Gage R&R
(Reproducibility & Repeatability)

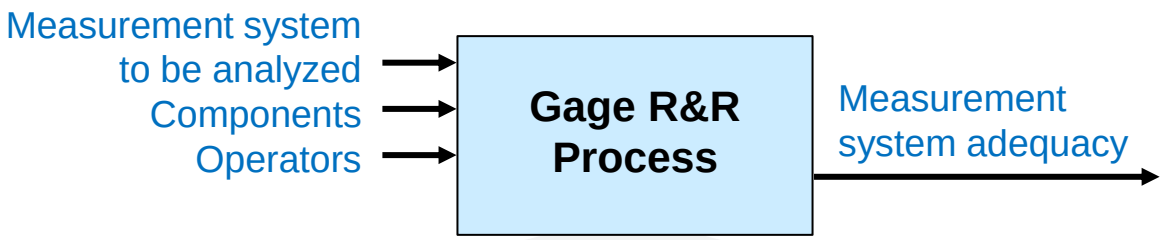
Problem
Hot to assess a measurement system?

Difficulty
Work with an SME

- A ***Gage R&R (GRR)*** study finds the **measurement error** in a measurement system.
- It addresses measurement system ***precision*** (it does not address ***accuracy***).

Measurement variance includes
- The ***product*** *variation*
- The ***equipment*** variation *(repeatability)*
- The ***operator*** variation *(reproducibility)*

There are different ***Gage R&R*** approaches
- ANOVA approach
- AIAG approach
- EMP approach (“evaluating the measurement process”)



Process
1. Determine standard that must be met
   - Example: AIAG = Automotive Industry Action Group
2. Specify measurement strategy
   - Example: 10 parts & 3 operators & 3 measurements each
3. Specify how samples are obtained
   - Example: “randomly” or “sequentially”
4. Obtain samples
5. Obtain measurements
6. Perform analysis of data and make conclusions
   - Use of a software package is recommended!
7. Document the results

GRR Types
- ***Crossed GRR***: each operator measures each part
- ***Nested GRR***: only one operator measures each part

Gage R&R – Example – Sample output from Minitab

This table was created by Minitab

Inputs: piece number, operator number, measurement value

Key values
- **%Study Var** uses the sample's standard deviation
- **%Process** uses (historical) process standard deviation

Source	StdDev (SD)	Study Var (6 * SD)	%Study Var (%SV)	%Tolerance (SV/Toler)	%Process (SV/Proc)
Total Gage R&R	0.30237	1.81423	27.86	15.12	43.20
Repeatability	0.19993	1.19960	18.42	10.00	28.56
Reproducibility	0.22684	1.36103	20.90	11.34	32.41
Operator	0.22684	1.36103	20.90	11.34	32.41
Part-To-Part	1.04233	6.25396	96.04	52.12	148.90
Total Variation	1.08530	6.51180	100.00	54.26	155.04

Number of Distinct Categories = 4

Key error contributions

Number of Distinct Categories (NDC)
- NDC is the number of non-overlapping 97% confidence intervals that span the product variation.
- Often, require NDC > 5 for study validity.

Example category names
- NDC = 3 ➔ {Low, Medium, High}
- NDC = 5 ➔ {Very Low, Low, Medium, High, Very High}

What percentage of the allowed tolerance has been used

Conclusion: Since this value is between 10% and 30%, the measurement system is marginally acceptable

Gage R&R – Notes

Slide 1

1. Precision and accuracy are different. Precision might be given to 5 decimal places, while the accuracy only has 1 decimal place.
2. Gage R&R is about precision of a *measurement system*, as measured by
   - *repeatability* (run the machine two times and obtain the same result)
   - *reproducibility* (have two operators obtain the same result)
3. There are many different approaches to obtain a Gage R&R result.
4. A G&G analysis requires statistics.
5. Most statistical packages have Gage R&R capabilities (e.g., Minitab).
6. Help from a SME is recommended.

Slide 2

1. Output from statistical packages is fairly standardized.
2. Usual outputs include the “total Gage R&R” a well as the “repeatability” and “reproducibility” components making up the total Gage R&R.
3. One output is the “Number of Distinct Categories” (NDC). This is the number of categories that the measurement system can distinguish between. If a measurement system can statistically distinguish between {very small, small, medium, …}, then it is more capable than a measurement system that can only distinguish between “small” and “large.”
4. There is threshold value that the Gage R&R value should meet (typically 10%) for a measurement system to be deemed “acceptable”.

Recommended web sites for additional information

- https://quality-one.com/grr/
- https://www.goskills.com/Lean-Six-Sigma/Resources/Gage-rr