limits are stated.