ROHINI

COLLEGE OF ENGINEERING AND TECHNOLOGY

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## DEPARTMENT OF MECHANICAL ENGINEERING

# 24ME403 - METROLOGY & MEASUREMENTS

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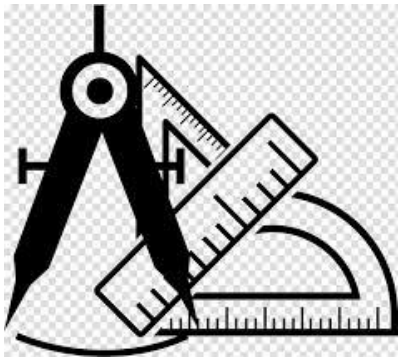


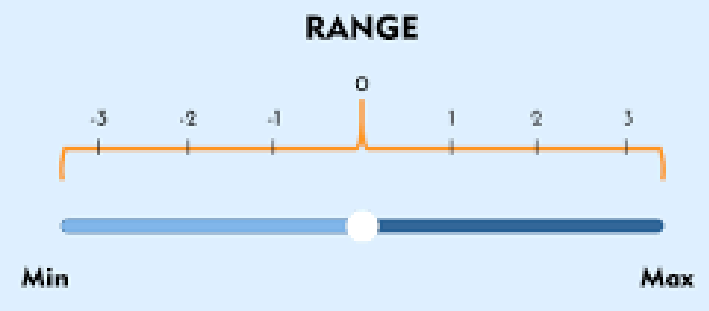
# UNIT I: BASICS OF METROLOGY

**CO1:** To explain the basics of standards of measurement and errors in industrial applications.

## Terminologies used in Measurement

1. **Range**: Range is the minimum and maximum value of a quantity for which an instrument is designed measure.

   **Example**: For a 15 cm scale, the range of measurement: 0 to 15 cm.



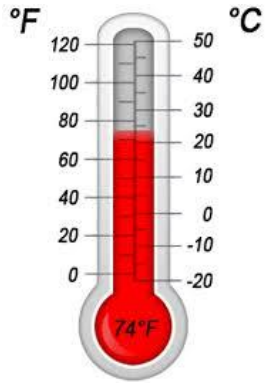

2. **Span**: Span is the difference between the maximum and minimum value of the measurement range.

   **Example**: For a 15 cm scale, the span is = 15 – 0 = 15 cm.


3. **Error**: The difference between the true value (exact value) and the obtained value is called as 'Error'.

   Error = Measured value – True value

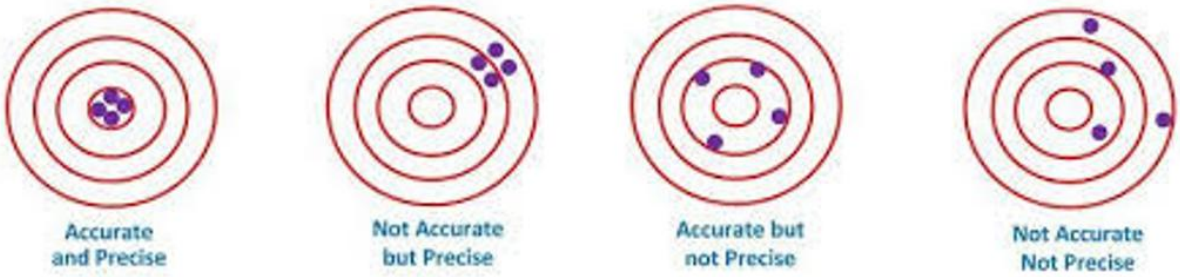
   **Example**: a temperature measurement has its measured value as 34ºC, and the true value as 35ºC, the error is = 35 – 34 = 1ºC.




4. **Accuracy**: Accuracy is how close a measured value is to the true or accepted value of the quantity being measured.
5. **Precision**: Precision is the degree of closeness among repeated measurements of the same quantity.

   Precision indicates the consistency or reproducibility of a measurement process, not how close they are to the true value.

   **Accuracy vs Precision (Example)**: Hitting a target, accuracy means your shots are close to the bullseye, while precision means your shots are clustered tightly together, even if they're away from the centre.

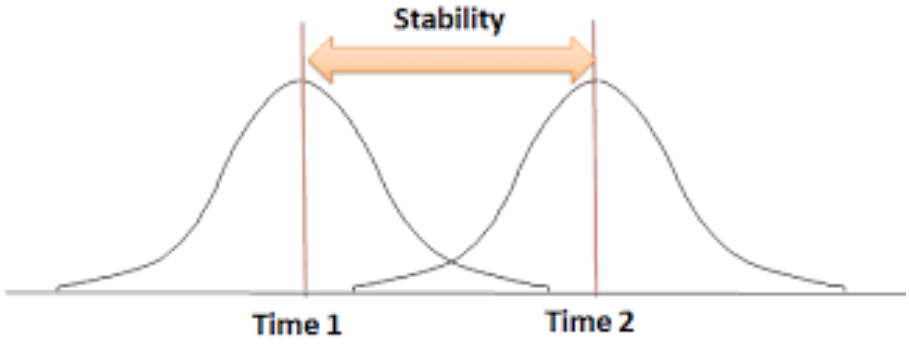



6. **Sensitivity**: Sensitivity is the smallest change in the measured quantity that the instrument can detect and display as a change in the reading.

   **Example**: A thermometer with high sensitivity can detect a temperature change as small as 0.01°C.

7. **Stability**: Stability refers to the ability of an instrument to give consistent and repeatable readings over time when measuring the same quantity under the same conditions.

   **Example**: A digital weighing scale that shows the same 50.0 kg reading for an object when measured repeatedly over several months demonstrates excellent stability.




8. **Threshold**: Threshold is the minimum value below which no output change can be detected when the input of an instrument is increased gradually from zero.

   **Example:** A pressure sensor with a 0.5 Pa threshold will not register any output change until the applied pressure exceeds 0.5 Pa.

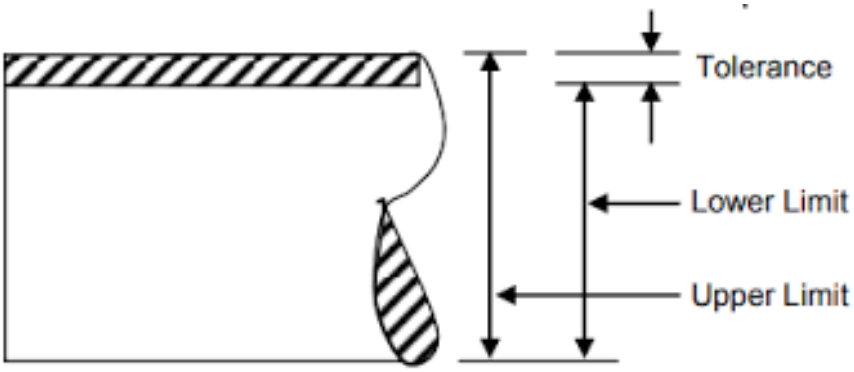
9. **Calibration**: In measurement, calibration means comparing a measuring instrument with a known, accurate standard to check its readings and adjust it if needed, so that it measures correctly.

   **Example**: Calibrating a laboratory balance involves comparing its readings against a set of certified standard weights to ensure accurate measurement.

10. **Tolerance**: Tolerance means the allowable amount of variation in a measurement or dimension without causing problems.

    It is the maximum allowable error in the measurement.

**Example:** A machined shaft with a specified diameter of 25.00 mm ± 0.05 mm has a tolerance of 0.10 mm, meaning any measurement between 24.95 mm and 25.05 mm is acceptable.




11. **Drift**: Drift is the variation of change in output for a given input over a period of time.

    **Example:** A temperature sensor that reads 22.0°C at the start of a test but slowly increases to 22.8°C over eight hours without any change in the actual temperature is exhibiting drift.

12. **Zero Drift**: Zero drift is the change which occurs in the output when there is zero input is given.

    **Example**: A digital micrometer that reads +0.005 mm when its measuring faces are fully closed and in contact (zero condition) is exhibiting zero drift, requiring recalibration before use.

13. **Uncertainty**: In measurement, uncertainty means the doubt or range of possible error in any measurement.

    It tells you how much you can trust a measurement.

    **Example:** When measuring a steel block's length with a caliper, the reported value is 50.25 mm ± 0.02 mm, where ±0.02 mm represents the measurement uncertainty.

14. Response time: Response time is the time an instrument takes to show a correct, stable reading after a change in the quantity being measured.

    **Example:** A thermocouple installed in an engine exhaust has a response time of 200 milliseconds.

15. **Repeatability & Reproducibility**: Repeatability is measurement consistency by the same person, same equipment, same conditions; reproducibility is consistency across different people, different labs, or different equipment (broader reliability).

Repeatability shows immediate precision and operator skill, while reproducibility validates a method's universal applicability, ensuring results aren't just a fluke of one specific setup, crucial for scientific trust.


**Repeatability vs Reproducibility (Example):** Repeatability is when the same operator uses the same micrometer on the same shaft ten times and gets nearly identical results; reproducibility is when three different operators in three different labs measure the same shaft with different micrometers and all arrive at the same result within an acceptable range.