

Quality



Quality means doing it right, when no one is looking.
Henry Ford

GREEN BELT TRAINING

STEP 5: VALIDATE MEASUREMENT SYSTEM

Dr. Gopal Sivakumar

Venue: GCT-Coimbatore

Date: 7th Dec'19

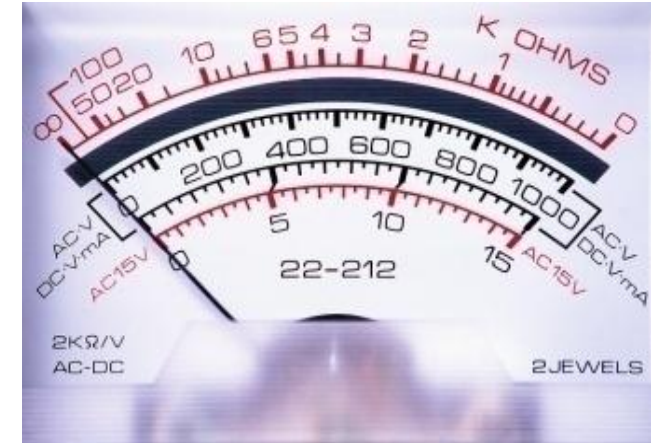
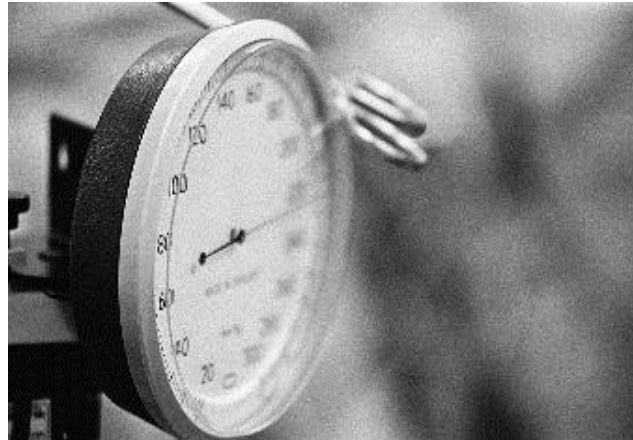


Ministry of Micro, Small and Medium Enterprises,
Government of India



MICRO, SMALL & MEDIUM ENTERPRISES
सूक्ष्म, लघु एवं मध्यम उद्यम

How good are these measurements?



Are these data credible?

Are these measurement data free from errors?

Measurement System Analysis

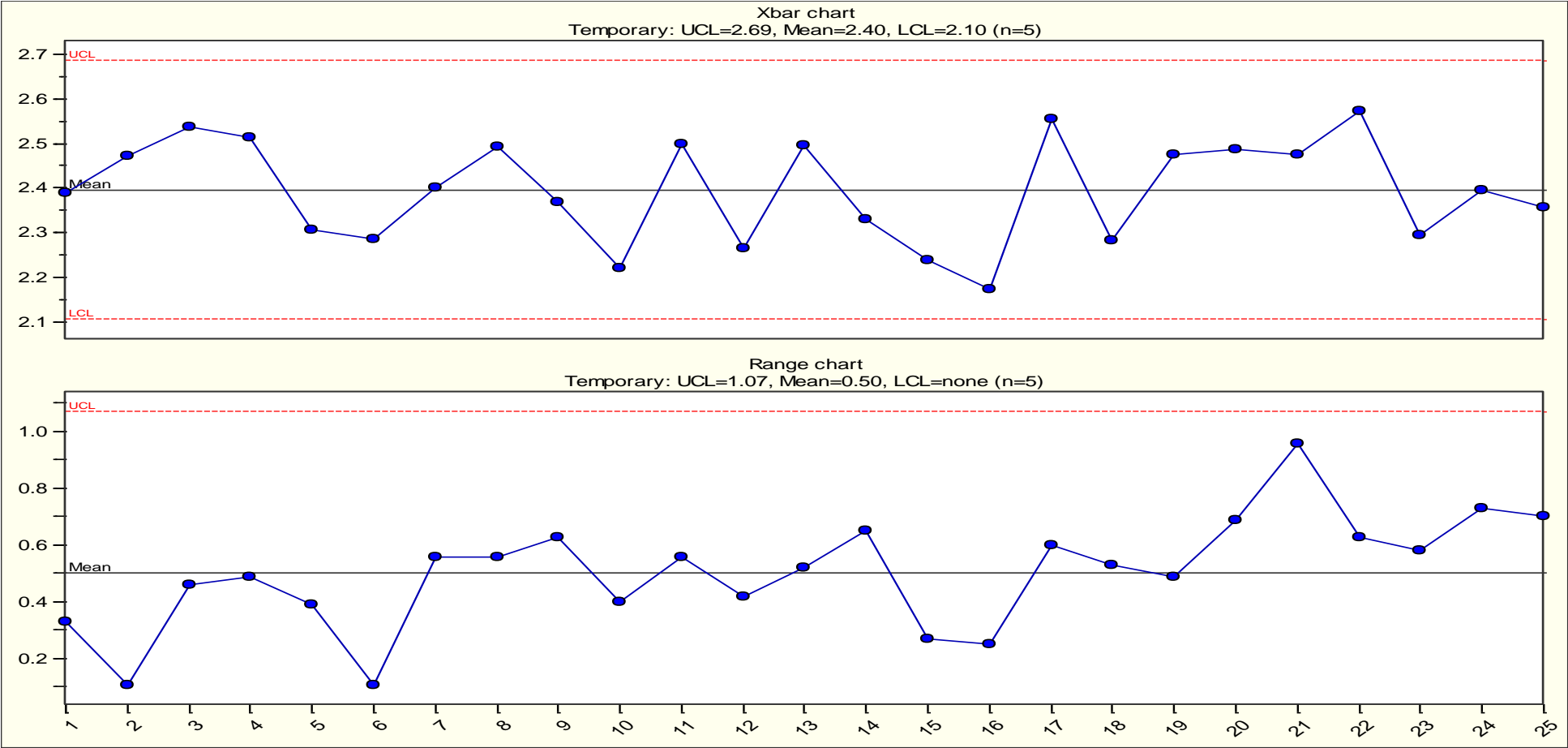
PURPOSE OF MSA

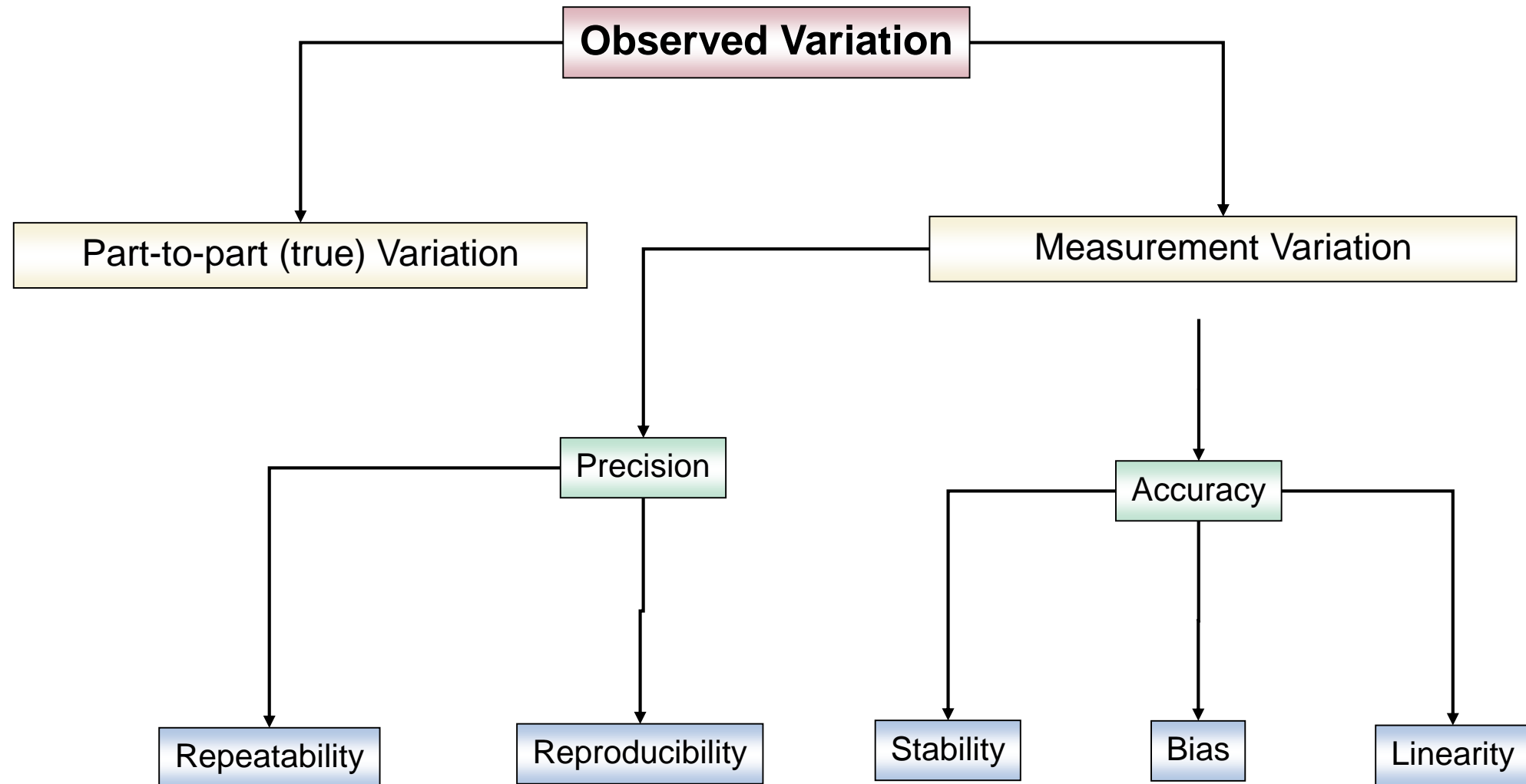
- Measure the % of measurement variation in the data collected
- Compare measurements between operators
- Compare measurements between two (or more) measurement devices
- Evaluate a suspect gage
- Evaluate a gage before and after repair
- Determine true process variation

CONCEPT OF VARIATION

- No two things are alike, Variation always exists
- Even if variations are small, precision instruments show differences
- **Ability to measure the variation is necessary before you can control the process**

RESULTANT DATA = PROCESS VARIATION + MEASUREMENT VARIATION





DATA GATHERING

- What is Data ?

Data is a numerical expression of an activity.

Conclusions based on facts and data are necessary for any improvement -K. Ishikawa

If you are not able to express a phenomenon in numbers, you do not know about it adequately - Lord Kelvin

TYPES OF DATA

CONTINUOUS OR VARIABLE DATA

CONTINUOUS

- Measurable
- Have decimals
- Critical dimensions
- Carries more information

CAN BE MEASURED IN

- Interval Scale (no zero point)
- Ratio Scale (true zero point)

EXAMPLE

- Temperature
- Length, Time
- Costs per transaction
- Cycle Time

DISCRETE OR ATTRIBUTE DATA

ATTRIBUTE

- Countable
- Always integers
- Subjective
- Carries less information

CAN BE MEASURED IN

- Nominal Scale (categorises)
- Ordinal Scale (ranks)

EXAMPLE

- Accepted / Rejected
- Score in a beauty contest
- Surface imperfections
- Customer Service Response

CONTINUOUS or DISCRETE DATA?

Width of sheet

No. of liners thinned

No. of Tubes rejected

Diameter of Piston

Height of a Man

Sheet thickness

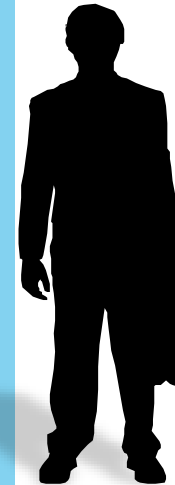
Out of 100 sheets the numbers that meet the thickness 4 ± 0.9

Time taken to process a purchase order

No. of bugs in a program

Continuous

Discrete



WHAT IS A MEASUREMENT SYSTEM

A **Measurement System** is the combination of people, equipment, materials, methods and environment involved in obtaining measurements

A Typical MS

- Type of Data
- Specification Limits
- Operational Definition
- Measuring Equipment
- Appraiser



Data: Dimensions of a part

- A Vernier Caliper
- A CMM
- Go/No Go gauge
- Appraiser
- Operating Procedure
- Environmental conditions - temperature or vibration level

MSA TERMINOLOGY – A QUICK VIEW

TERM	SHORT DEFINITION
RESOLUTION	The lowest value to which, measurement system will respond
BIAS OR ACCURACY	difference between the average measured value and the True value
STABILITY	Accuracy or Bias, when measured over a longer period of time
LINEARITY	bias remains constant across the entire measurement range, then the system is linear
REPEATABILITY	the variation in the measurements within same appraiser
REPRODUCIBILITY	The variation between the appraiser

RELATIONSHIP – RESOLUTION & NDC

- RESOLUTION OR DISCRIMINATIVE POWER
- NO. OF DISTINCT DATA CATEGORIES (NDC)

RESOLUTION & NDC ARE DIRECTLY PROPORTIONAL

RESOLUTION

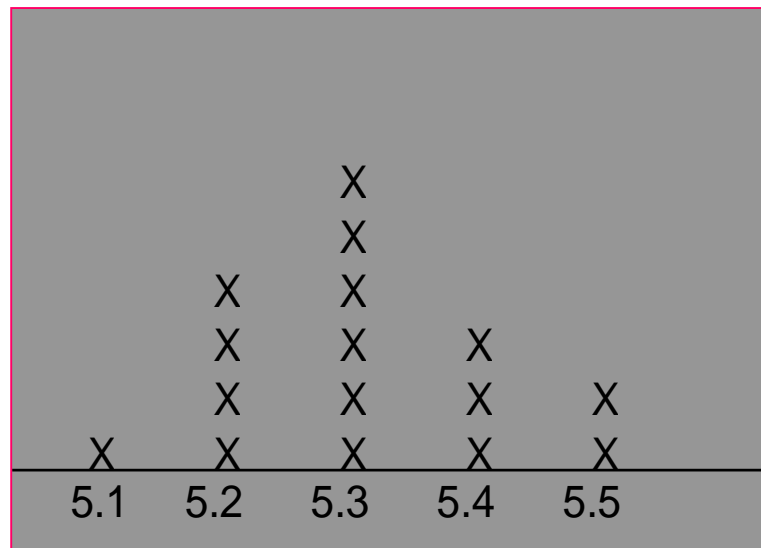


Resolution is the incremental ability of a measurement system to discriminate between measurement values.

The measurement system should have a **minimum of 20 measurement increments** within the product tolerance (e.g, for a full tolerance of 1, minimum resolution is .05)



DESIRED NDC FOR CONTINUOUS VARIABLES



Good if, 5 or more
distinct values are
observed

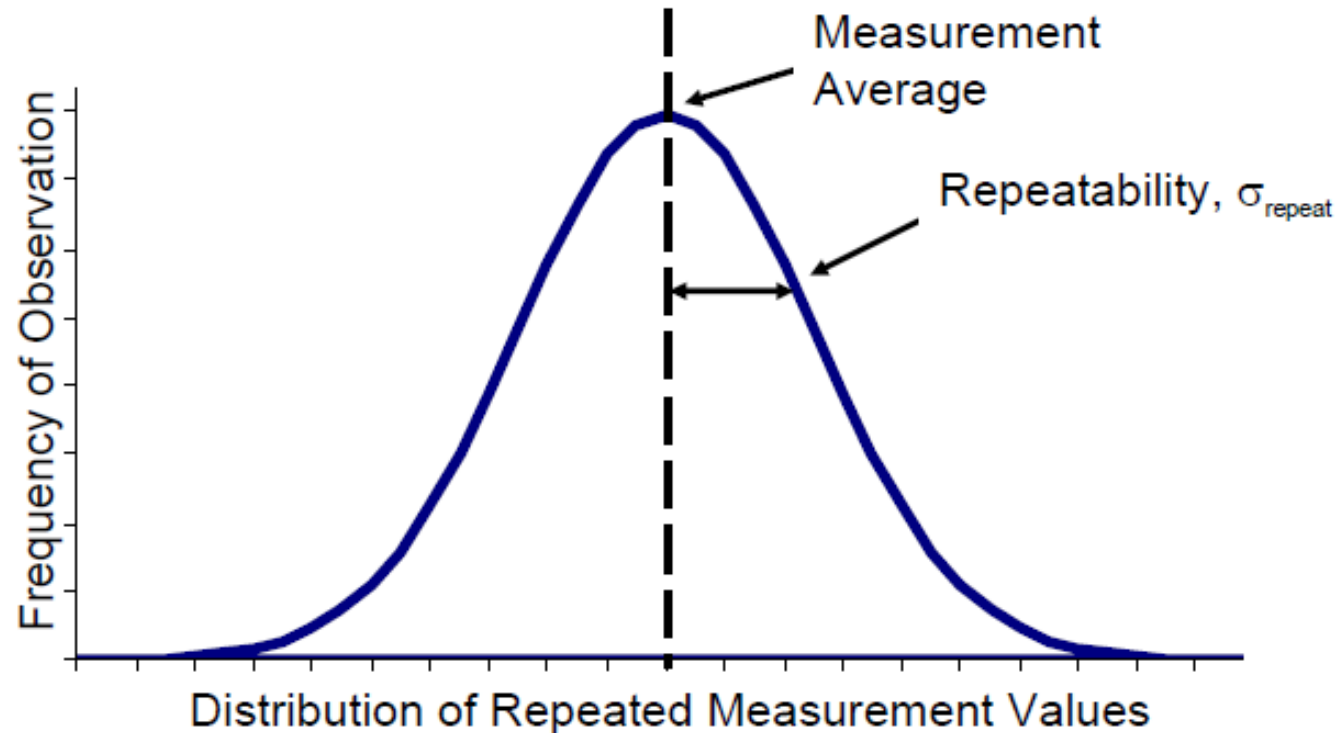
Discrimination index (D.I) also known as **no. of distinct data categories (ndc)** compares **Measurement Variation & Process Variation**, to determine if the measurement system is capable of discriminating different parts.

PRECISION ERRORS

- ➡ REPEATABILITY ERROR
- ➡ REPRODUCIBILITY ERROR

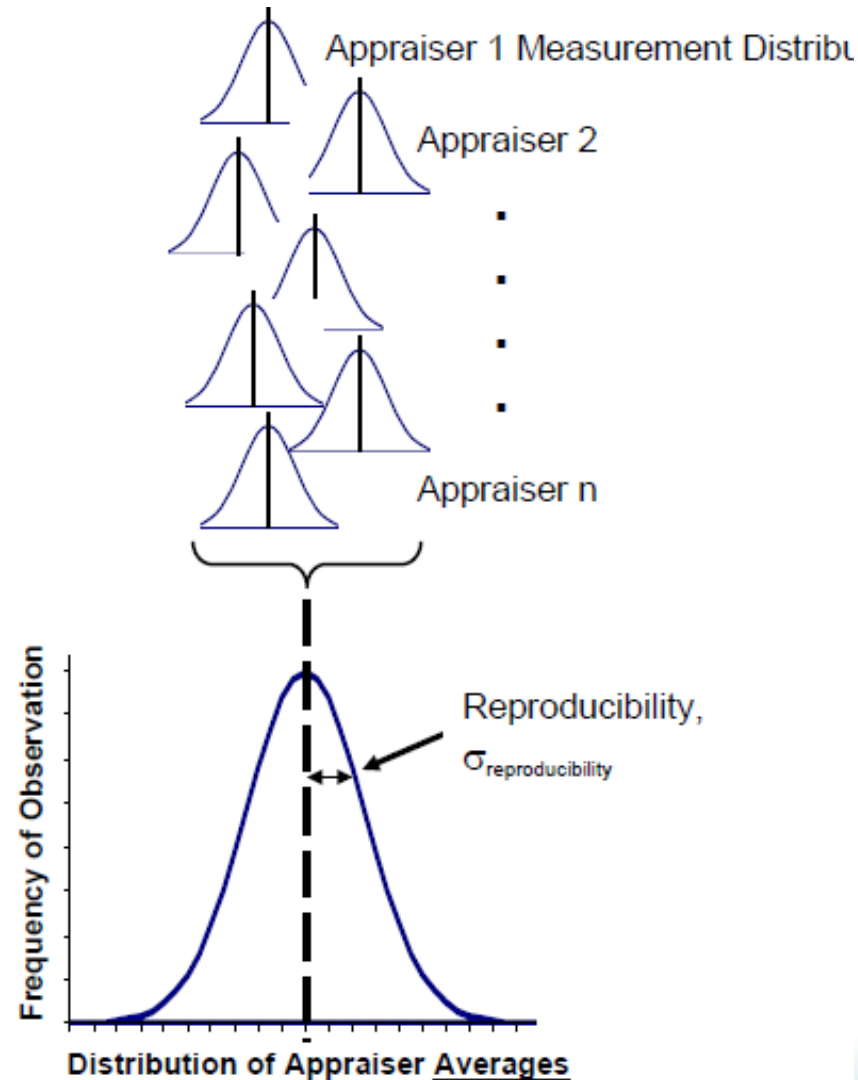
REPEATABILITY

Repeatability is the consistency of a single appraiser to measure the same part multiple times with the same measurement system; it is related to the standard deviation of the measured values



REPRODUCIBILITY

Reproducibility is the consistency of different appraisers in measuring the same part with the same measurement system; it is related to standard deviation of the distribution of appraiser averages



MEASUREMENT METRICS

- Generally, **precision is the principle concern**; inaccuracy due to linearity or constant bias can typically be corrected through calibration
- **Measurement Error** is the statistical summing of the error generated by Repeatability (the variation within an appraiser) and Reproducibility (the variation between appraisers)
 - $\sigma_{\text{error}} = \sqrt{(\sigma_{\text{repeatability}})^2 + (\sigma_{\text{reproducibility}})^2}$
- **Total Measurement Error** spans the interval that contains 99% of probable measurement values from a measurement system, using a single part
 - Total Measurement Error = $5.15 * \sigma_{\text{error}}$
- Measurement system **precision** is defined by the **Precision/Tolerance Ratio**, the ratio between Total Measurement Error and the part tolerance
 - P/T Ratio = $5.15 * \sigma_{\text{error}} / (\text{Upper Spec Limit} - \text{Lower Spec Limit})$

MSA – Acceptance Rule FOR GAGE R&R

- Combined *repeatability* and *reproducibility* defines the capability of measurement system.
- Compares the measurement system variation with the Specification/Tolerance/Total Variation
 - < 10% - Good
 - 10 – 30% - Conditionally Acceptable
 - > 30% - Not Acceptable



सत्यमेव जयते

Ministry of Micro, Small and Medium Enterprises,
Government of India



MICRO, SMALL & MEDIUM ENTERPRISES

सूक्ष्म, लघु एवं मध्यम उद्यम

[Dr.Gopal Sivakumar](#)

tagsivakumar@gmail.com