

HOW TO USE MINITAB:

GAGE R & R STUDIES



1

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08/27/14

TYPES OF STUDIES IN MINITAB

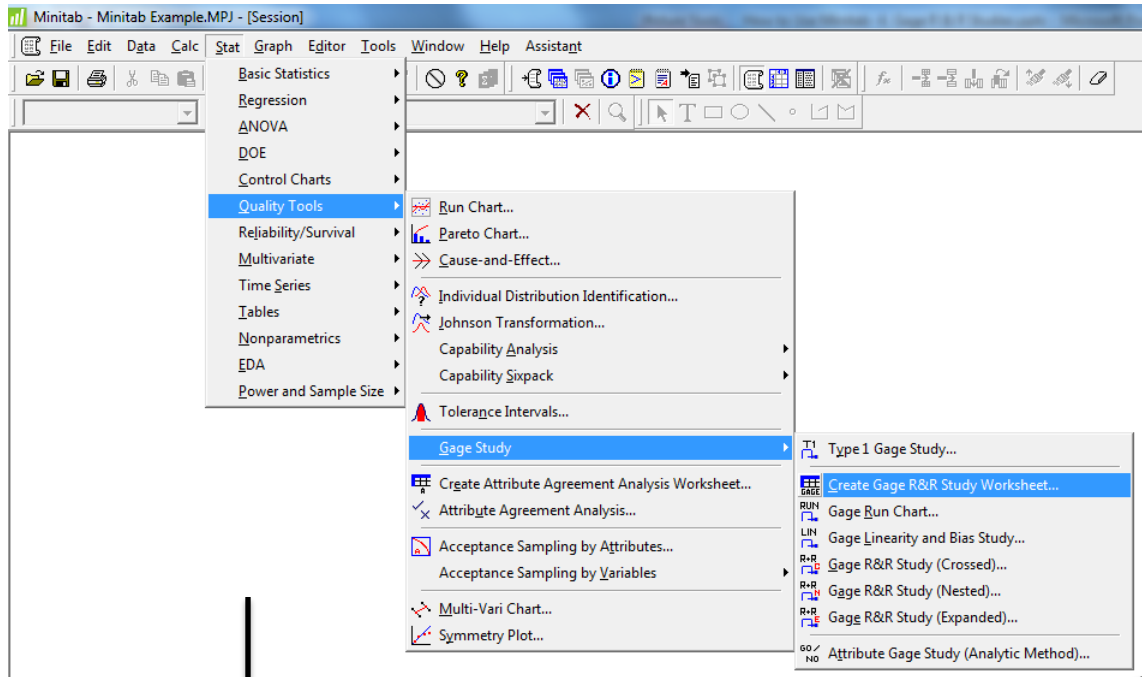
○ Gage R & R Study (Crossed)

- Best one to use, if you can
- Each operator measures each part
- Parts are measured more than once
- # observations per part is the same
- ex.) 3 operators, 4 parts, 5 observations per part
total of $3 \times 4 \times 5 = 60$ observations

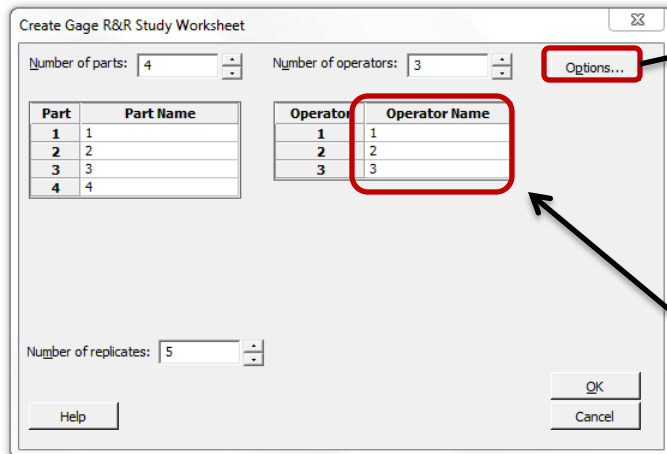
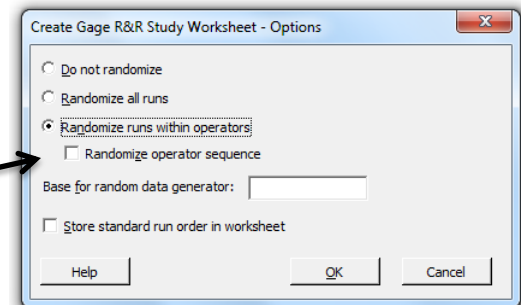
○ Gage R & R Study (Nested)

- When you don't have the "balanced" design above. Most often, you use this if all operators cannot measure all parts.
- ex. Operator 1 measures parts A and B, Operator 2 measures parts B and C.

DESIGNING A STUDY



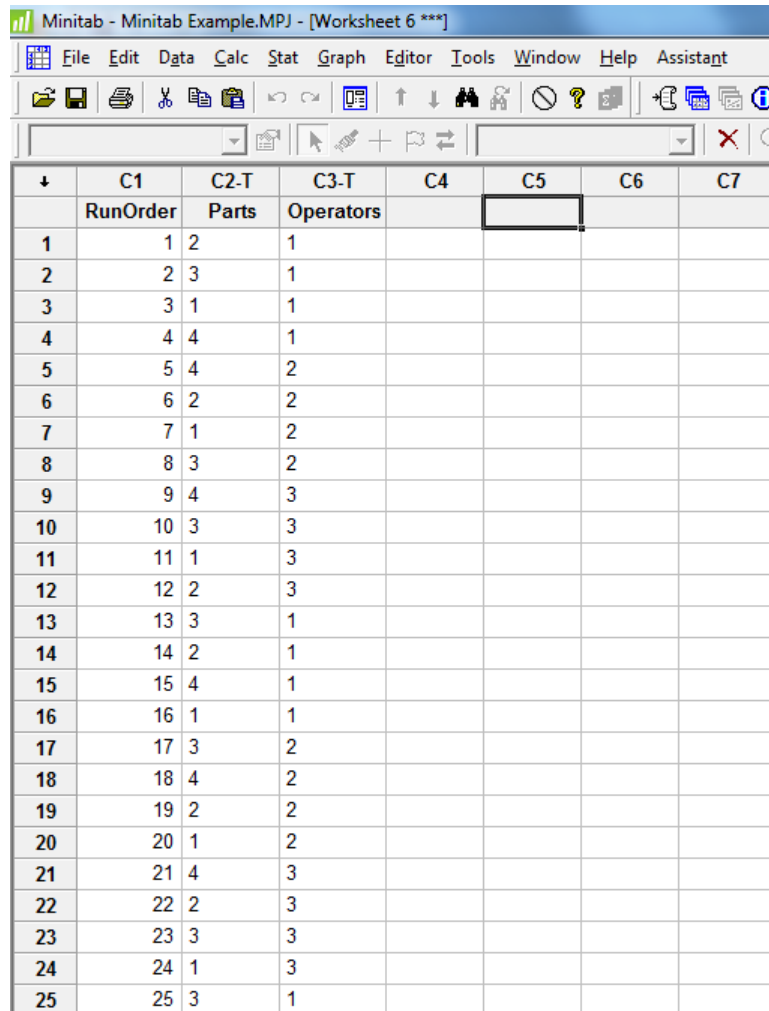
You can create a crossed (balanced) study in Minitab



Should keep randomization if you can. If you can randomize all runs, do so.

You can change the names of parts and operators.

DESIGNING A STUDY



The screenshot shows the Minitab software interface with a worksheet titled 'Minitab - Minitab Example.MPJ - [Worksheet 6 ***]'. The menu bar includes File, Edit, Data, Calc, Stat, Graph, Editor, Tools, Window, Help, and Assistant. The toolbar contains various icons for file operations, editing, and data manipulation. The worksheet displays a data table with 25 rows and 7 columns. The columns are labeled C1, C2-T, C3-T, C4, C5, C6, and C7. The first three columns contain numerical data, while the remaining four columns are empty. The cell at the intersection of row 1 and column C5 is currently selected.

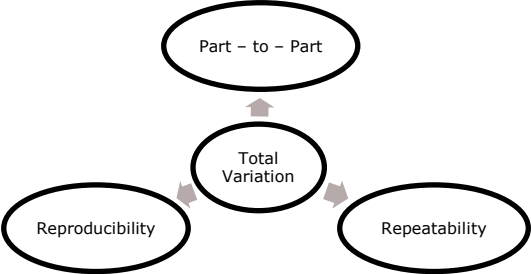
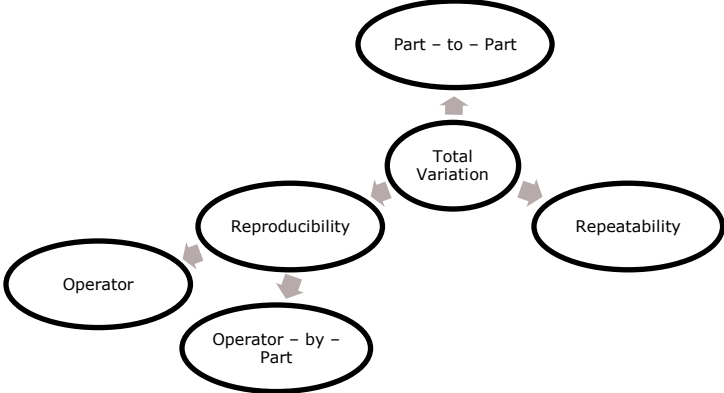
	C1	C2-T	C3-T	C4	C5	C6	C7
	RunOrder	Parts	Operators				
1	1	2	1				
2	2	3	1				
3	3	1	1				
4	4	4	1				
5	5	4	2				
6	6	2	2				
7	7	1	2				
8	8	3	2				
9	9	4	3				
10	10	3	3				
11	11	1	3				
12	12	2	3				
13	13	3	1				
14	14	2	1				
15	15	4	1				
16	16	1	1				
17	17	3	2				
18	18	4	2				
19	19	2	2				
20	20	1	2				
21	21	4	3				
22	22	2	3				
23	23	3	3				
24	24	1	3				
25	25	3	1				

Output: New worksheet with the design of your study

In the next column (C4) enter in your measured data, once you have it

METHODS FOR ANALYZING A STUDY

Two Methods for analyzing a Gage R & R Study (in Minitab)

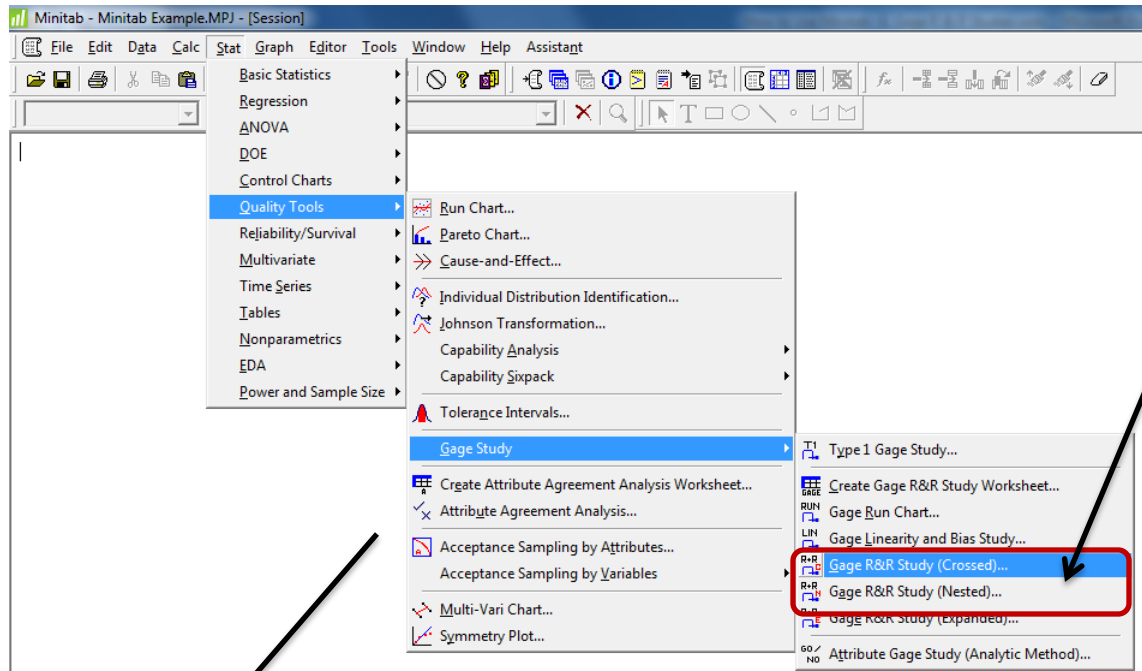
Xbar - R	ANOVA
<p>1. Uses the average range to estimate variation</p> <p>2. Breaks down the overall variation into three categories</p>  <p>3. Sometimes, can produce biased estimates.</p> <p>4. Because of (2) and (3), not the best method.</p> <p>Click HERE for more information.</p>	<p>1. As the name suggests, uses an Analysis of Variance table to estimate variation</p> <p>2. Goes one step further and splits reproducibility into 2 parts</p>  <p>3. Much better method, because it produces unbiased estimates.</p> <p>4. ANOVA more accurate, so I suggest using this one all the time.</p> <p>Click HERE for more information.</p>

What is **Bias**? The difference between the expected value and the actual (true) value.

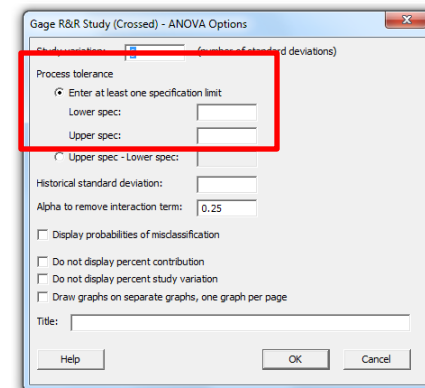
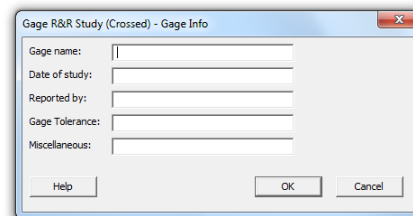
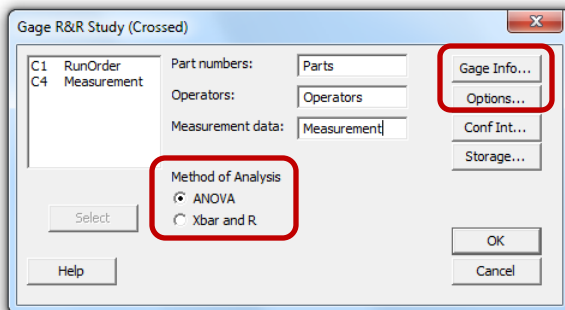
Many people look to use estimates that have zero bias because expected = actual. These are called unbiased. There is a trade-off between bias and variation, however. As bias goes down, variance often goes up (and vice versa).

ANALYZING GAGE R & R STUDY

Remember, *crossed* is the “balanced” study, and *nested* is when all operators cannot measure all parts



By entering in specification limits, you will output a column of %Tolerance. The %Tolerance compares the estimates of variation with the allowable spread of variation.



For Crossed studies, have the option of using either ANOVA or Xbar - R

ANALYZING GAGE R & R STUDY- OUTPUT

Gage R&R Study - ANOVA Method

Gage R&R for Height

Gage name: Tencor P-6
 Misc: LSL = 1.6 USL = 2.4 Target = 2

Two-Way ANOVA Table With Interaction

Source	DF	SS	MS	F	P
Part	9	0.0562044	0.0062449	321.822	0.000
Operator	2	0.0002798	0.0001399	7.210	0.005
Part * Operator	18	0.0003493	0.0000194	0.960	0.515
Repeatability	60	0.0012127	0.0000202		
Total	89	0.0580462			

Alpha to remove interaction term = 0.25

Two-Way ANOVA Table Without Interaction

Source	DF	SS	MS	F	P
Part	9	0.0562044	0.0062449	311.856	0.000
Operator	2	0.0002798	0.0001399	6.987	0.002
Repeatability	78	0.0015620	0.0000200		
Total	89	0.0580462			

Gage R&R

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.0000240	3.36
Repeatability	0.0000200	2.80
Reproducibility	0.0000040	0.56
Operator	0.0000040	0.56
Part-To-Part	0.0006917	96.64
Total Variation	0.0007157	100.00

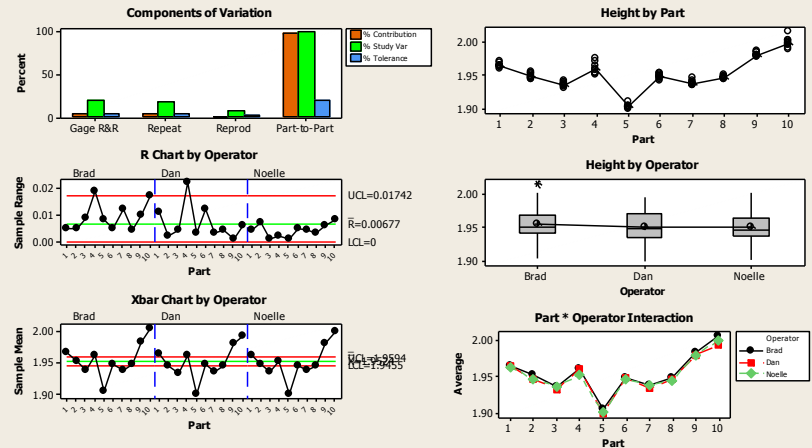
Process tolerance = 0.8

Source	StdDev (SD)	Study Var (6 * SD)	%Study Var (%SV)	%Tolerance (SV/Toler)
Total Gage R&R	0.0049012	0.029407	18.32	3.68
Repeatability	0.0044749	0.026850	16.73	3.36
Reproducibility	0.0019991	0.011994	7.47	1.50
Operator	0.0019991	0.011994	7.47	1.50
Part-To-Part	0.0262994	0.157796	98.31	19.72
Total Variation	0.0267522	0.160513	100.00	20.06

Gage R&R (ANOVA) for Measurement

Gage name: Tencor P-6
 Date of study:

Reported by:
 Tolerance:
 Misc: LSL = 1.6 USL = 2.4 Target = 2

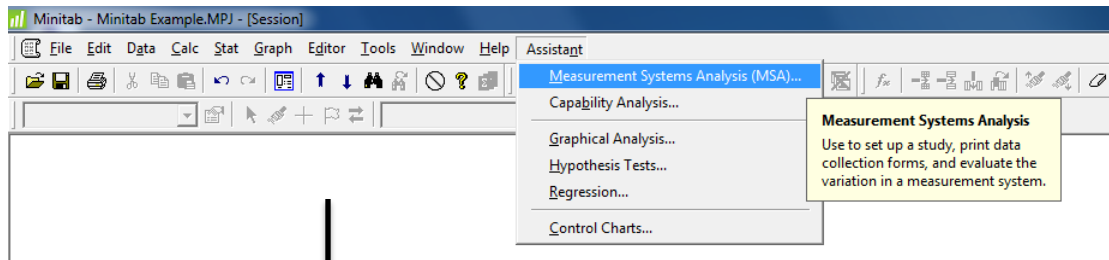


Shows how the variation is split up

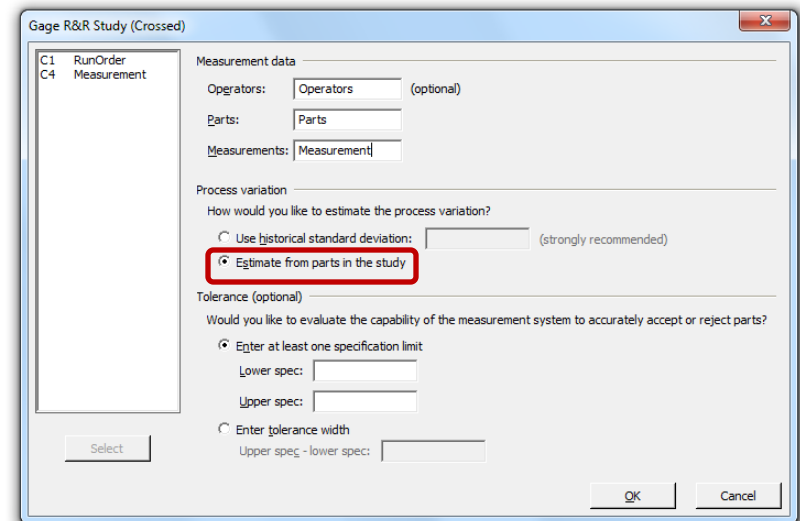
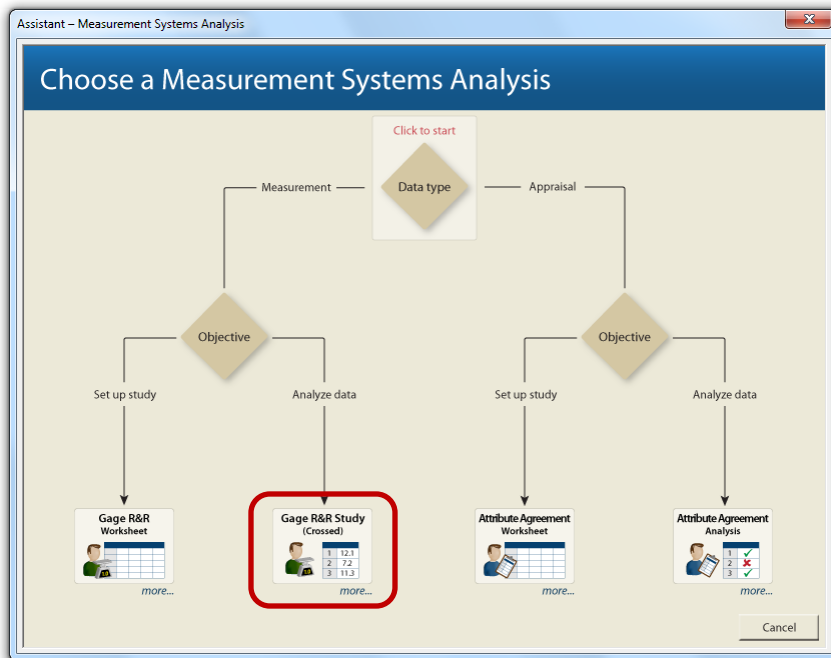
Sometimes, the interaction term (part)x(operator) may not be significant. If so, it will not influence reproducibility. Minitab will remove the interaction term from the calculations, to make things simpler, if the term is insignificant.

Compares variation to specification limits

ANALYZING CROSSED GAGE R & R STUDY

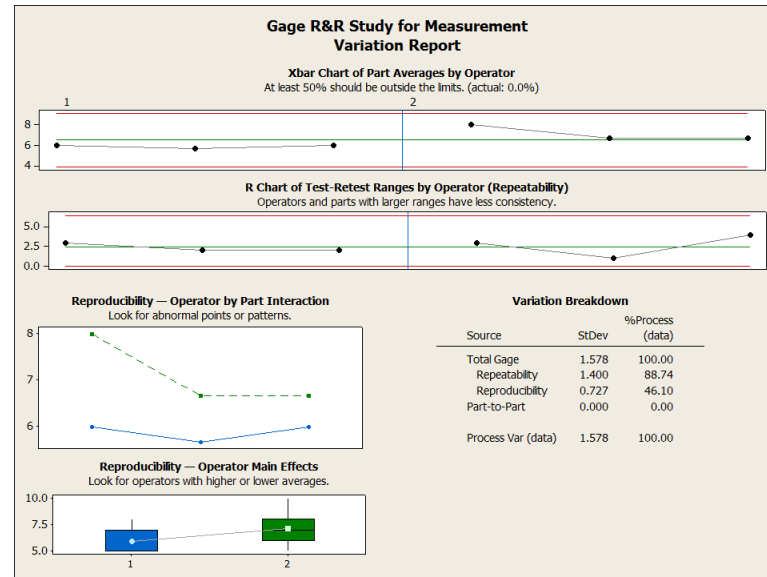
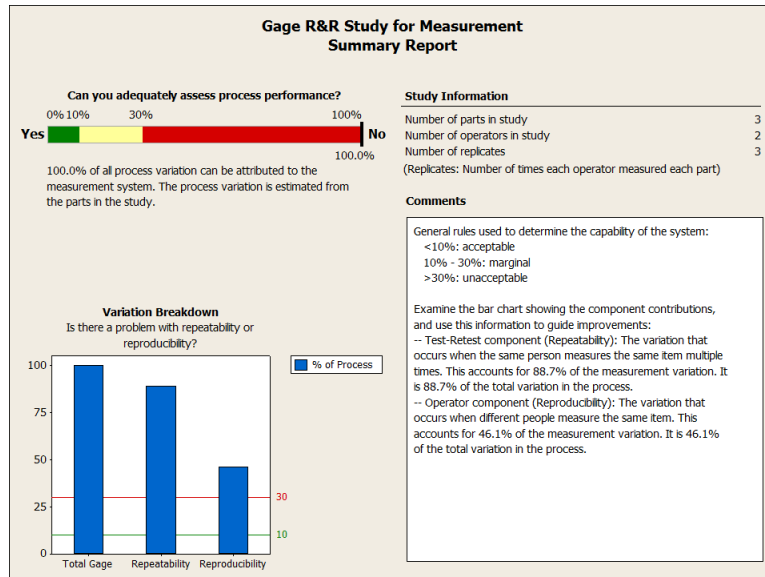


Can also use Minitab's Assistant feature (for crossed only).



Unless you already know the process standard deviation, you must estimate it.

OUTPUT- ASSISTANT



Gage R&R Study for Measurement Report Card

Check	Status	Description
Amount of Data		To determine if a measurement system is capable of assessing process performance, you need good estimates of the process variation and the measurement variation. -- Process variation: Comprised of part-to-part and measurement variation. It can be estimated from a large sample of historical data, or from the parts in the study. You chose to estimate from the parts but have fewer (3) than the typical requirement of 10. The precision of this estimate may not be adequate. If the selected parts do not represent typical process variability, consider entering a historical estimate or using more parts. -- Measurement variation: Estimated from the parts, it is broken down into Reproducibility and Repeatability. The number of parts (3) or operators (2) does not meet the typical requirement of 10 parts and 3 operators. The estimates of measurement variation may not be precise. You should view the estimates as indicating general tendencies, rather than precise results.
Xbar Chart		The control limits are based on Repeatability. Ideally, the variation from repeated measurements is much less than the variation between parts. Guidelines suggest that approximately 50% or more should fall outside the limits. In this study, no points are outside.
R Chart		Each point is the range of the measurements for a part. In this study, no points are above the upper control limit, indicating all parts were measured with similar consistency.

REFERENCES

- Khan, R. M. (2013). *Problem solving and data analysis using minitab: A clear and easy guide to six sigma methodology* (1st ed.). West Sussex, United Kingdom: Wiley.

- Minitab's Help Section

