



**Repeatable Expectations for GR&R
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It seems axiomatic that the more precise we try to be, the less certain we become. In today's manufacturing world, nothing is flat, round, smooth, or exactly the same length. Tenths have turned into thousandths and now millionths. While it seems very easy to put a dimension on a part print, it's neither so easy to make the part nor to design a gage to measure that tolerance with some certainty.

The process of determining the capability of a gage—GR&R—requires the analysis of the complete measurement process involving that gage. This includes looking at each one of the individual elements, which we all remember as SWIPE: the standard, the workpiece, the instrument, the people and the environment. Each element can be a source of error and if you change any one element, you have to reanalyze the entire process again.

The heart of the measurement process is still the gage. There are many design characteristics that need to be incorporated to help the gage meet its requirements. The tighter the tolerance, the more consideration needs to be given to how the part is staged, how the contacts meet the part, and how deviation is displayed. Just as it is easy sometimes to put a very tight tolerance on a part, it's just as easy to require that a gage meet a 10% GR&R requirement on that very tight tolerance.

Since the gage is only part of the measuring process, it is allowed only a percentage of the total GR&R spread. The way this is calculated is that, in the worst case, the repeatability allowance for the gage, by itself, on the master, is only 4% of the tolerance. What does that mean with today's shrinking tolerances? The following chart might help. If we look at the tolerance spread and take 4% of it, some very small numbers begin to appear.

| <u>Tolerance Span</u> | <u>Required Repeatability To Achieve 10% GR&R</u> |
|-----------------------|---|
| .020" | .0008" |
| .010" | .0004" |
| .005" | .0002" |
| .002" | .00008" |
| .001" | .00004"*** |
| .0005" | .00002"*** |
| .0001" | .000004"*** |
| .00005" | .000002"*** |
| .00002" | .0000008"*** |

There are a few interesting things to consider when looking at this list.

Most importantly, it puts in perspective just how good the gage must be to achieve the 10% GR&R. We have to think about what the repeatability test should consist of to verify the requirement. What this spec calls out is how well the gage can repeat only on the master. It says nothing about the gage calibration, bias or linearity. It is talking about just the repeatability. Still, even in this case, we are really dealing with the whole measurement process, but trying to isolate just a small portion for the gage.



We must assume that the environment is stable and one operator is capable enough to put the master in the gage the same way every time. Usually, the test will consist of one operator measuring the master 30 times. Therefore, the master should be appropriate for the test: right form and surface finish, and stabilized for the test. After thirty measurements, done in a series over a short time, the results are analyzed for total span. If the span falls within the 4% of the tolerance, there is a good chance that the gage repeatability will not be the determining factor in the 10% GR&R requirement. Other parts of the process will all need to be reviewed as the test is done.

You will also notice that I marked some of the 4% requirements with a double asterisk. This was done to note that in many gaging applications, this may not be attainable. We are referring to those gaging applications that would be performed in the typical shop environment. To even think about achieving these types of performances, you would have to consider the measurement as a millionth class gaging requirement. There are gages that can do this—gage block comparators and precision length machines—but these are specialized machines designed to meet specific requirements. This is not to say that production gages cannot be designed to this level—they can and they have been—but they require automatic control, special environments, and design criteria for millionth measurement, along with a lot of investment.

The point here is that it's often a casual thought to put a GR&R requirement on the gaging request for quote. Before it goes on the paper, both the tolerance and the expectations need to be reviewed to see if the requirement is achievable.

