Minimum Weight & Rules of good weighing

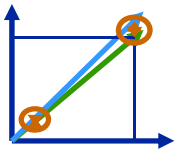
Content

- Introduction to "minimum weight"
  specifications of a balance influencing the results
- Minimum weight
- Rules of good weighing
  how to perform weighing the right way

Essentials

- Nominal properties
  - Readability (RD)

- Measurement properties
  - Sensitivity (SE)

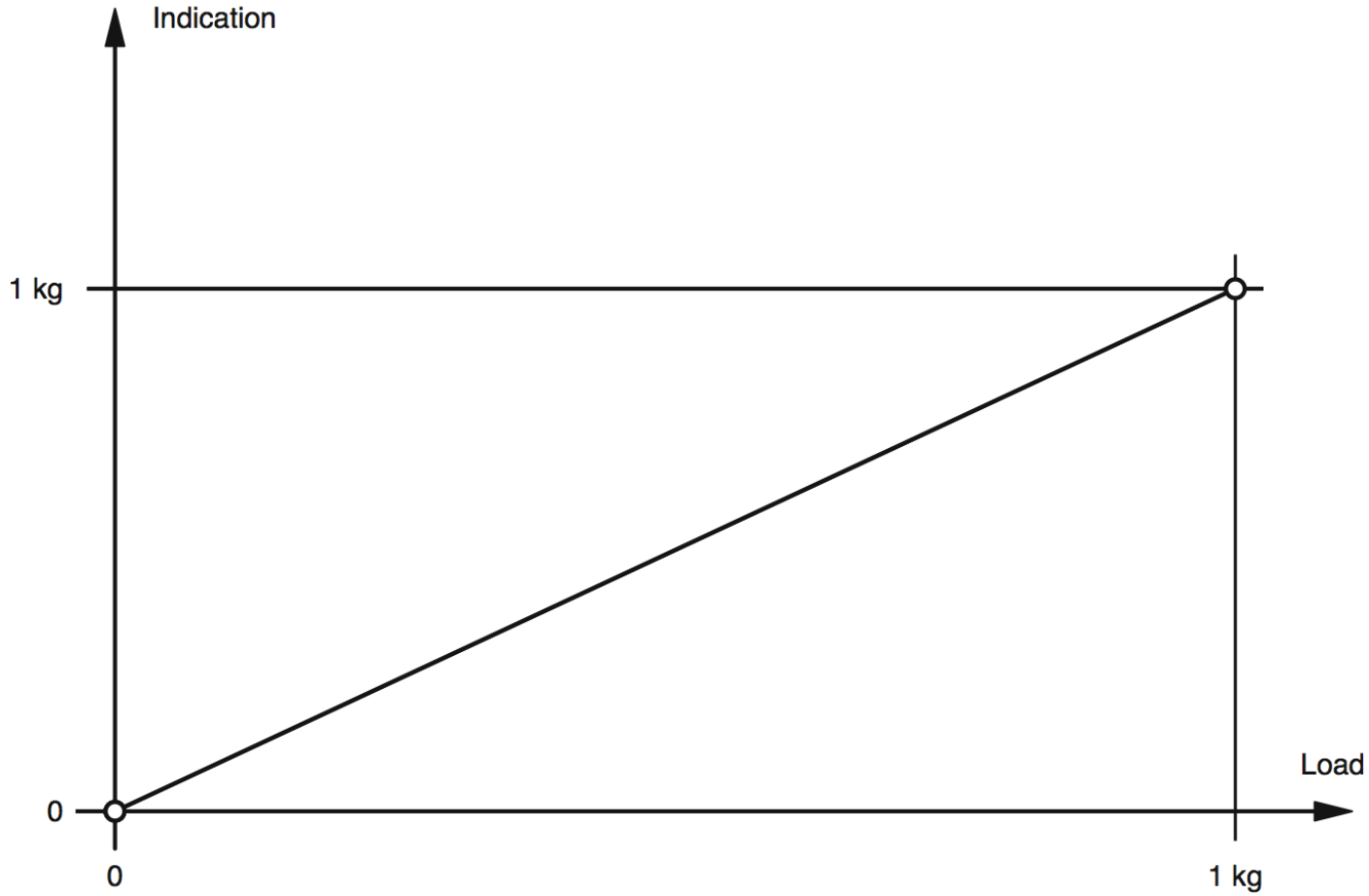


  - Non-linearity (NL)

  - Eccentricity (EC)

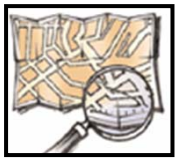
  - Repeatability (RP)

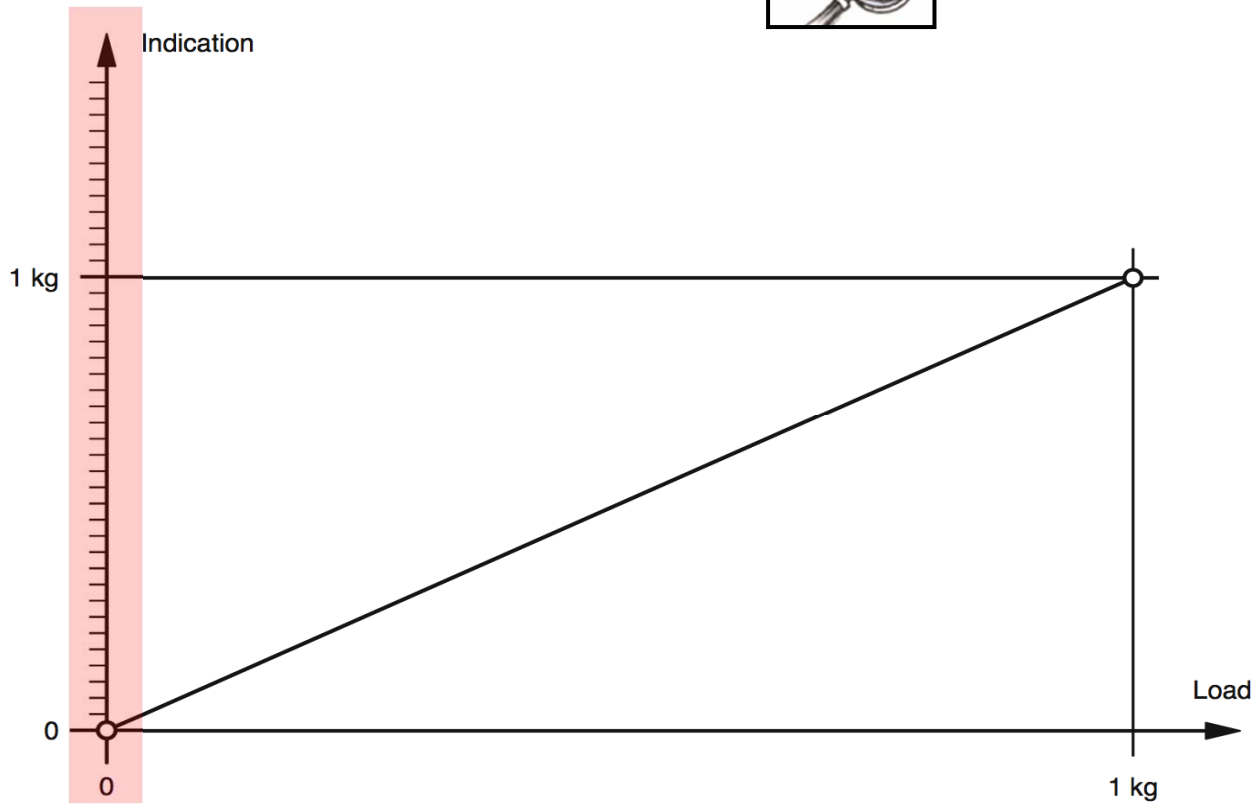
A perfect balance…



A perfect balance…

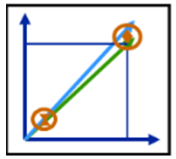
- …impaired by readability (RD)

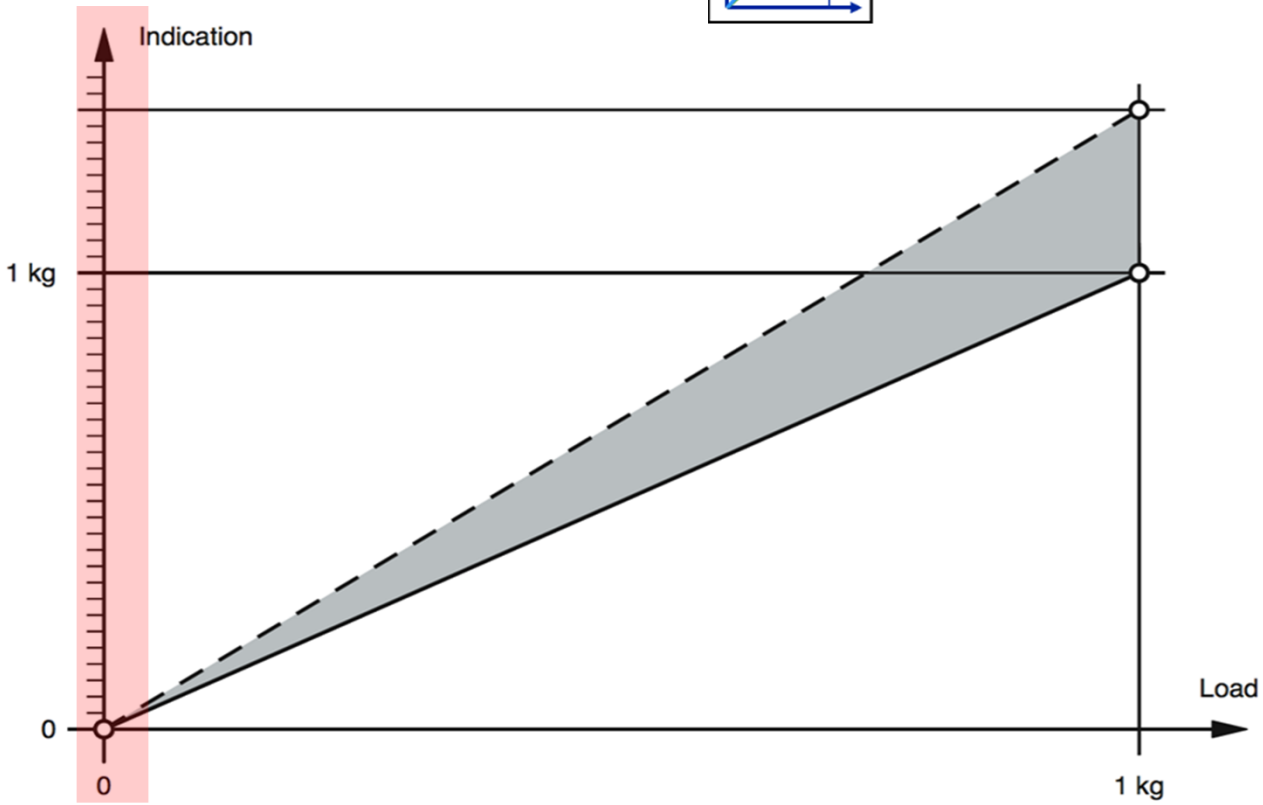




A perfect balance…

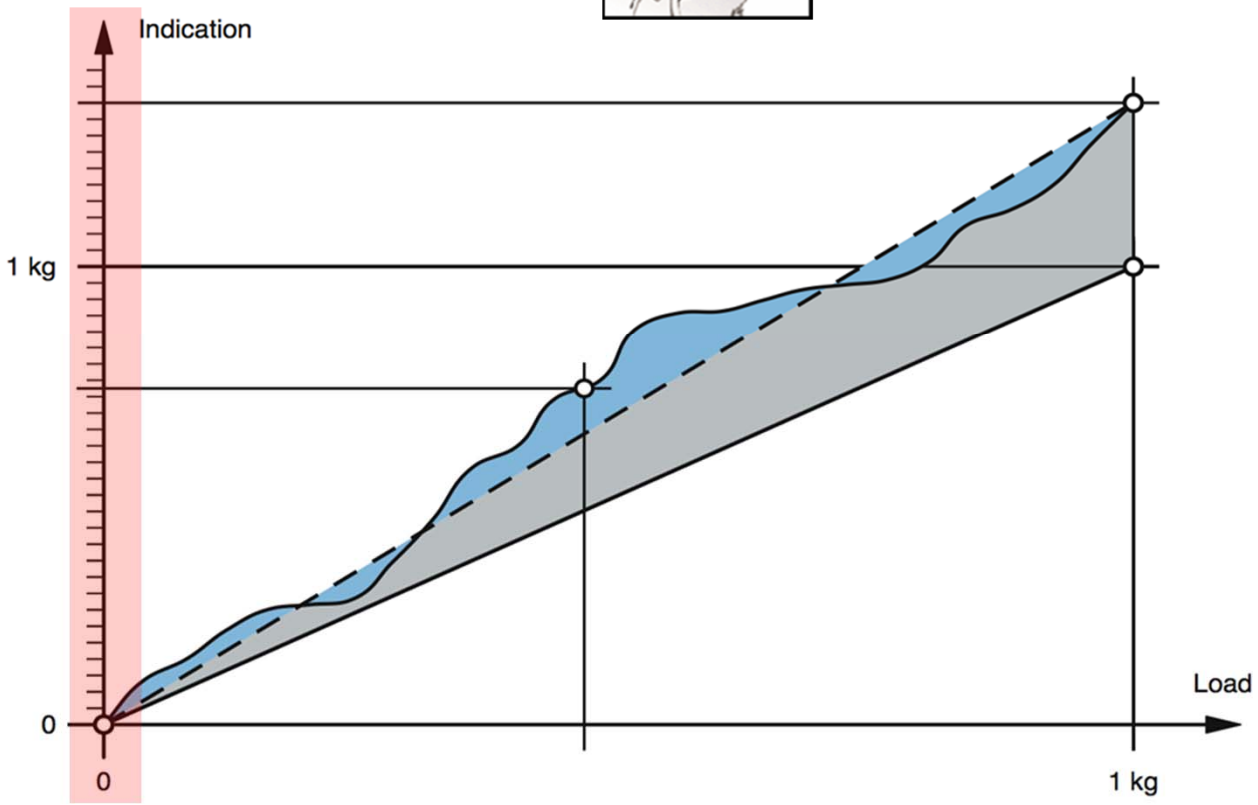
- …and sensitivity offset (SE)





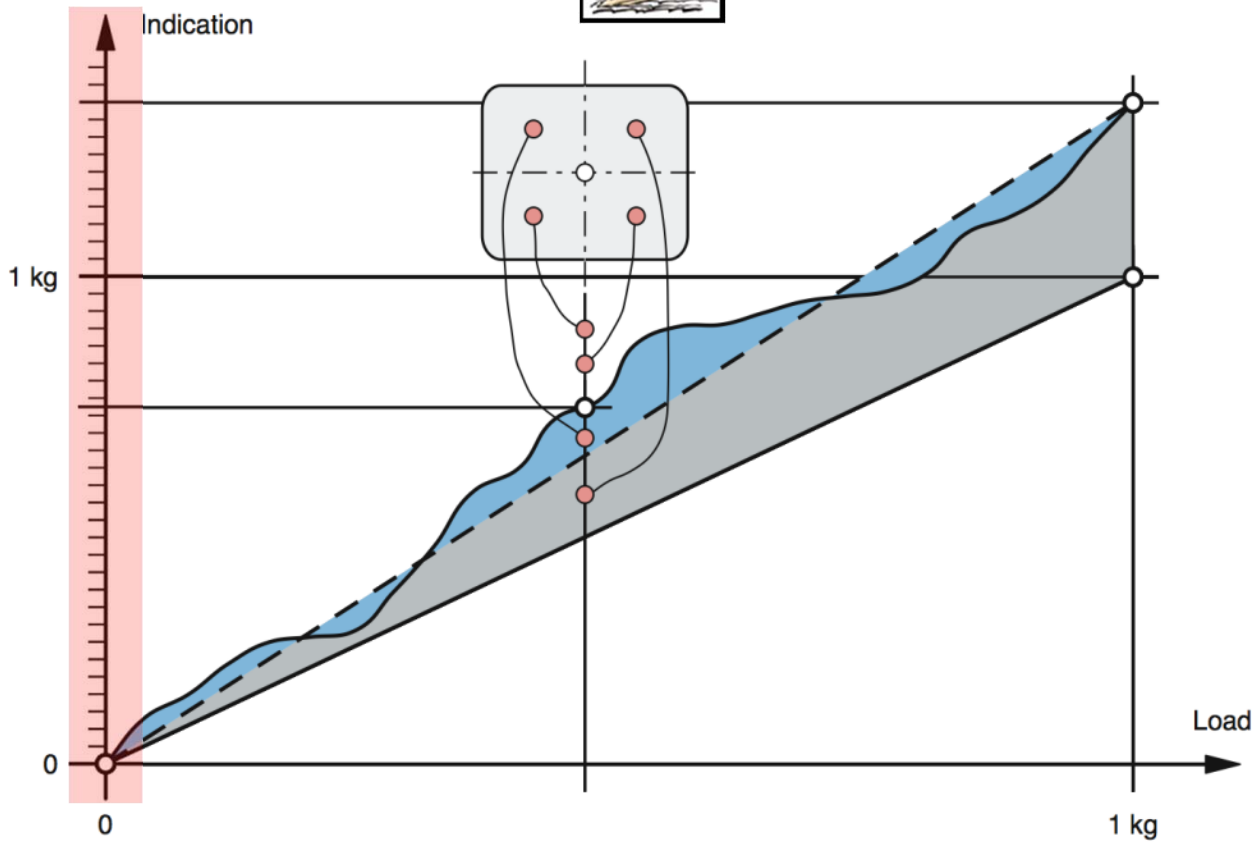
A perfect balance…

- …and non-linearity (NL)



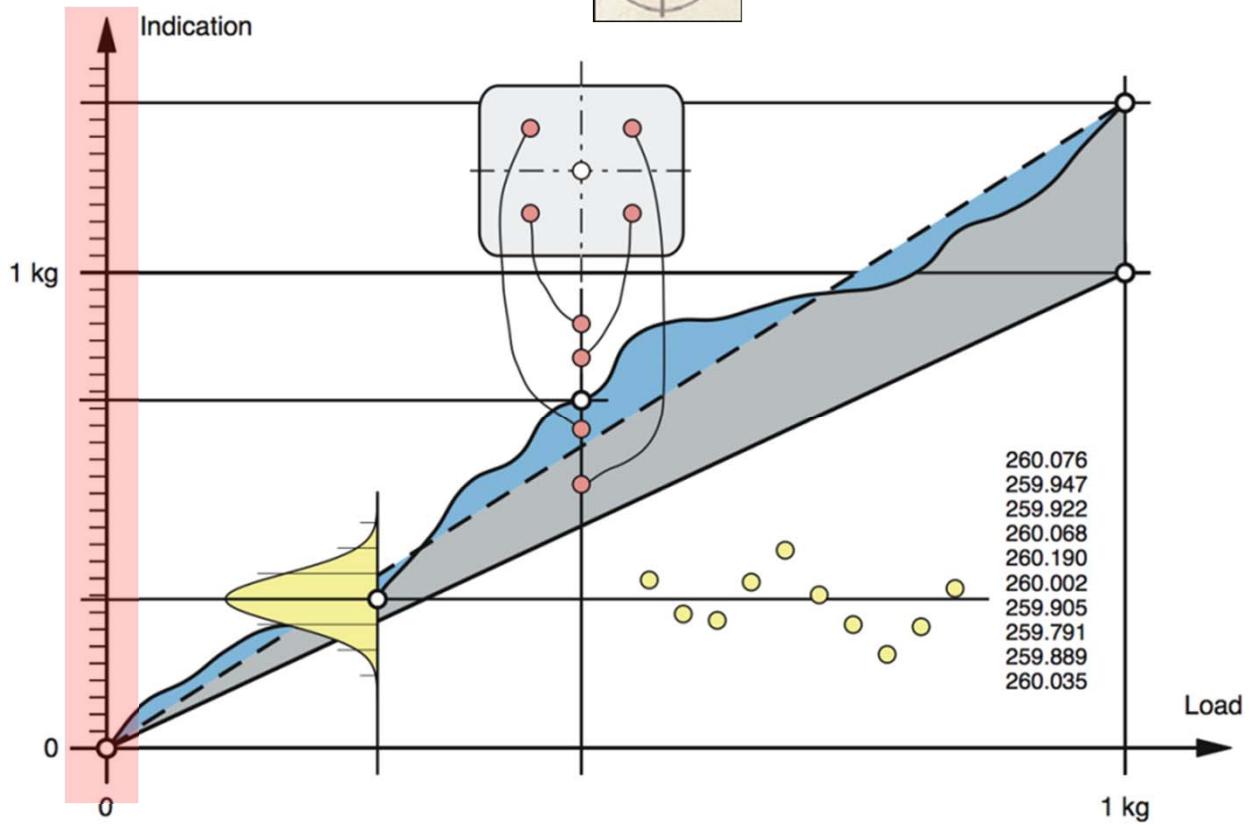
A perfect balance…

- …and eccentricity (EC)



A perfect balance…

- …and repeatabilty (RP)



It's all about repeatability…

- **Repeatability** is the ability of a weighing instrument to provide identical results as the same load is placed several times and in practically identical way on a load receptor, under relatively the same test conditions.
- Standard deviation s_{RP} of a series of measurements is a suitable measure to determine the value of repeatability.

$$S_{RP} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(X_i - \bar{X})^2}$$

Where $\bar{X}$ is the average of n readings
and n is the number of indivifual results

It's all about repeatability…

- **Repeatability** is influenced by many factors, such as:
  - Balance's model and configuration
  - Gross load (including TARE)
  - Operator (weighing skills)
  - Ambient conditions (temperature, humidity, drafts, vibrations…)
  - Equipment used (size of the weighed object, vessel type & size…)

- Repeatability estimation may not be reproducible!
  - …and there is a high probability it will differ if estimated on other occasions

Can I trust my balance's reading?

Actual sample weight	Display value	Relative error
0.05mg	0.1mg	**100%**
0.149mg	0.1mg	33%

- A 4-decimal place balance will show 0,1mg whether 0,05mg or 0,149mg is placed on the pan.
- For very small weights, the relative measurement uncertainty can be so high that the weight cannot be trusted anymore!
- 100% error is unacceptable, especially in pharmaceutical industry.

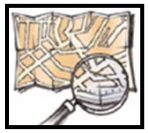
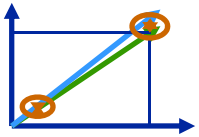
Is 0,1mg always 0,1mg?

Actual weight (g)	Displayed Value (g)	Relative measurement error
0.00005	0.0001	100.000000%
0.00095	0.0010	5.263158%
0.00995	0.0100	0.502513%
0.09995	0.1000	0.050025%
0.99995	1.0000	0.005000%
9.99995	10.0000	0.000500%
99.99995	100.0000	0.000050%
199.99995	200.0000	0.000025%

EX224
d=0,0001g

- The more the sample's actual weight is, the smaller the relative error

Is 0,1mg always 0,1mg?

Readability	(RD)	
Sensitivity	(SE)	
Non-linearity	(NL)	
Eccentricity	(EC)	
Repeatability	(RP)	

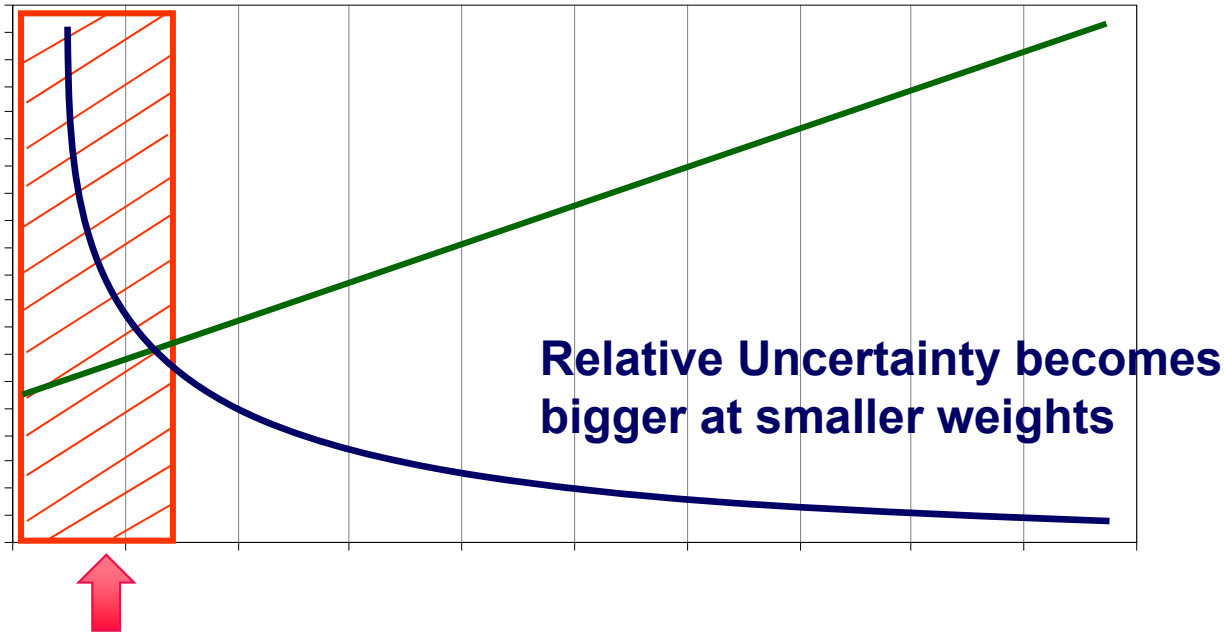
This is determined during calibration

All these factors add up to the uncertainty of measurement, repeatability being the strongly influencing one!

Uncertainty and safe areas

Relative Measurement Uncertainty [%] = Absolute Measurement Uncertainty / Load

Absolute Measurement Uncertainty [g]



Unacceptable relative measurement uncertainty

Minimum Sample Weight

- Smallest sample required to achieve a specified relative accuracy of weighing. Provided that systematic errors have already been corrected, the minimum sample weight m_{min} can be determined from the allowed uncertainty U and the repeatability of the weighing s_{RP}

$$m_{min} = \frac{k}{U} s_{RP}$$

$k \rightarrow$ expansion factor

Corresponding requirements are described, for instance, in pharmacopeias (e.g. → USP U = 0.10%, k = 2 [USP<41>]12), or may be defined in the user's process specifications.

It's all about repeatability…

- The value for s_{RP}, which is the standard deviation for *n* replicate weighing's (n ≥ 10), X_i under actual conditions of use, and is easily calculated from the first equation.

$$S_{RP} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(X_i - \bar{X})^2} \qquad m_{min} = \frac{k}{U} s_{RP}$$

The problem is when the repeatability of the balance is so good that s_{RP} becomes zero. To get round this problem, if s_{RP} is smaller than 0,4d, s_{RP} =0,4d.

Safe-weighing areas

Actual weight (g)	Displayed Value (g)	Relative measurement error
0.00005	0.0001	100.000000%
0.00095	0.0010	5.263158%
0.00995	0.0100	0.502513%
0.09995	0.1000	0.050025%
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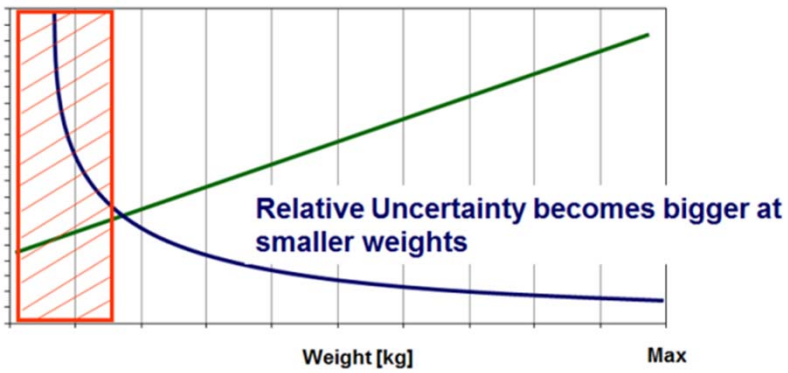
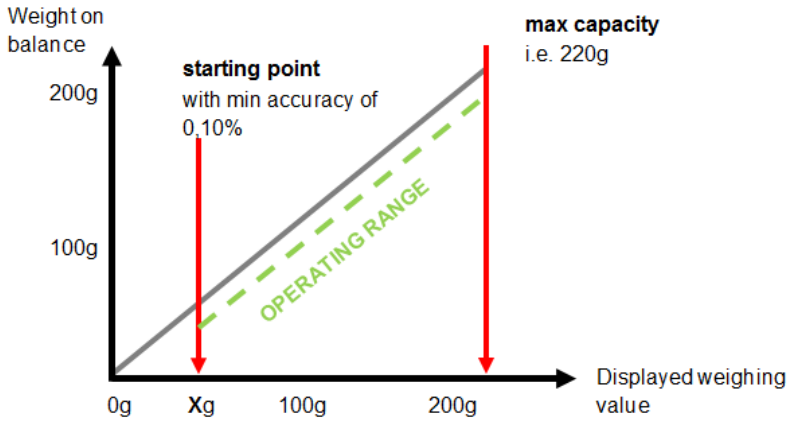
EX224
d=0,0001g





EX224 - example

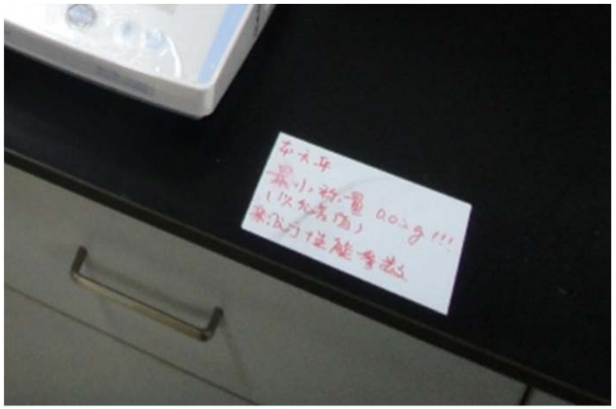
- Tested under actual environment, the s_{RP} = 0,08mg
- In the given conditions, results are as follows:

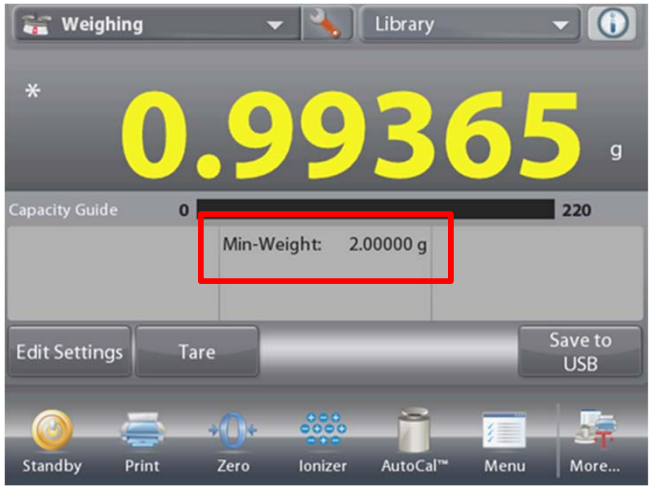
Weighing Accuracy % (U)	Safety Factors (K)			
	1x	2x	3x	5x
	(no safety factor)	(safety factor of 2)	(safety factor of 3)	(safety factor of 5)
0,10	0,0800g	0,1600g	0,2400g	0,4000g
0,20	0,0400g	0,0800g	0,1200g	0,2000g
0,50	0,0160g	0,0320g	0,0480g	0,0800g
1,00	0,0080g	0,0160g	0,0240g	0,0400g
2,00	0,0040g	0,0080g	0,0120g	0,0200g
5,00	0,0016g	0,0032g	0,0048g	0,0080g

- According to USP *(U=0,10% and k=2)*, the minimum weight is 0,1600g

Below min-weight indication!

- It's not always easy to remember the min-weight value for a particular balance…
- OHAUS lab products are equipped with a below minimum weight indication!





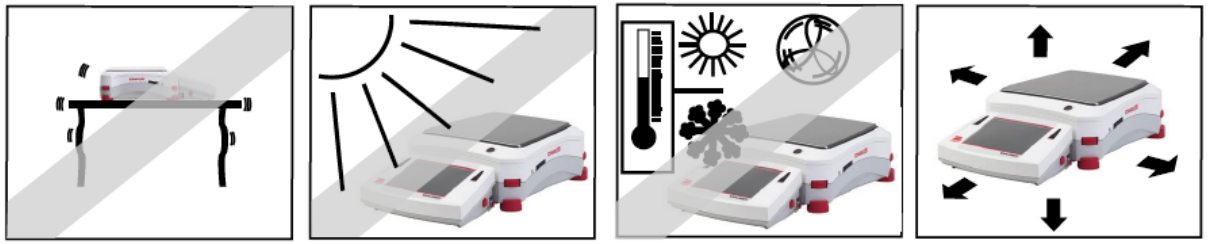
Did you know that…

- The environment, operation, will affect s_{RP}. It's better to test the instrument under actual environment to get the actual s_{RP},
- Minimum weight should be calculated according to user's required accuracy and safety factor,
- A baseline should be established when the balance is first installed.
- As the balance ages, the s_{RP} can change. The user will need to decide how frequently to check it.
- If the operational range of the balance changes, then this is a good time to recalculate s_{RP}.

Rules of Good Weighing

- Weighing – the most common task performed in the laboratory is so obvious that you might not realize that there are many factors influencing proper results. Modern balances are so advanced that using many of them minimizes the risk of error caused by the environment, however there are still influences disturbing the perfect weighing process.
- Especially with respect to the semi-micro balances where relatively light samples are being weighed, the risk of error increases drastically. To ensure your results are precise and accurate the following rules should be followed.

Location



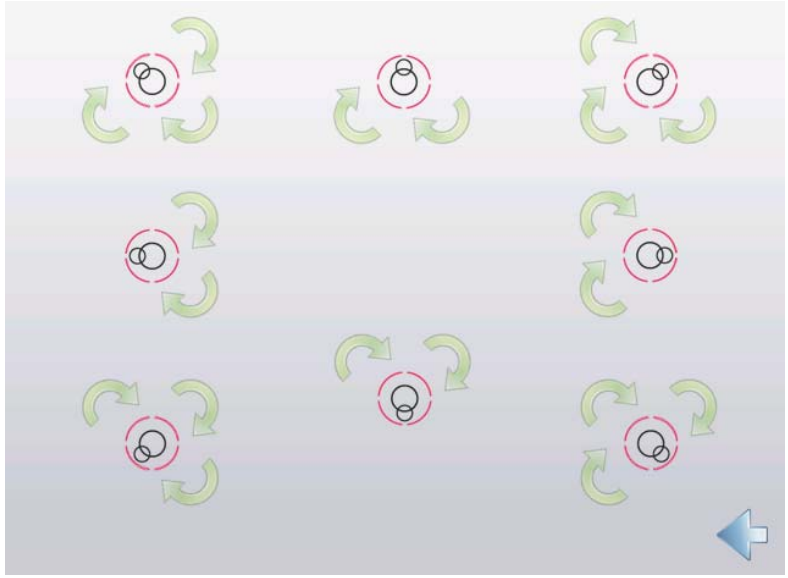
- Weighing room, free from drafts and vibrations
- Weighing table, free from vibrations
- Antimagnetic (no steel plates)
- Free from static charges (no plastic or glass)
- Mounted to either the floor or the wall

Power supply

- Keep the balance connected to a power outlet
- Leave it on stand-by mode when not in use

Leveling

- Level the balance

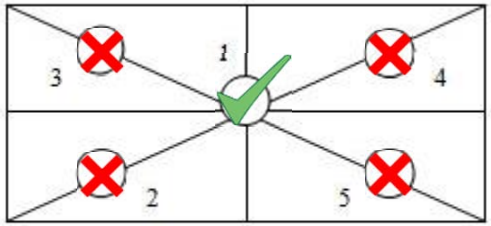


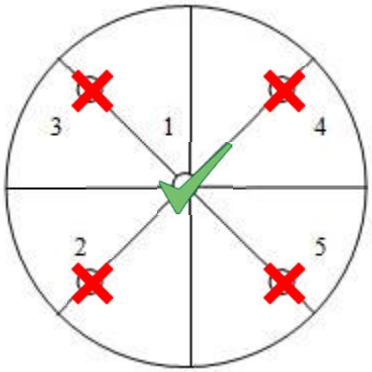
Calibration

- AutoCal™ helps compensating environment-related changes
- Automatic adjustment temperature- or time-triggered

Placing sample on the pan

- In the center – to avoid eccentricity errors





- Use smallest possible weighing vessels

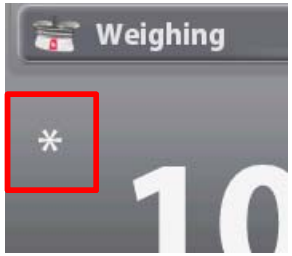
Static charges

- Avoid using vessels that migt be charged with static electricity (plastic)
- If required, eliminate the charges using an Ionizer

Reading the results

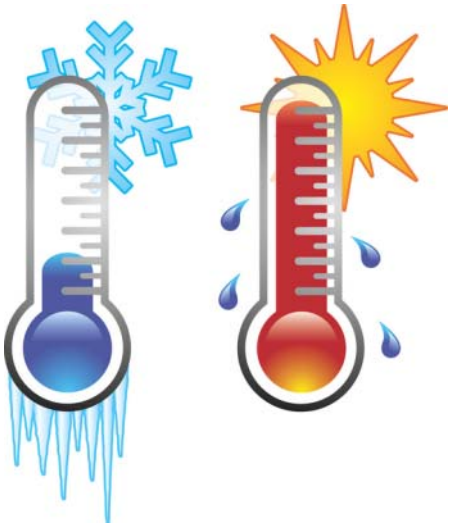
- Perform weighing only if the balance shows ZERO before each measurement

- Read only when stable



In-draftshield environment

- Keep the draftshield closed and open only when necessary



Take care of the balance!

- Keep the weighing pan and weighing chamber clean
- Use only clean vessels for weighing
- Do not brush contaminations into potential openings