ME 120 Experimental Methods

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Experimentation and Validity of Measurement

Why Measure?

- Research Investigation
- Product (or process) Development
- Performance Testing
- Operational Monitoring
- System Control

Measurand and Measurement System Output

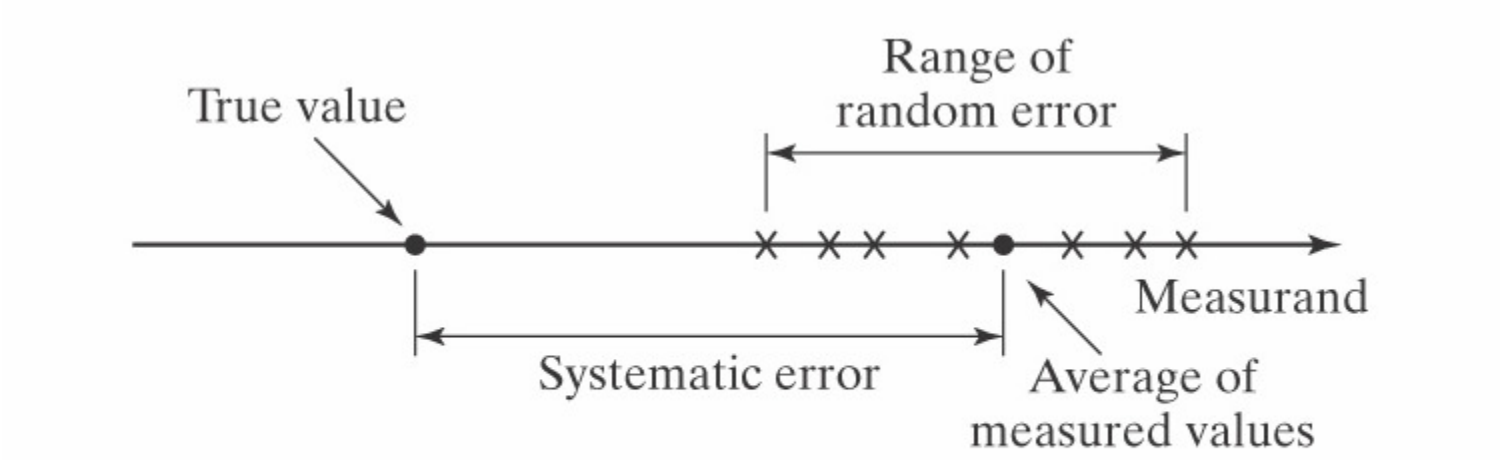
- All measurement systems have a measurand and an output.
- In small groups, make a block diagram of a generalized measurement system that shows what lies between the measurand and output.
- Alternatively, start with a few specific measurement systems, and then generalize.

Error and Uncertainty

- **Error** is the difference between the measured value and the true value.
- The error can not actually be known until after the measurement.
- **Uncertainty** is an estimate of the magnitude of error, typically expressed in terms of a confidence interval within which the error lies.

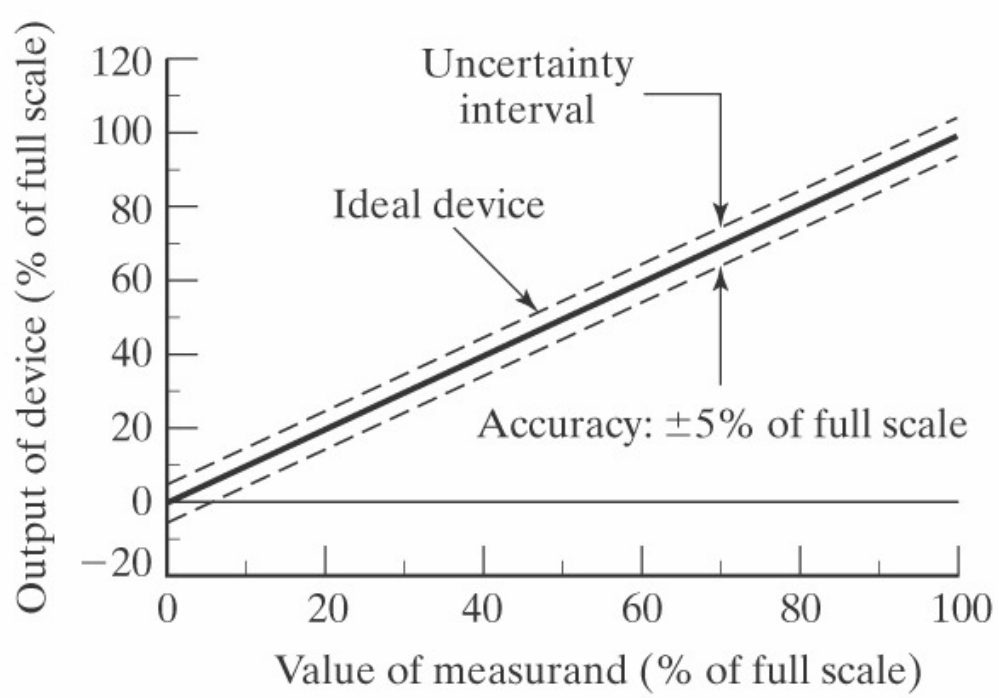
Systematic Error and Random Error

- **Systematic error** (or bias error) is repeatable.
  - e.g. imperfect calibration, residual loading, intrusive measurements, spatial bias
- **Random error** is not predictable.
  - e.g. environmental variability, noise, vibration



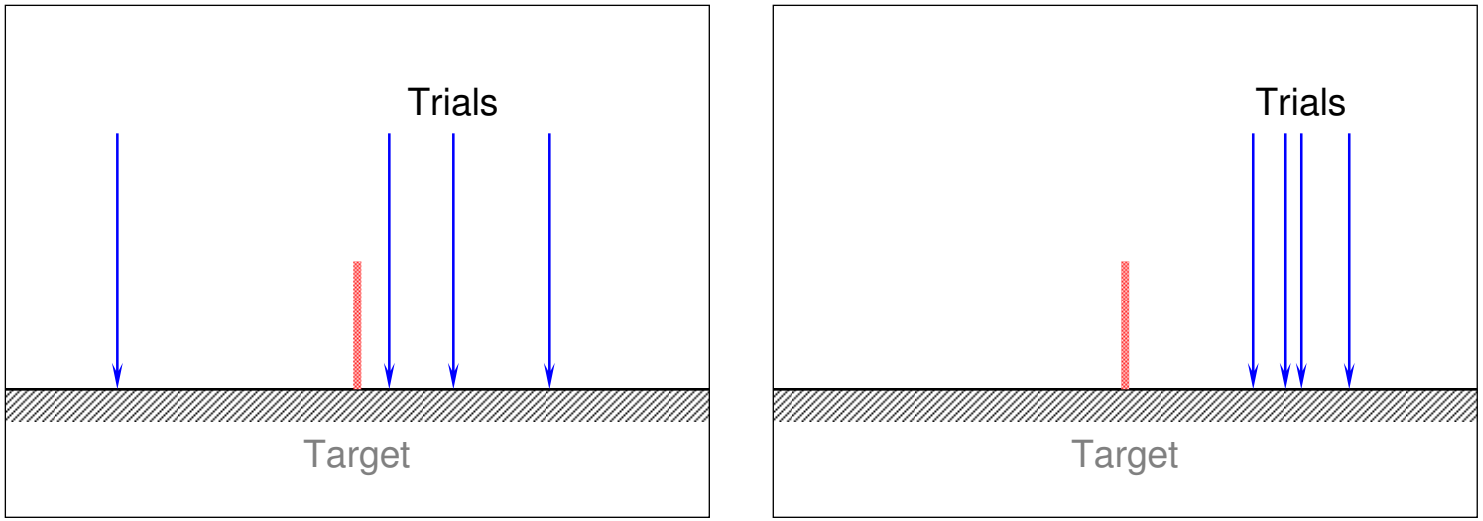
Accuracy

- **Accuracy** of a measurement is the closeness to true value, and quantified uncertainty.
- Specifications for sensors typically include both systematic and random errors, and are often expressed as % of full scale.



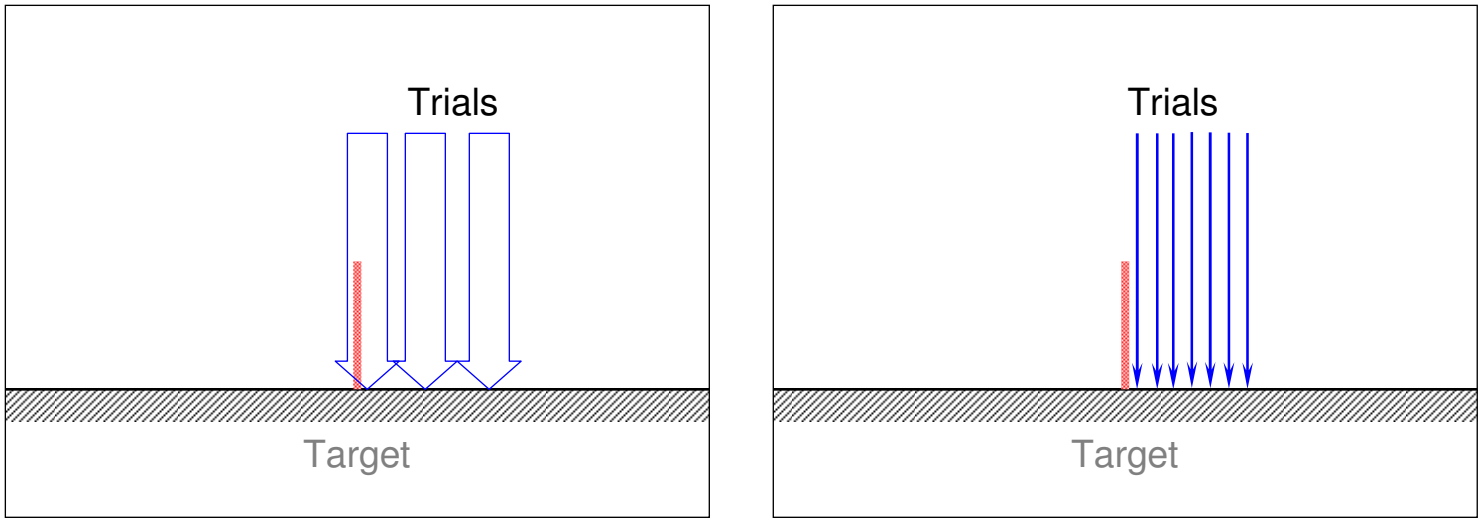
% full scale is a convenient way to acknowledge that sensors are limited to a finite **range**.

Repeatability and Precision



- **Repeatability** is the degree of reproducing the same result among multiple measurements that applied under identical measurement conditions.
- A measurement system is said to have good **precision** if it produces measurements with good repeatability…not to be confused with accuracy or resolution!

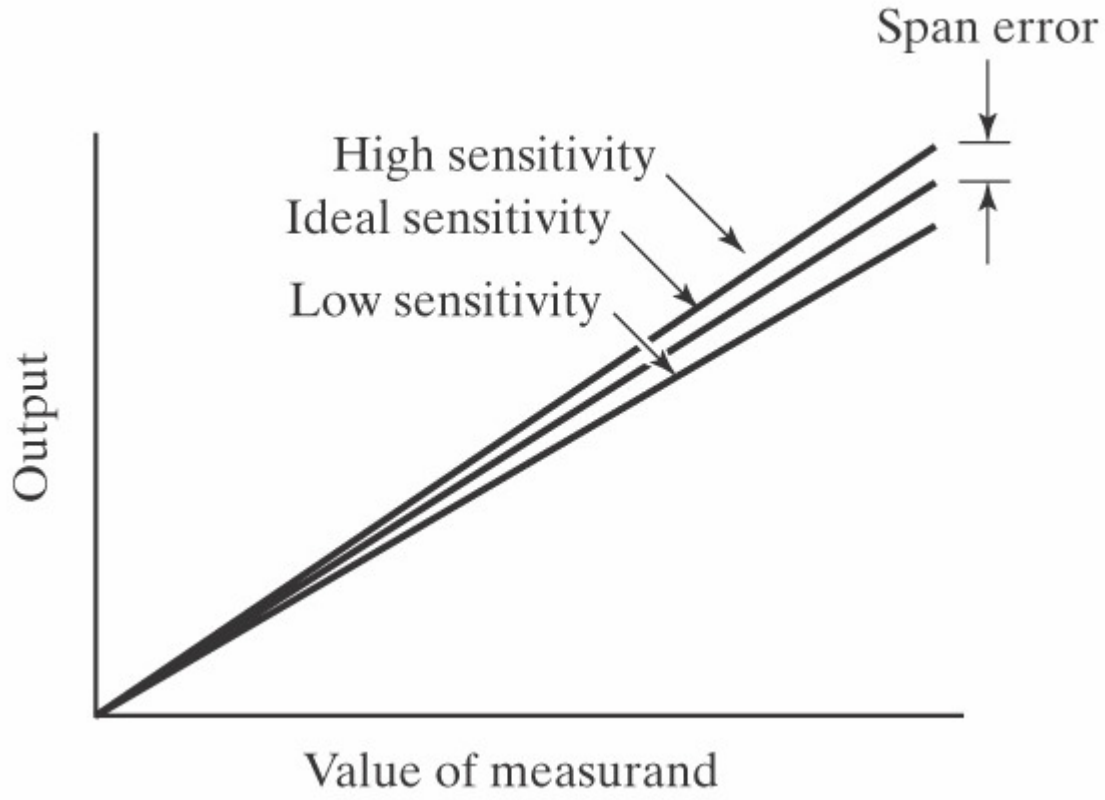
Resolution



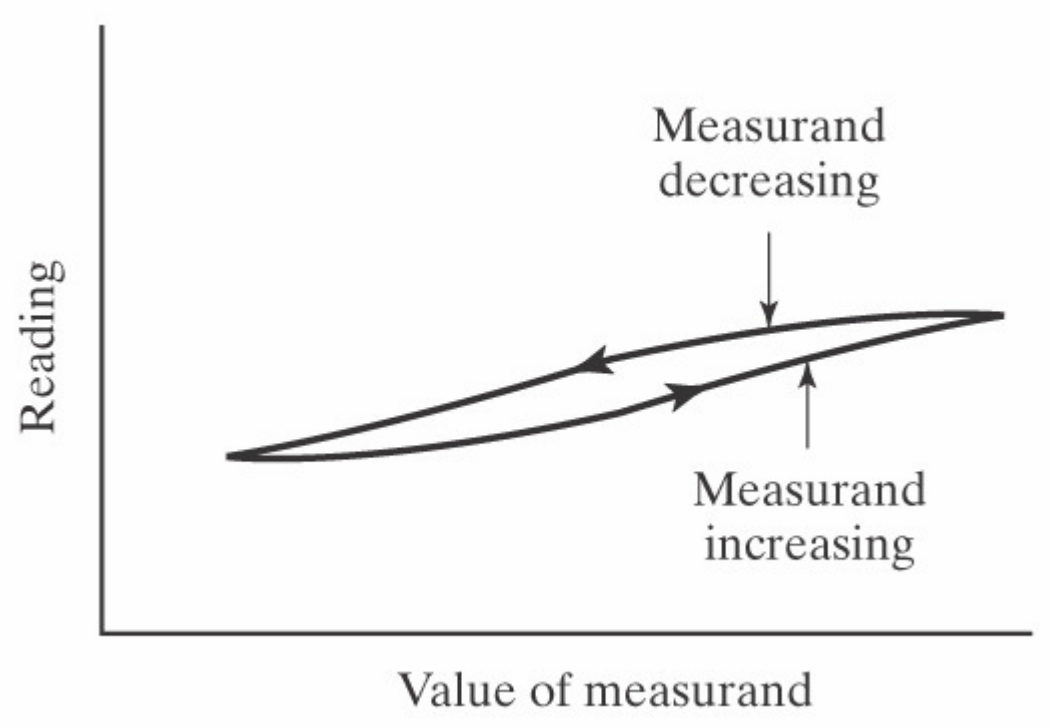
- **Resolution** is the capability of distinguishing individual units separately from one another.
- Resolution is often manifested in the smallest increment of the measurement device or display (e.g. ±0.5 the least significant digit).

Sensitivity

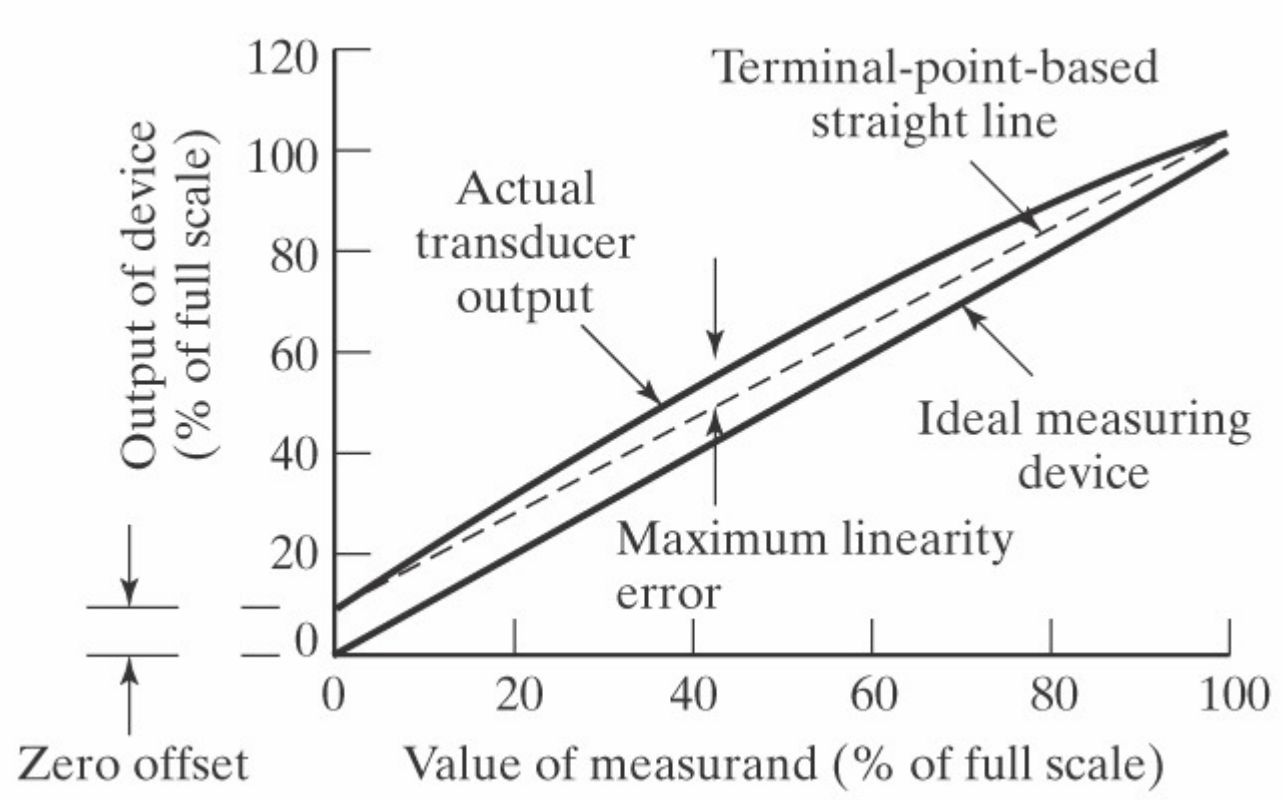
- **Sensitivity** of measurement device is the ratio of change in output to change in input, and is manifested as the slope of the output-vs.-measurand "line".



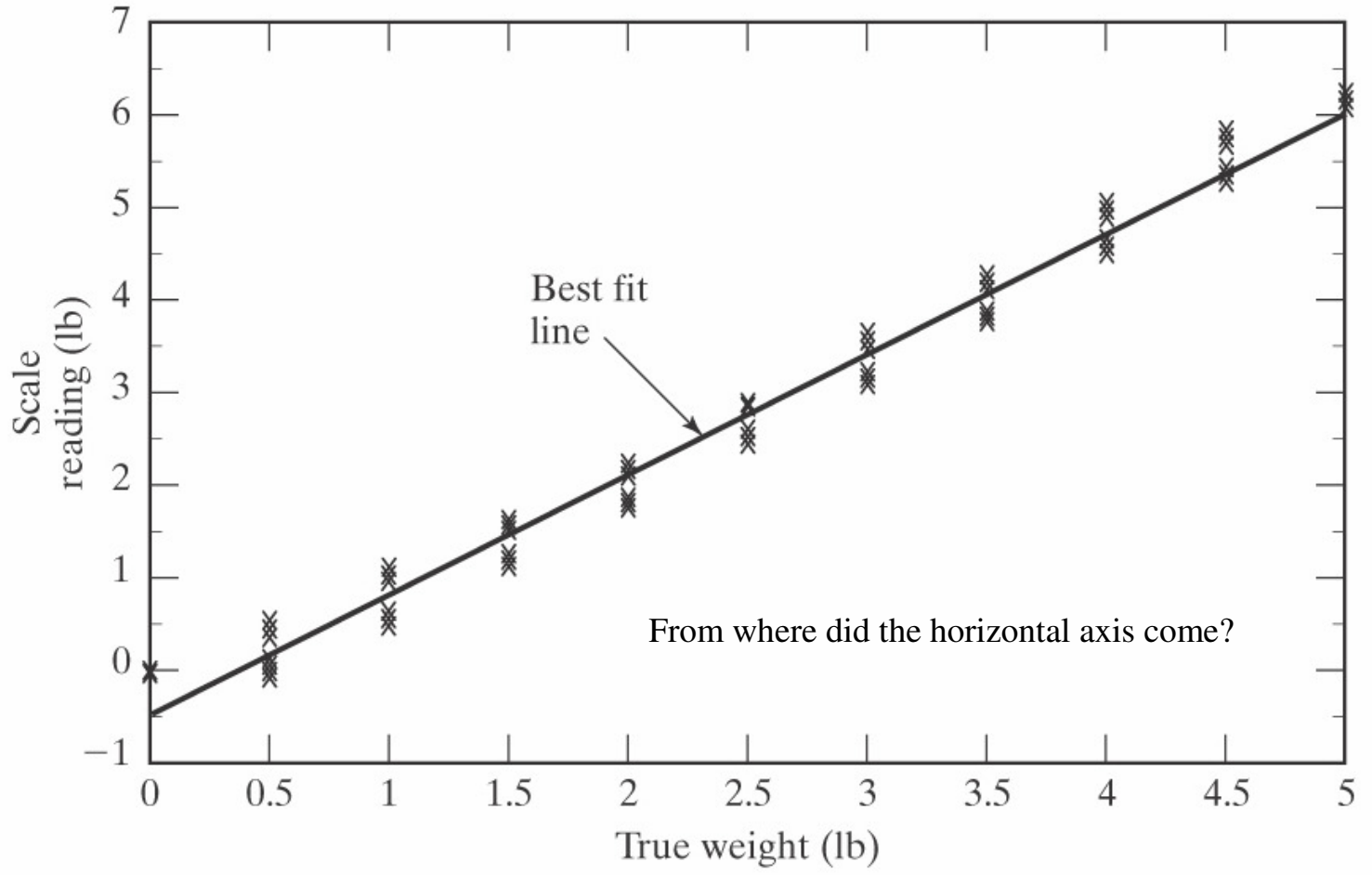
Hysteresis



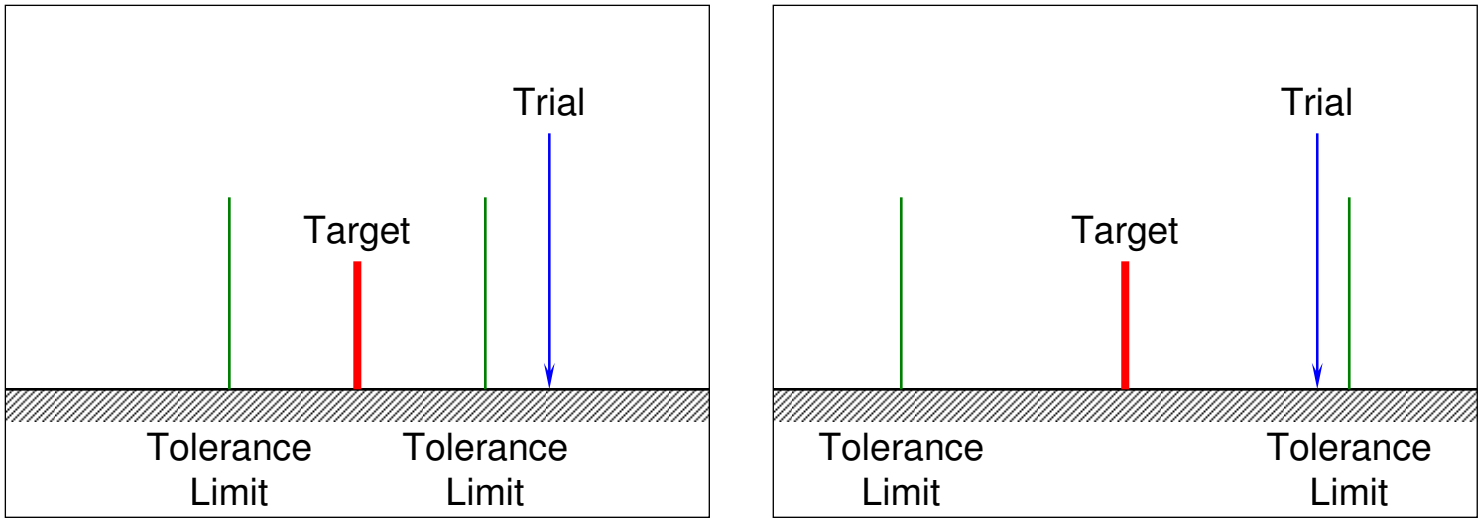
Zero Offset and Linearity Error



Calibration



Tolerance



- Tolerance is the acceptable deviation from a target value, or the range of acceptable limits with respect to a target value.
- Tolerance is "externally" imposed.
- Not necessarily symmetric.
- "Strict" or "Relaxed" ?