Availability :
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Master Document:	**Gage Repeatability and Reproducibility (Gage R&R)**
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Most recent change history:

Revision	Description of Change
B to C	Updated process owners and approver. Added link to template for suppliers. Added reference to AIAG's MSA 4th Edition.

Changes in relation to previous issue are written with red, alternatively for figures and tables with a red frame around

1 DEFINITION

We use measurements to understand and control our parts and processes. Our measurements are never exact. It is critical, therefore, to understand, quantify, and control the errors introduced by the measurement system itself. Excessive gage Variation (i.e. poor gage R&R) makes it very difficult to see (and control) what is really happening within a process.

The amount of potential error in the measurement is statistically quantified through a Gage R&R study. The result of a gage R&R study is a comparison of the variation in the measurement system compared to the specification and the corresponding percentage of the tolerance consumed by measurement system variation.

- **Repeatability** refers to the variation present when one person measures the same part several times with the same gage.
- **Reproducibility** is the variation resulting from different operators measuring the same parts with the same gage.

2 PROCEDURE

2.1 Preparation – Avoiding Common Mistakes

- The personnel who will be using the measuring equipment must be the ones involved in the Gage R&R. Do not use process engineers or quality technicians. Doing so may mask operator use and training issues.
- Make sure the operator understands that the Gage/Gaging Process is being assessed, not *their* ability. This is very important.
- As much as possible, have the operators take readings the same way as if they were running at production rate.

  The only exception to this is obvious improvements can be made (and maintained) to the gage/gaging process. In this case the changes should be made before beginning the study.

- Be very careful when recording data – the randomized sequence required can be very confusing. Make sure parts are well labeled and double check that data is recorded for the correct part.
- Don't let the operators record their own data. Seeing the differences in the measurement of the same part will change the result – even if it is only subconsciously.
- Use production hardware that is representative of a large percentage of the total process variation (greater than 50%). Consecutive pieces from the operation are NOT recommended. It is better to draw samples over a period of several hours/days.

2.2 Determine Study Format

- 3 and 10
  - Three Operators, Three Trials, 10 Parts
  - Standard Format
- Master
  - Use a single traceable standard or controlled "Golden Part"
  - Use 3 and 5 Method (3 operators, 5 trials, 1 part)

  Master Studies have a HIGH risk of operator bias (because the same part is re-measured) and are only suited for gages like Coordinate Measuring Machines (CMM's), Production Test Stands, or other gages where the data are automatically recorded and the operator cannot influence/bias the results.

2.3 Collect the Data

- Number the parts 1-10.
- Take measurements in the order provided below to help eliminate operator bias
  8 6 2 1 5 3 10 9 7 4 repeated 3x for each operator

  DO NOT collect the data as measuring 8 three times then measuring 6 three times, etc.

2.4 Perform the Calculations

- Put the data in the Excel Gage R&R Spreadsheet, available on Navigator under Quality ▸ Templates
  or for suppliers at the link below:
  www.sauer-danfoss.com/Procurement/InformationDownloads/GlobalStandards.

- Minitab or other commercial software packages can be used to complete the calculation provided the method used to interpret the data is the "Xbar and R" or "ANOVA" Method. Select either 5.15 Sigma Limits or 99% Confidence to get the same results as the Sauer-Danfoss template.

2.5 Interpreting the Results

Gage R&R:

- R&R of less than 20% - Measurement System Acceptable
- R&R 20% to 30% - Measurement System May Be Acceptable. Make your decision based on the classification of characteristics (i.e. 8's, 6's, 4's), operator training issues, hardware application, part-to-part variation, customer input, realistic tolerancing, etc. Do not automatically assume that a new measurement system is needed.
- R&R over 30% - Measurement System Unacceptable. Find the problem and remove the root cause. Evaluate other measurement systems after attempting to correct the current system.

Number of Distinct Categories:

- The number of distinct Categories is another indicator of the measurement systems capability. An acceptable system should have a minimum of 5 distinct categories. This indicates that the measurement system is able to divide the data into 5 or more groups and it can tell the difference between parts falling into one of those groups.

2.6 Improving the Measurement System

If Repeatability is large compared to Reproducibility, some of the reasons may be:

- Instrument needs maintenance
- The clamping or location for the gaging needs improvement
- There is excessive with-in part variation (tapered bores, surface which are not flat, etc)
- The Gage/Fixture should be re-designed to be more rigid.

If Reproducibility is large compared with Repeatability, some of the reasons may be:

- The appraisers need to be better trained on how to use and read the gage instrument
- The gage is hard to read
- Fixturing to obtain more consistent measurement process are needed.

3 REFERENCES:

Measurement Systems Analysis (MSA)
Reference manual, February 1990 by Chrysler, Ford and General Motors
Fourth edition of 2010.

A Fishbone Diagram is shown in Appendix A to be an additional aid in improving Measurement Systems.

CHANGE HISTORY:

Date	Old/New Rev.	Description of Change
2007-10-30	A / B	Template no longer embedded in GS. Added details about Master Study in 2.2 and to alternative calculation methods in 2.4
2011-03-18	B / C	Updated process owners and approver. Added link to template for suppliers. Added reference to AIAG's MSA 4th Edition.

Appendix A

Sources of Variation in a Gaging System