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

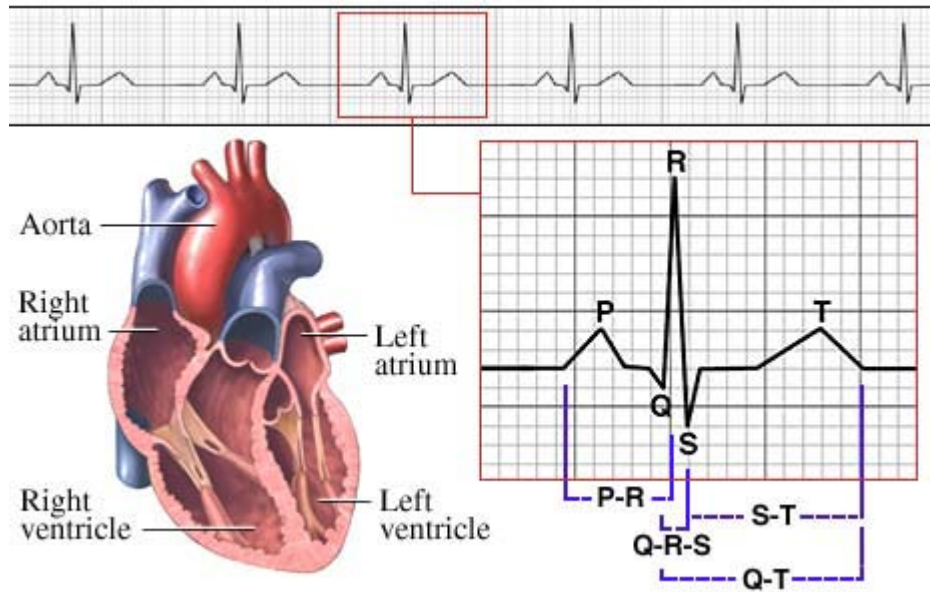
A specifically designed programme for

Da Afghanistan Breshna Sherkat (DABS)
Afghanistan

Metrology

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

Life is full of measurements



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

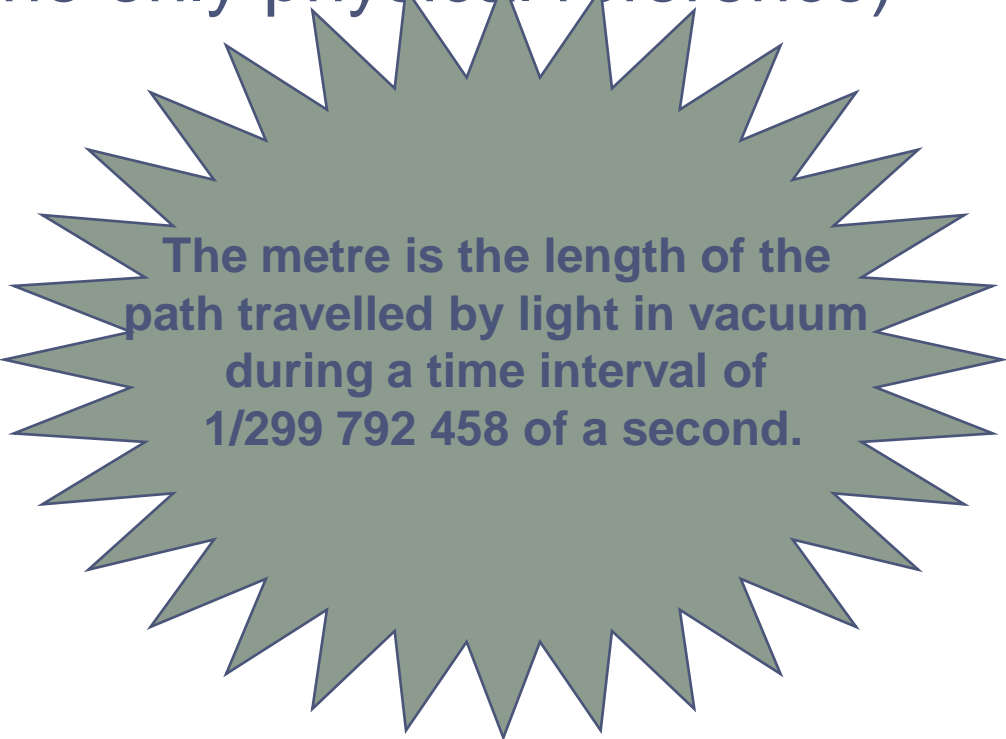
- A value approximating to the true value of a quantity such that, for the purpose for which that value is used, the difference between these two values can be neglected.

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.

A large, green, multi-pointed starburst shape with a white outline, containing text.

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.

- 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.

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

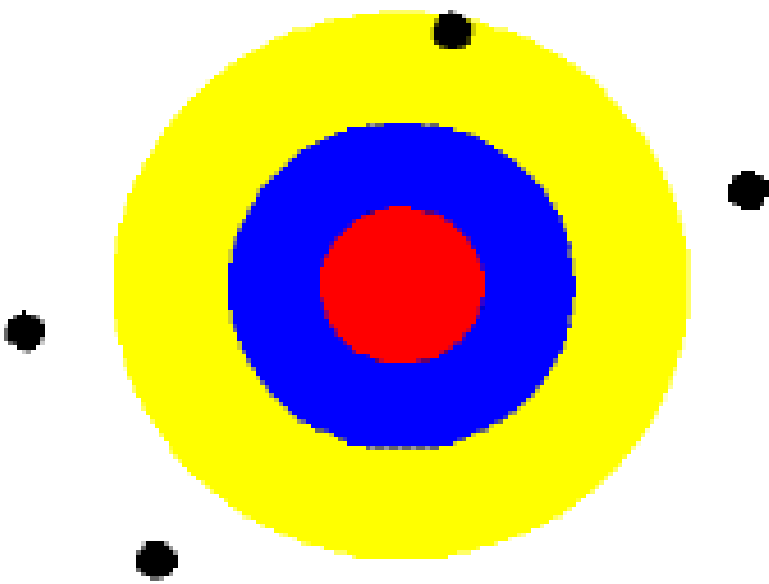
- A quantitative expression of the closeness of the agreement between the results of successive measurements of the same value of the same quantity , where individual measurements are made under different defined conditions, e.g. :
 - by different methods or,
 - by different observers,
 - at different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

Precision

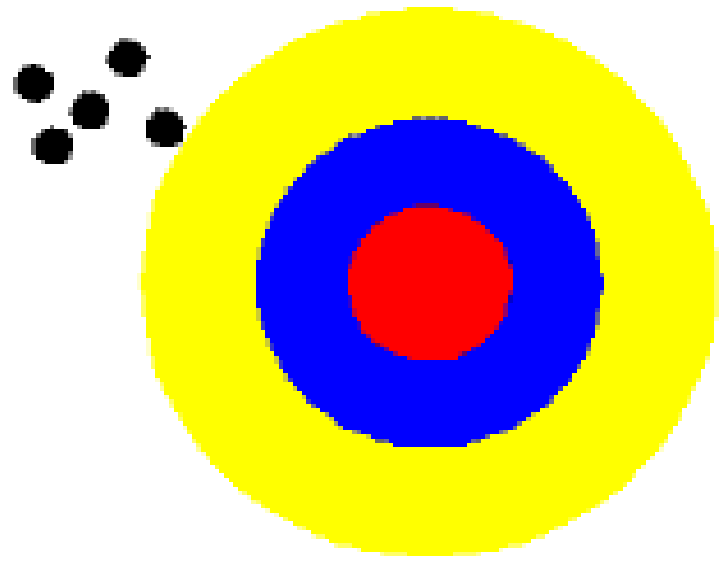
- Commonly considered as synonym of accuracy
- A measure of repeatability



Accuracy and Precision

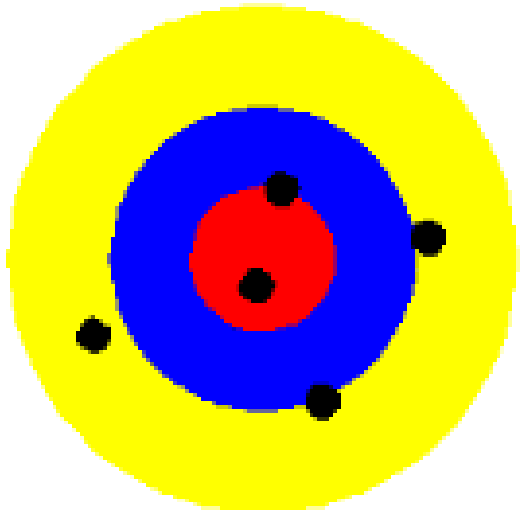


**Neither accurate
nor precise**

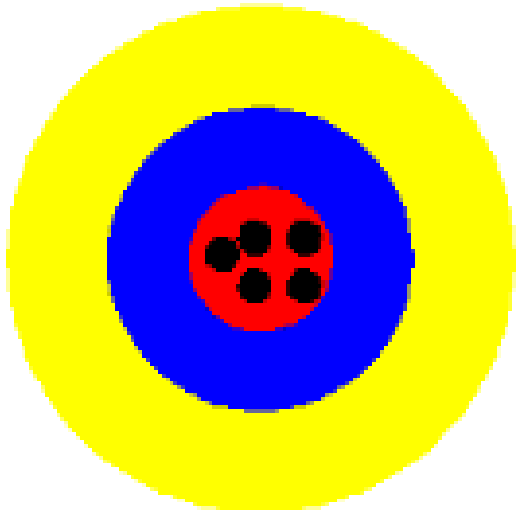


**Precise but not
accurate**

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*



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

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

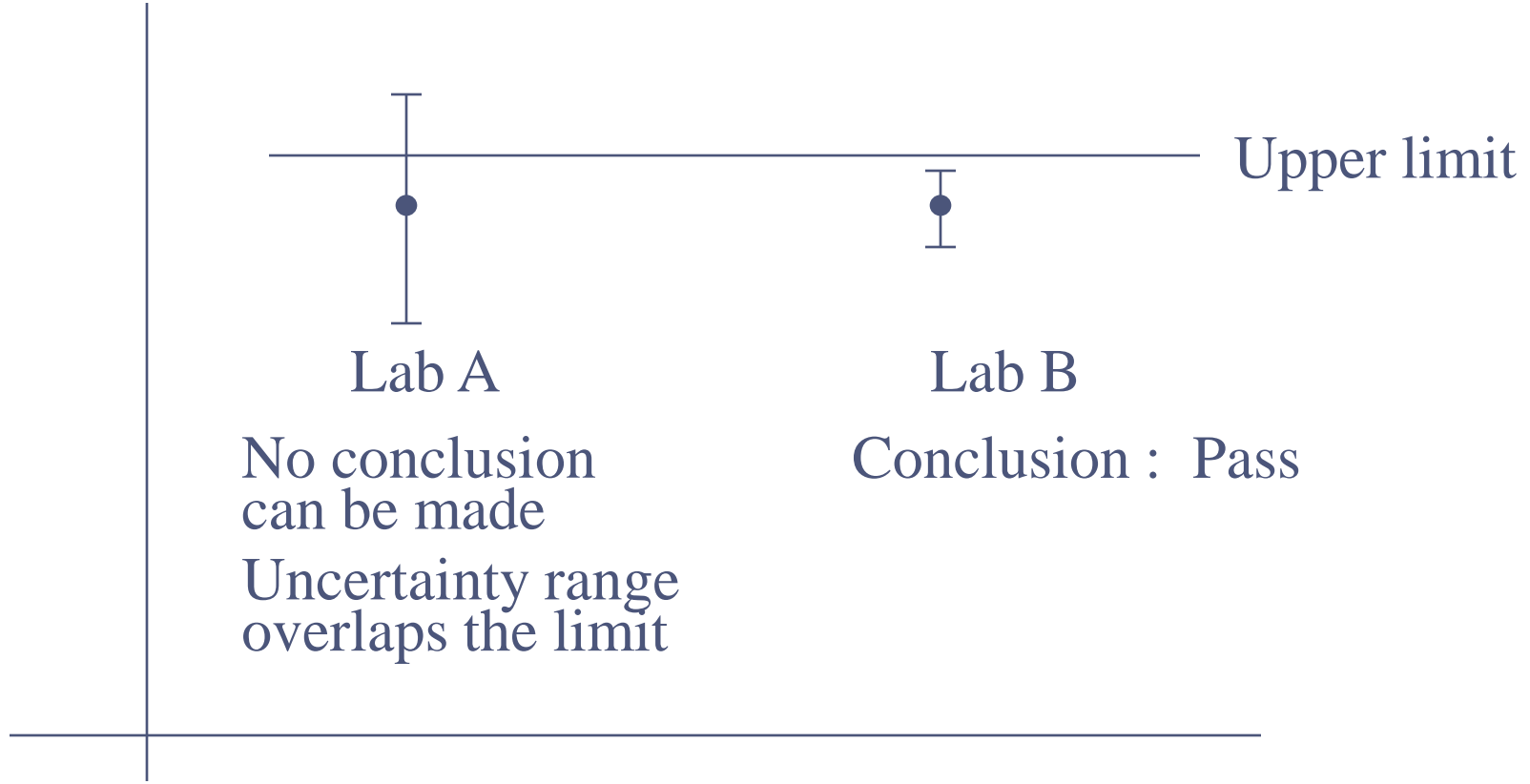
Uncertainty of measurement

- 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

What is a good lab?

- Equipment
- Methods
- Personnel
- Management commitment
- Quality management system
- Environment



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Concept of Laboratory Accreditation Global Perspective

- What is laboratory accreditation?
- Advantages of accreditation
- Accreditation Bodies
- National and international status
- IEC 17025 and its structure
- ISO9000 V/s IEC 17025

What is 'laboratory accreditation'?

- LA a means of determining and formal recognition of the competence of laboratories to perform specific types of testing, measurement and calibration.
- involves an independent assessment by technical experts.
- laboratory to determine whether it is performing its work correctly and to appropriate standards and decide its desired "scope of accreditation".



Why to get accreditation?

- Increase of confidence in Testing/ Calibration data and of personnel performing work.
- Better control of laboratory operations and feedback to laboratories as to whether they have sound Quality Assurance System and are technically competent.
- Savings in terms of time and money due to reduction or elimination of the need for re-testing of products.
- Distinct Marketing/ competitive advantage.
- Will help to assure customers of quality of measurement results.

(To a Lab it gives a status and recognition)

- NABL Accreditation is granted in compliance to IS/ISO/IEC 17025:2005

*General requirements for the competence of
testing
and calibration laboratories.*

ISO CASCO

- International Organization for Standardization
- Committee on Conformity Assessment

Conformity assessment

- “Activity that provides demonstration that specified requirements relating to product, process, system, person or body are fulfilled”
- Covers such activities as: testing, inspection and certification as well as accreditation of conformity assessment bodies

Accreditation (of conformity assessment bodies)

- “third-party attestation that a conformity assessment body fulfils specified requirements and is competent to carry out specific conformity assessment tasks”

Accreditation body (conformity assessment)

- Note: The authority of an accreditation body is typically derived from government”
- In India it is National Accreditation Board for calibration and testing Laboratories (NABL), Dept of Science and Technology, GOI.

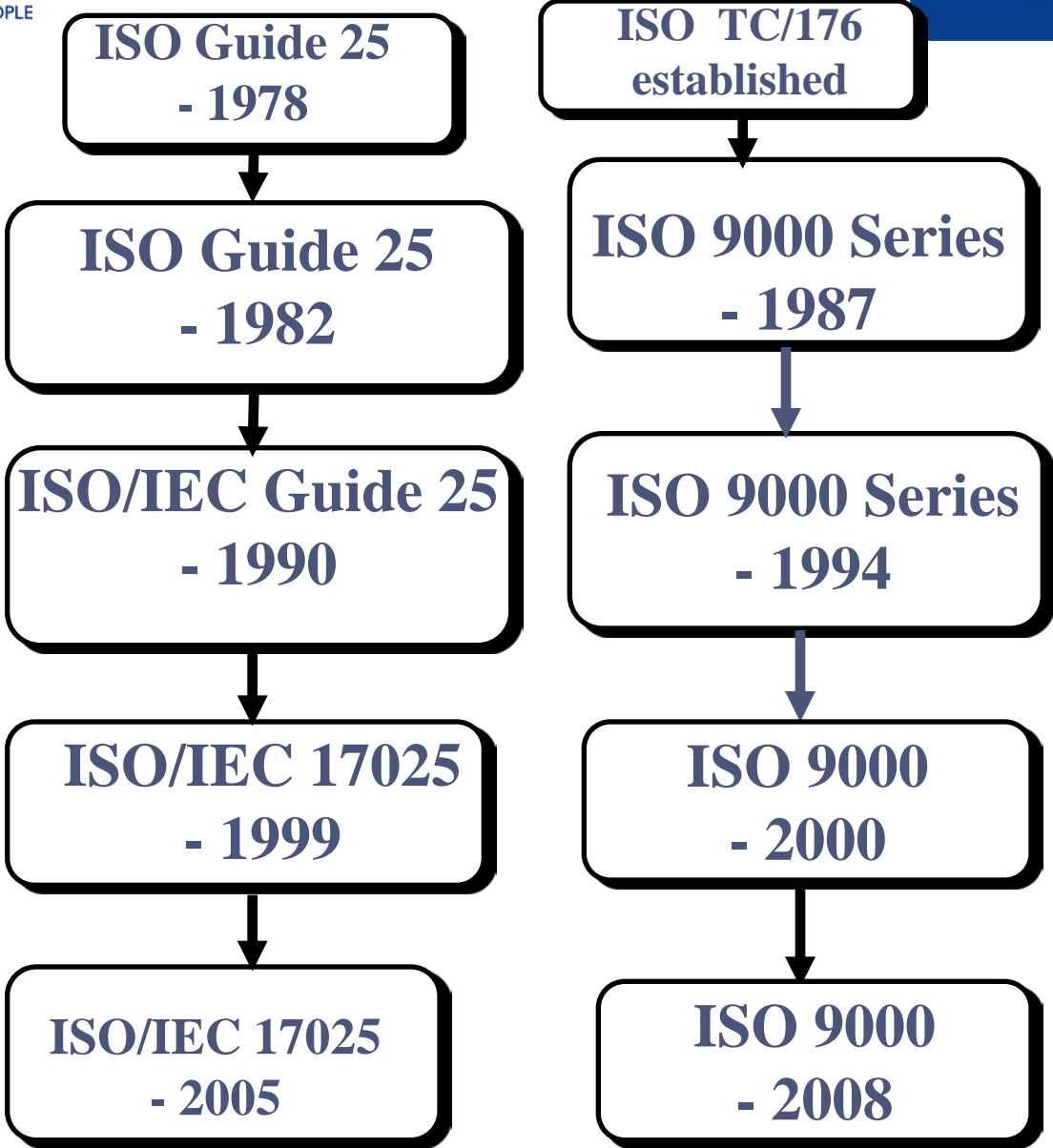


International Laboratory Accreditation Cooperation.... conference 1978, cooperation in 1996

- Development, promotion, recognition of LA practices
- ILAC is the world's principal international forum for the development of laboratory accreditation practices
- specific regions have also established their own accreditation co-operations, notably in Europe (EA) and the Asia-Pacific (APLAC).
- Over 40 laboratory accreditation bodies have signed the multi-lateral, mutual recognition arrangement (the “ILAC Arrangement”) to promote the acceptance of accredited test and calibration data
- ILAC arrangement w.e.f. 31 Jan 2001.

Mutual Recognition Agreement

- Mutual Recognition Arrangements, are crucial in enabling test data to be accepted between various countries.
- In effect, each partner in such an arrangement recognizes the other partner's accredited laboratories as if they themselves had undertaken the accreditation of the other partner's laboratories.
- Over 22000 labs accredited by members of ILAC, MRA signatories



Structure of ISO 17025 standard

1. Scope
2. Normative references
3. Terms and definitions
4. Management requirements
5. Technical requirements

More specific requirements of IS/ISO17025

- Demonstrate that a Lab operates to a quality system.
- Lab is technically competent.
- Lab is able to generate technically Valid results.

Technical requirements

- Identification of specific equipments for a purpose.
- Each equipment must be certified from an accredited lab. (in our case NABL)
- Traceability in SI units must be established to international standards thru an unbroken chain of measurements.
- Uncertainty of measurement and BMC must be computed and declared.
- Demonstrate compliance to standards of
 - Test set up
 - Method and process
 - Measurement results

Technical and other requirementscontd.

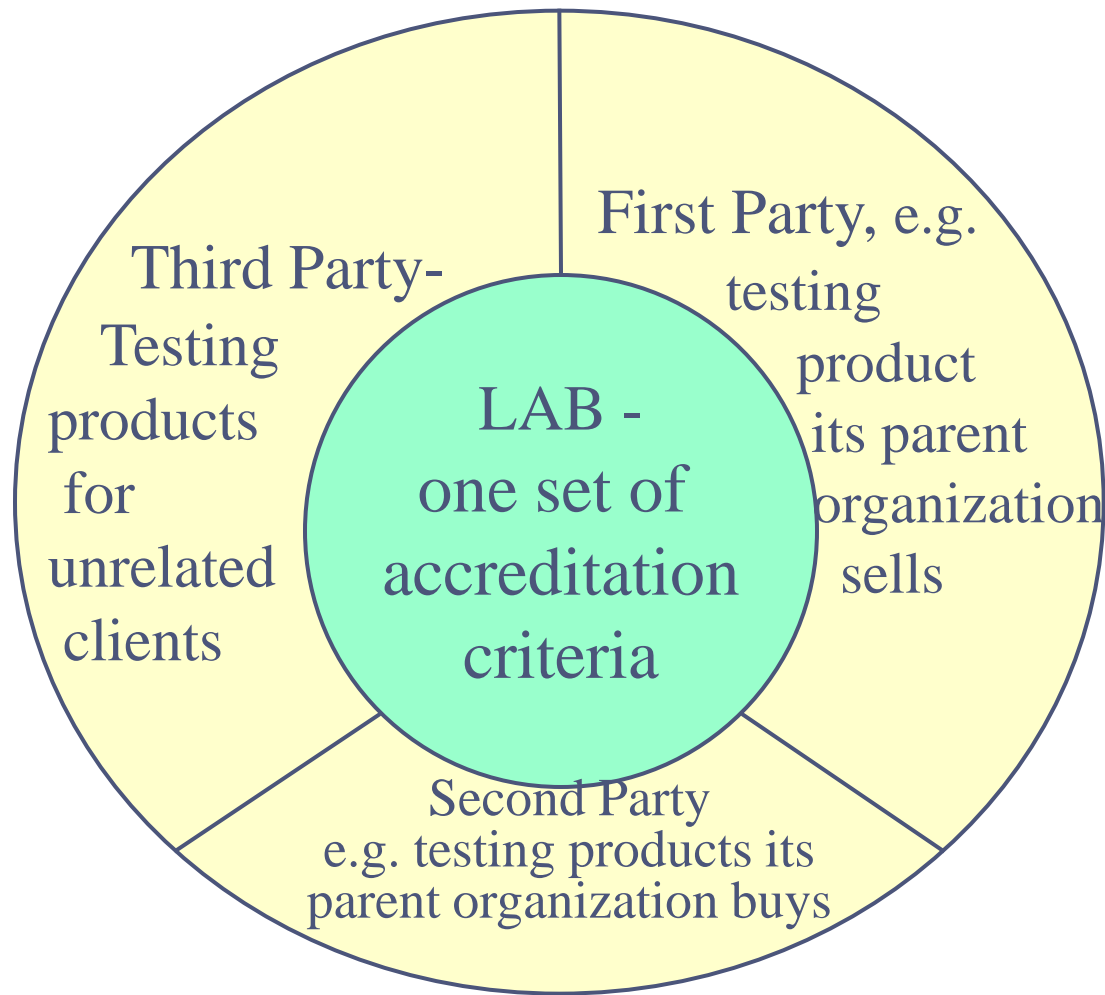
- Prove technical capabilities periodically thru proficiency testing programs and Inter-Lab comparisons.
- Audit of all the data, results, calculations, s/w tools , all requires better technical records and control..
- More specific requirements on Manpower qualification, duties and training/ skills.
- Declared authorized signatories for certificates, approved by auditors.
- Accommodation, environment, Access, security and confidentiality.



Laboratory quality system under ISO 17025

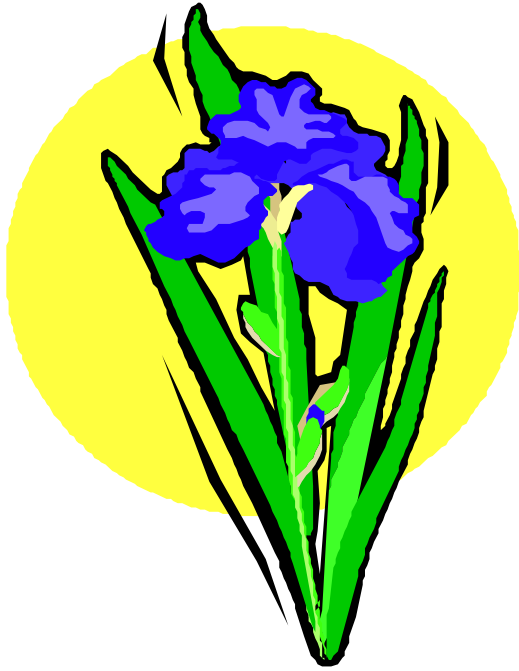
provides documentary evidence for a given test result that,

- **Work is done by properly qualified & trained persons who had access to all information necessary to carry out the work**
- **Methods used were technically sound, appropriate for samples & requirements of client**
- **Equipment used were properly maintained & calibrated at the time of use**
- **All appropriate QC checks were carried out & results of controls fell within the specifications**





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Thanks