Name _____

GAGE Repeatability & Reproducibility (Gage R&R)

Purpose

The purpose of this laboratory exercise is to conduct a gage repeatability and reproducibility study.   This laboratory will incorporate both measurement technique and data analysis.

Format

Five stations are set-up with different product parts, a drawing and the necessary dimensioning tool. Each student will be randomly assigned a station and partner(s).   Each station will also have the data collection sheets needed for recording the measurement results for the individual studies.

The gages used in this exercise are precision tools and must be handled with care so as not to damage them or compromise their accuracy. Proper handling and use of the gages will be provided before the exercise starts.

Background

One of the biggest issues in manufacturing is to ensure accurate measurement of product and process variation. This laboratory will explore accuracy and precision of a measurement tool.

Gage repeatability and reproducibility (gage R&R) is the evaluation of a measurement tool's accuracy. When conducting a study the focus is to determine whether there is close agreement among consecutive measurements using the same tool, under the same conditions on the same parts.   Repeatability relates to instrument (tool) variation and reproducibility relates to the appraiser's variation.

Guidelines for acceptance of a gage study are (MSA, printed by AIAG, 1995):

Less than 10% error	Measurement system is acceptable
10% - 30% error	May be acceptable Consider importance of application, cost of gauge, cost of repairs, etc.
Greater than 30%	Measurement system needs improvement

When conducting a study the following need to be considered and planned:
- Determine the number of appraisers, sample parts and repeat readings
- Select appraiser who normally operate the equipment
  - A mixture of novice, intermediate and experienced personnel is ideal
  - Appraisers will remain anonymous when reporting the data
- Select sample parts
  - When evaluating the measurement tool, the parts need to represent the process but do not have to include the full process range
  - When evaluating process control, the parts should represent the full process range.
- Measurement tool should allow at least 1/10 discrimination of the expected characteristic dimension
  - Example: dimension 0.156 +/- 0.005 inches, the tool should be able to measure 0.xxxx.
- Defined (implemented) measurement procedure shall be followed.

The analysis of the results assumes statistical independence of the various readings. To minimize misleading results:

- Measurements made in random order
- Readings should be recorded as displayed by the instrument (all digits for digital)
- Each appraiser should use the same procedure, all steps, to obtain the readings
- An observer is recommended.

Due Date: November 16, 2016
Completed spreadsheet, gage analysis form and post-lab questions

Laboratory Exercise:

- Five measurement stations have been set-up. Each student will complete the measurement cycles at their individual station only. Prints for the individual parts and the randomized check sheets are available at each station.
    - Only one dimension per part will be measured.
    - Ten parts are available and each will be measured in the order specified on the data sheet.
    - Each team member will measure the ten parts three times.
    - Each team member will complete a set of 10 parts, prior to moving onto the next trial.
    - Team members not measuring will observe to ensure the procedure is followed and record data as requested.

- The data sheets located at each station have been randomized for individual team members and parts. It is critical to the study that the individual parts be measured in the order they are specified on the data sheets and that there is a rest period between trials.

- The Tables on pages 6-7 were taken from "Measurement System Analysis (MSA) Reference Manual, published by AIAG, 1995. They will be referenced for calculating the results. The calculations required in Table 1 have been set-up in an Excel® spreadsheet that is available on blackboard.

Measurement Procedure:

1. Select a station to begin the exercise. Locate the print and familiarize yourself with the tools.
2. Review the print and the data sheet to verify the correct part.
3. These should be treated as production documents; good documentation practices shall be followed.
4. Individual data sheets have been provided for each student.
    a. The individual parts will be measured by each team member three (3) times.
    b. There needs to be a rest period between trials.
    c. The parts have been numbered 1 – 10.
       Note: If there are less than 10 parts located at the station, for the missing numbers enter n/a on the check sheet.
    d. They shall be measured in the order as printed on the data sheet.
       Note: This is a critical step to the integrity of the study. Part numbers have been randomized between the three trials and between analysts.
5. Team member(s) not measuring shall be observers.
6. Procedures for each part / dimension are listed below.

NOTE: Force is not required when using these tools.
       Use "medium" pressure for the calipers & micrometers

Station #1 – Mounting Post

The dimension to be studied is the length of the part, excluding the threads (4.15 inches +- 0.02 inches)
A digital caliper will be used for taking the measurements.

The length shall be measured in the location indicated on the print; refer to the document located at the station.
The calipers should rest on the bottom of the part and the edge at the base of the threads.

The external blades shall be used for taking the measurement
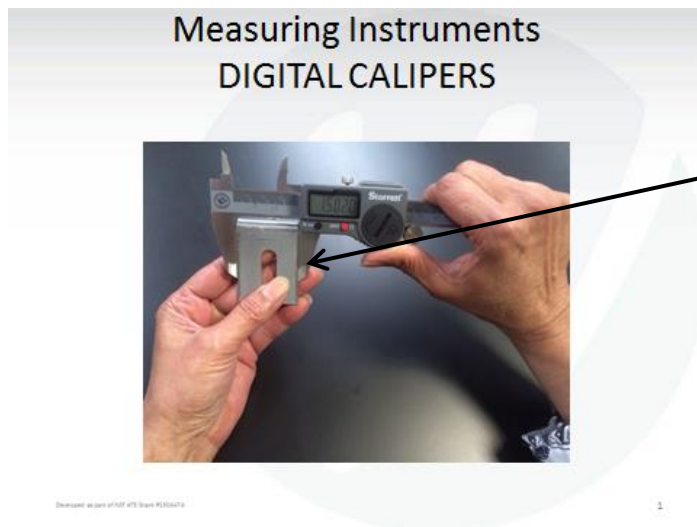
Station #2 – Washer Machined

The dimension to be studied is the thickness of the part (0.09 inches +/- 0.02 inches)
A digital micrometer will be used for taking the measurements.

The thickness shall be measured in the location indicated on the print; refer to the document located at the station.
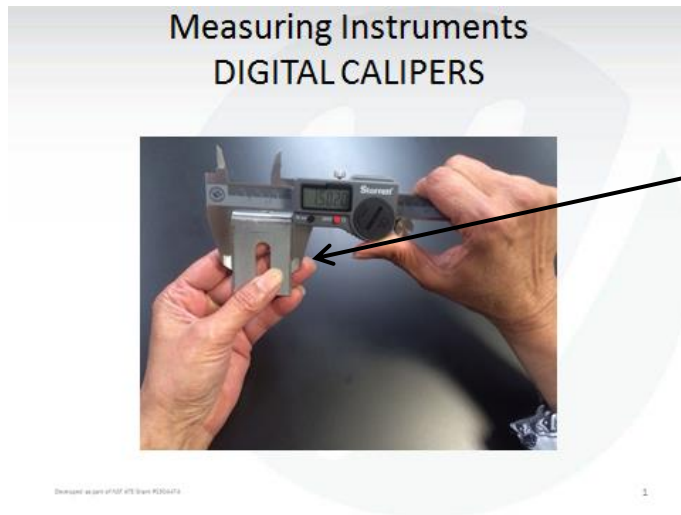
Station #3 – Cone head bolt

The dimension to be studied is the hex width (1.12 inches +- 0.03 inches)
A digital caliper will be used for taking the measurements.

The calipers should rest on the edge of the bolt.

The external blades shall be used for taking the measurement

External blades; the part shall be measured as pictured here.

Station #4 – Bracket

The dimension to be studied is the inside length of the large oval slot (1.00 inches +/- 0.02 inches)
A digital caliper will be used for taking the measurements.

The length shall be measured in the location indicated on the print; refer to the document located at the station.

The external blades shall be used for taking the measurement
The tips of the caliper blades shall just touch the edges of the slot

Internal blades; the part shall be measured as pictured here.

Station #5 - Fastener

The dimension to be studied is width of the part (0.75 inches +/- 0.02 inches)
A digital micrometer will be used for taking the measurements.

The width shall be measured in the location indicated on the print; refer to the document located at the station.

Calipers or micrometer can be used for this measurement.
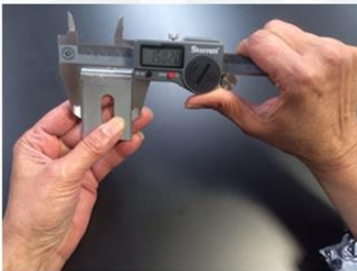
Analysis Procedure:

1. A spreadsheet combing all analyst data for a specific part is necessary to complete the analysis.

2. The spreadsheet is available on blackboard in course content/laboratory exercises/lab #8..

   a. Enter the results into the spreadsheet

   b. Record $\bar{X}_a, \bar{R}_a, \bar{X}_b, \bar{R}_b, \bar{X}_c, \bar{R}_c$ below. These are the averages and ranges for the individual analysts.

$\bar{X}_a$	$\bar{R}_a$	$\bar{X}_b$	$\bar{R}_b$	$\bar{X}_c,$	$\bar{R}_c$

   c. Record $\bar{\bar{X}}, R_p, \bar{\bar{R}}, X_{Diff}, UCL_R, LCL_R$ below.

$\bar{\bar{X}}$	R_p	$\bar{\bar{R}}$	$X_{Diff,}$	UCL_R	LCL_R

3. Table 1 describes the calculations being completed in the spreadsheet.
4. Using the values determined above, complete the Gage R&R Report (page

Table 1. Data Analysis - Gage Repeatability & Reproducibility

Appraiser	Trial #	Sample Number										Average	
		1	2	3	4	5	6	7	8	9	10		
1	1												
2	2												
3 (A)	3												
4	Average												$(\overline{X}_a)$ average for analyst A
5	range												$(\overline{R}_a)$ average range for analyst A
6	1												
7	2												
8 (B)	3												
9	Average												$(\overline{X}_b)$ average for analyst B
10	range												$(\overline{R}_b)$ average range for analyst B
16	Part Average $(\overline{X}_{p)}$												$\overline{\overline{X}}$ overall average of all part
17													R_p range of part averages
18													$\overline{\overline{R}}$ Average Range (appraisers) (Ra, Rb, Rc)
19						0	0	0					$\overline{X}_{DIFF}$ Range of appraiser averages $(\overline{X}_a, \overline{X}_b, \overline{X}_{c)}$
20													UCL_R
21													LCL_R

Worksheet from AIAG manual

Post-Lab Questions

Describe experience of conducting the measurement study (e.g. randomness of parts, consciousness of previous values, etc.)

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Would you have set the study up differently? How? Why?

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Were the team results within the acceptable range?

If not, what areas need improvement (tool, analyst, etc..)

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