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*Calibration and Testing metrology, Good Laboratory Practices*  
*By B.M.Vyas*

A specifically designed programme for

Da Afghanistan Breshna Sherkat (DABS)  
Afghanistan



## Metrology

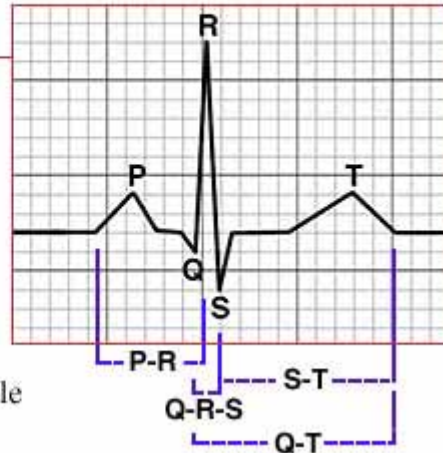
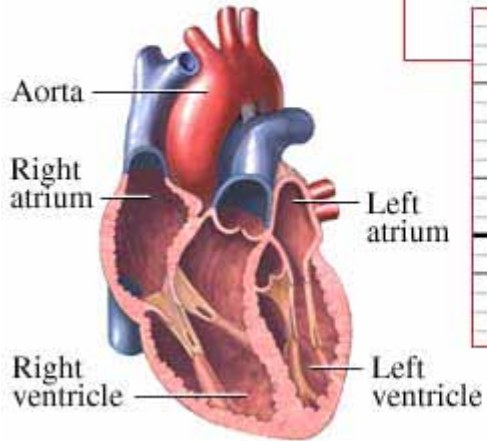
- The Science of Measurements
- “Meteorology” is science of climates and whether



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## Life is full of measurements





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## What is measurement?

- Is a process
- For determination of value of a quantity



## Accuracy

- Most commonly used term
- Very loosely used term

### Definition

The quality (of measurement) which characterizes the ability of a measuring instrument to give indication equivalent to the true value of the quantity measured



## Accuracy

- What is an Accuracy Class for energy meter?
- Does a class 0.2 accuracy guarantee measurements within  $\pm 0.2\%$ ?



## True Value

- The value which characterizes a quantity perfectly defined.
- This is only theoretical concept.
- No quantity can be measured perfectly



## Conventional True Value

- A value approximating to the true value of a quantity such that, for the purpose for which that value is used, the difference between these two values can be neglected.



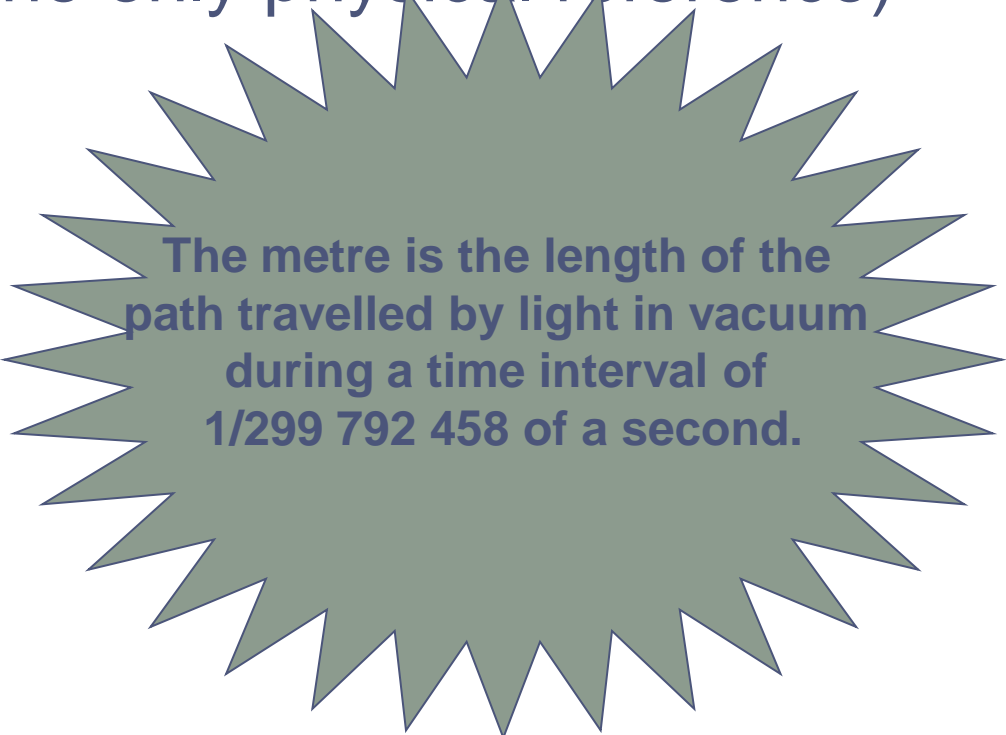
## SI units

- The 11th General Conference on Weights and Measures (1960) adopted the name *Système International d'Unités* (International System of Units, international abbreviation SI), for the recommended practical system of units of measurement.



## Base units

- the metre,
- the kilogram, (The only physical reference)
- the second,
- the ampere,
- the kelvin,
- the mole, and
- the candela.



The metre is the length of the path travelled by light in vacuum during a time interval of  $1/299\,792\,458$  of a second.



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- All others are derived units
- For example velocity is m/sec



## Electrical Power

$$VI = \frac{\text{Energy}}{\text{Charge}} * \frac{\text{Charge}}{\text{sec}}$$

$$VI = \frac{\text{Energy}}{\text{sec}}$$

= Rate of energy consumption

= Electric Power



## Primary Standard

- A standard of a particular quantity which has the highest class of metrological qualities in a given field.
  - *NOTE: The concept of a primary standard is equally valid for base units and for derived units.*



## *National Standard*

- *A standard recognized by a national decision as the basis for fixing the value, in a country, of all other standards of the given quantity.*
- *National Physical laboratory in India*
  - *Generally does not have primary standards*



# Reference Standard

- The measurement standard of best accuracy level at a particular location for the particular quantity is called reference standard.
  - Reference standards are generally reserved for calibration of working standards against them.



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# Working Standard

- A measurement standard, not specifically reserved as a reference standard, which is intended to verify measuring instruments of lower accuracy.



## Traceability

- "the property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties."



# Traceability



National standard accurate to

0.005%

Calibration laboratory

0.01%

Company 'master' item

0.02%

Company production equipment

0.1%

Produced product

1%





## Repeatability (of measurement)

- A quantitative expression of the closeness of the agreement between the results of successive measurements
  - of the same value,
  - of the same quantity,
  - carried out by the same method,
  - by the same observer,
  - with the same measuring instrument,
  - at the same location
  - at appropriately short interval of time.



## Reproducibility

- A quantitative expression of the closeness of the agreement between the results of successive measurements of the same value of the same quantity , where individual measurements are made under different defined conditions, e.g. :
  - by different methods or,
  - by different observers,
  - at different locations,
  - after long duration etc.



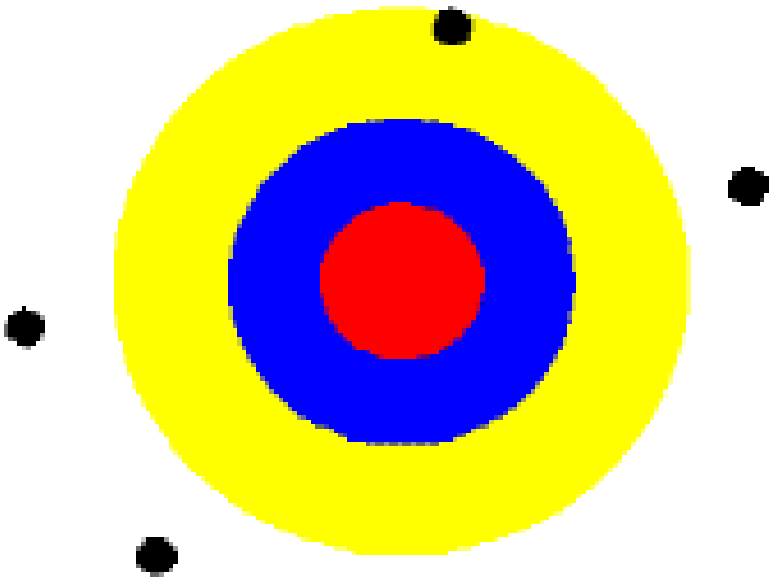
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## Precision

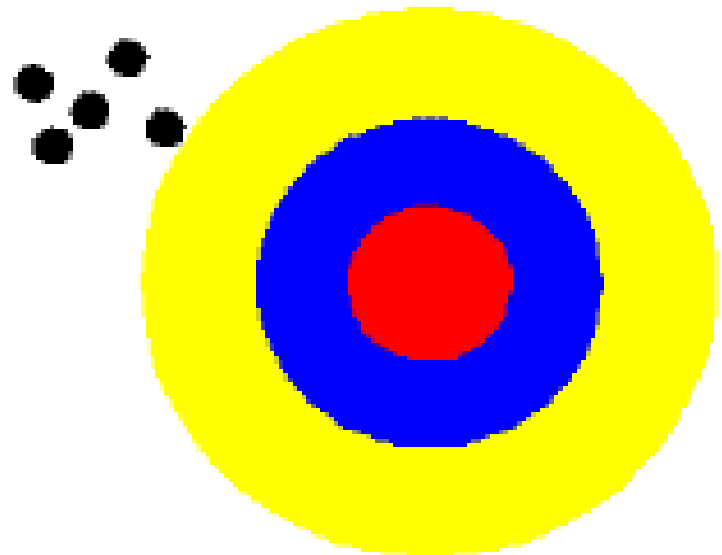
- Commonly considered as synonym of accuracy
- A measure of repeatability



## Accuracy and Precision



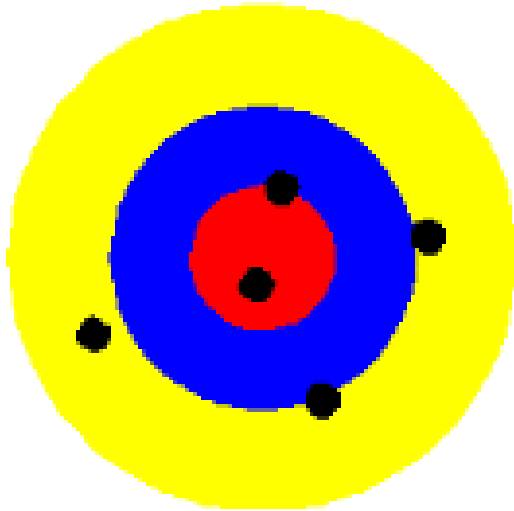
**Neither accurate  
nor precise**



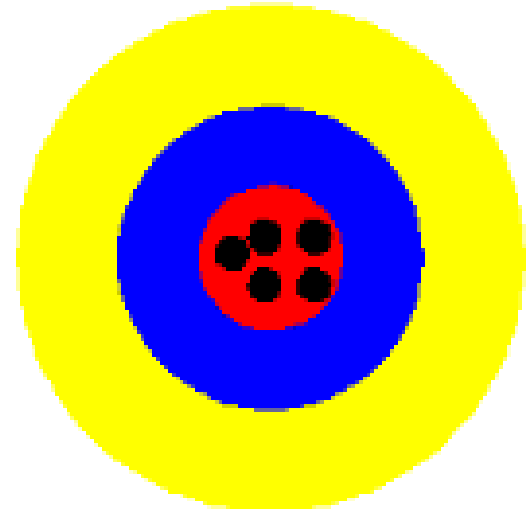
**Precise but not  
accurate**



## Accuracy and Precision



**accurate but  
not Precise**



**Precise and  
accurate**



## In terms of % error

Meter No.	Results (% error)					Average	Conclusion
1	0.00	0.01	-0.01	0.02	0.0	0.00	Accurate and precise
2	0.00	0.05	-0.07	0.03	-0.02	0.00	Accurate but not precise
3	0.20	0.19	0.21	0.18	0.20	0.20	Not accurate but precise
4	0.50	0.23	0.65	0.55	0.30	0.45	Neither accurate nor precise



## What affects accuracy and precision?

- Equipment
- Environmental conditions
- Method
- Person and
- Of course, the Measurand



# Calibration

- All the operations for the purpose of determining the values of the errors of a measuring instrument (and if necessary, to determine other metrological properties)
  - *May include adjustment*
  - *Can a laboratory adjust error of instruments? If yes, what is expected?*
  - *Pre-adjustment errors must be reported*



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## Resolution of energy measurement?

- Display
- Counter
- LED



## Error

- The discrepancy between the result of measurement and the true value of the quality measured.
  - Random Error
  - Systematic error



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## Uncertainty of measurement

- No measurement can be perfect
- There are many sources contributing to error
- Some can be compensated for
- Others not
- The uncompensated sources of error determines uncertainty



## Uncertainty of measurement

- Range of values within which true value is estimated to lie with defined confidence

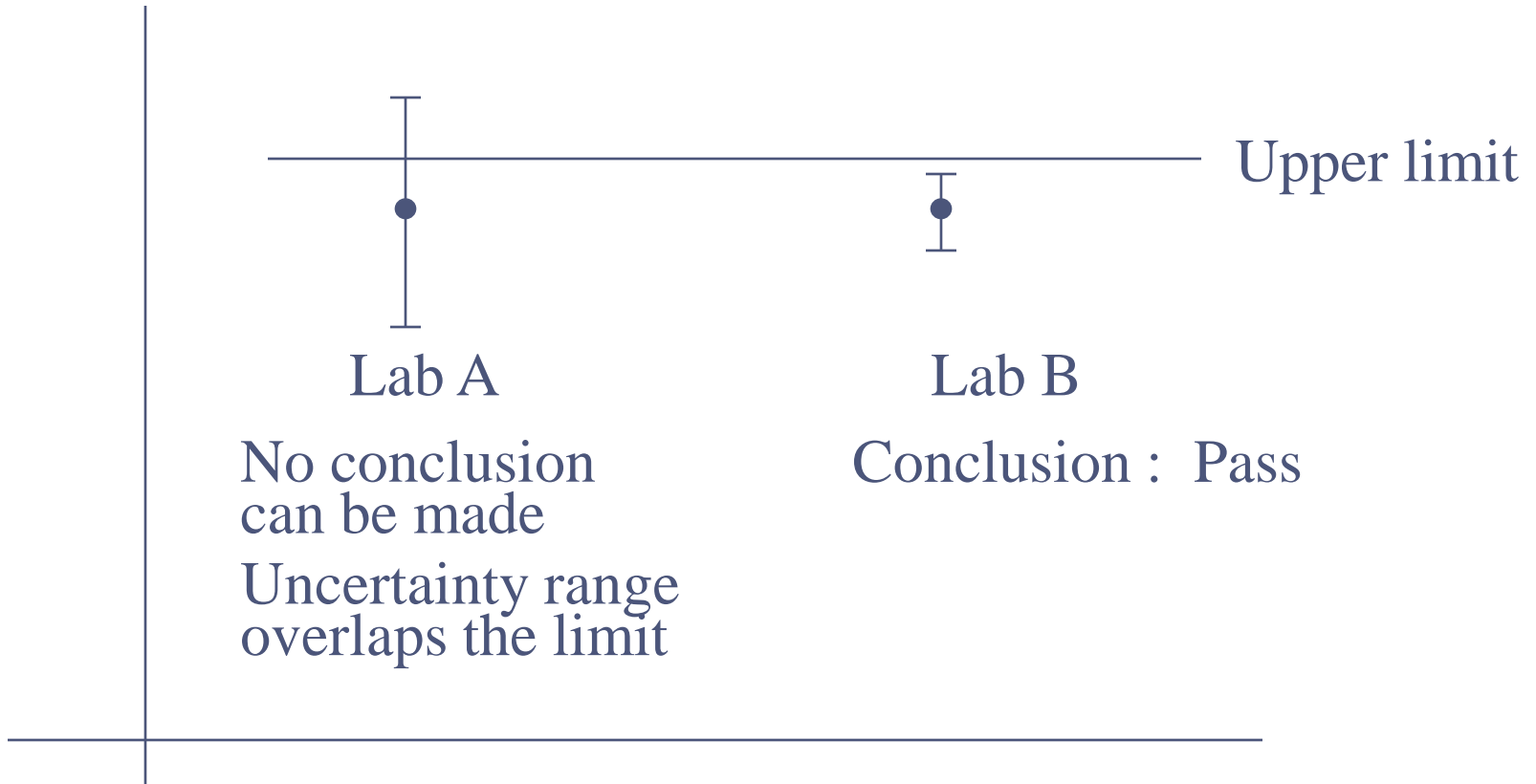


## Uncertainty of measurement

- A measurement value without uncertainty is incomplete
- This is important component of measurement for comparing two measurement results
- Particularly important at boundary conditions



# Uncertainty Matters





- Identify sources contributing to error in energy meter accuracy testing
  - In lab
  - In field



## In lab

- Repeatability of METER UNDER TEST
- Calibration uncertainty of the calibrator:
- Error of the calibrator (if no correction is being applied to the results):
- Accuracy Specifications of calibrator or aging:
- Temperature Coefficient of the calibrator:
- Display resolution of the calibrator:

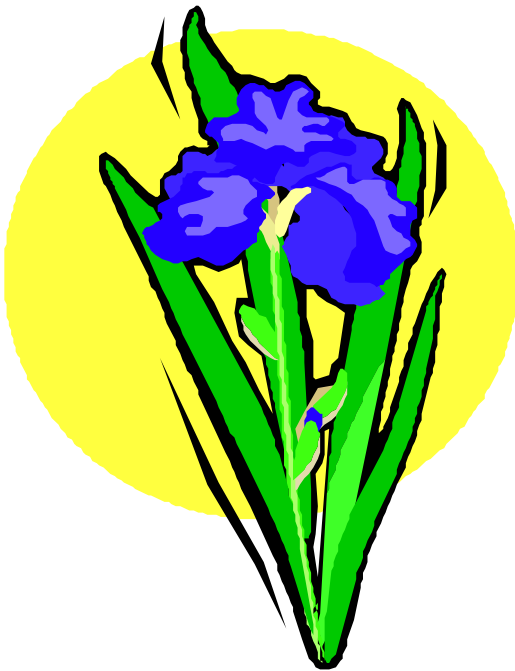


## In field

- Repeatability of METER UNDER TEST
- Calibration uncertainty of the calibrator:
- Error of the calibrator (if no correction is being applied to the results):
- Accuracy Specifications of calibrator or aging:
- Temperature Coefficient of the calibrator:
- Display resolution of the calibrator:
- And Uncontrolled environment



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*Thanks*