MEASUREMENT PROCESS CAPABILITY - PART 1

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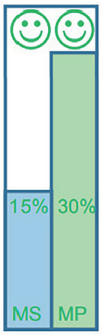
There is still need for discussion – a working paper

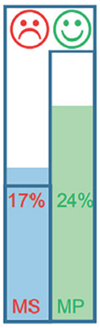
Nowadays, measurement process capability according to VDA Volume 5 and/or ISO 22514-7 is well-established. The Volkswagen group (VW, Audi, Seat, Skoda...) adapted their VW 10119 guideline years ago, the LF5 Daimler guideline is already based on the latest edition of VDA Volume 5, BMW modified the group standard 98000 accordingly, Bosch updated booklet 8... however, this fact alone does not answer all the questions. This article discusses some current aspects that leave room for interpretation since they are not based on any "official" regulations. Read part 1 of this series of articles.

MEASURING SYSTEM N.O.K., MEASUREMENT PROCESS O.K.?

Page 42 of VDA Volume 5 says: " The limits for the capability of measuring systems and measurements processes must be determined. It is important to consider that the influences of the form deviation of test parts can affect the evaluation of the measurement process considerably. It is recommended that the capability ratio for measuring systems, Q_{MS_max} amounts to 15% and, for measurement processes, Q_{MP_max} amounts to 30%."



The limits VDA Volume 5 recommends are interpreted in a way that the capability ratio for the measuring system shall be $Q_{MS} \leq 15\%$ while the capability ratio of the measurement process shall amount to $Q_{MP} \leq 30\%$. VDA Volume 5's flow chart (Figure 7, p. 41) supports this point of view assuming that half the uncertainty budget is caused by the measuring system and half of it comes from other influence components of the measurement process. (Whoever wants to assess specific figures has to consider that the calculation of measurement uncertainties is based on a quadratic addition.)



Nonetheless, the measuring system frequently exceeds its budget (e.g. Q_{MS} = 17% > 15%) while the total process does not even reach its limit (e.g. Q_{MP} = 24% < 30%) and is thus capable. Especially characteristics with tight tolerances and standards/reference parts having a relatively high calibration uncertainty that is physically hardly feasible typically cause problems.

The question is whether the measurement process as a whole has proved to be not capable, and justifiably so, since it is not important at all, at least in most use cases, whether influences from the measuring system or from the measurement process dominate the measurement uncertainty U = 12%.

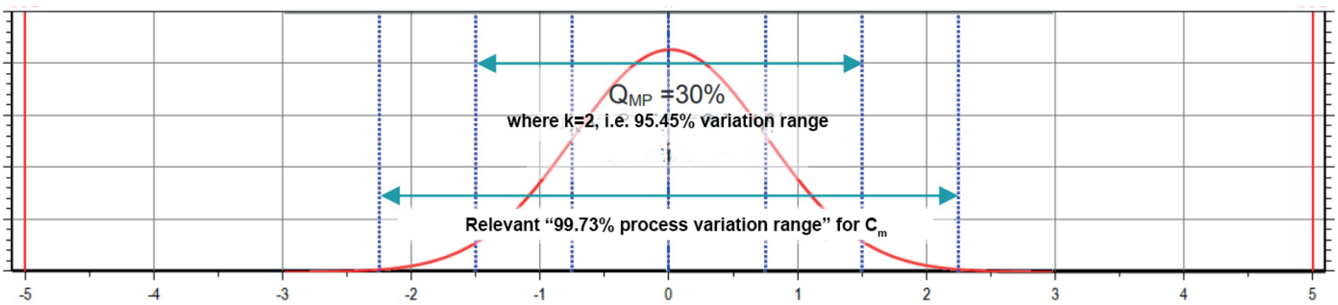
A possible solution is to leave out the evaluation of Q_{MS}. You only use Q_{MP} to evaluate an existing measurement process.

Another possibility is to raise the limit QMS in general. This might, however, cause inconsistencies, especially when you evaluate a measuring system to make a preselection. The limit of $Q_{MS} \leq 15\%$ will then be fairly appropriate to have reasonable scope left for the hitherto unknown measurement process.

MEASUREMENT PROCESS CAPABLE BUT STILL USELESS?

Even the limit of $Q_{MP} \leq 30\%$ has already caused some debates. There is no doubt that measurement engineers are hardly able to observe it. For now, let us look at the consequences this limit has.

Q_{MP} indicates the uncertainty variation range based on a “probability of 95%”. Strictly speaking, the probability amounts to 95.45%; broadly speaking it is also referred to as “4s”. Loosely speaking, this is the “variation” caused by the measurement process alone. It is a kind of noise floor caused by the measurement process alone. Let us assume you start a machine acceptance test and expect $C_m/C_{mk} \geq 2.0$. Even if the production facility does not cause any variation at all and you identify nothing but the “noise floor” of the measurement process, you will have to include the 99.73% variation range (“6s”) of the measurement uncertainty in your calculation of C_m. Believe it or not, in case of Q_{MP} = 30%, this range amounts to 45% of the tolerance and thus leads to C_m = 2.22. The scope left for the machine is limited. The analysed machine needs to reach a capability of $C_m \geq 4.6$ under real conditions in order that the evaluation sheet shows $C_m \geq 2$ in the end. This is just utopian. And what is the consequence? A capable measurement process does not have to be capable for a machine capability analysis.

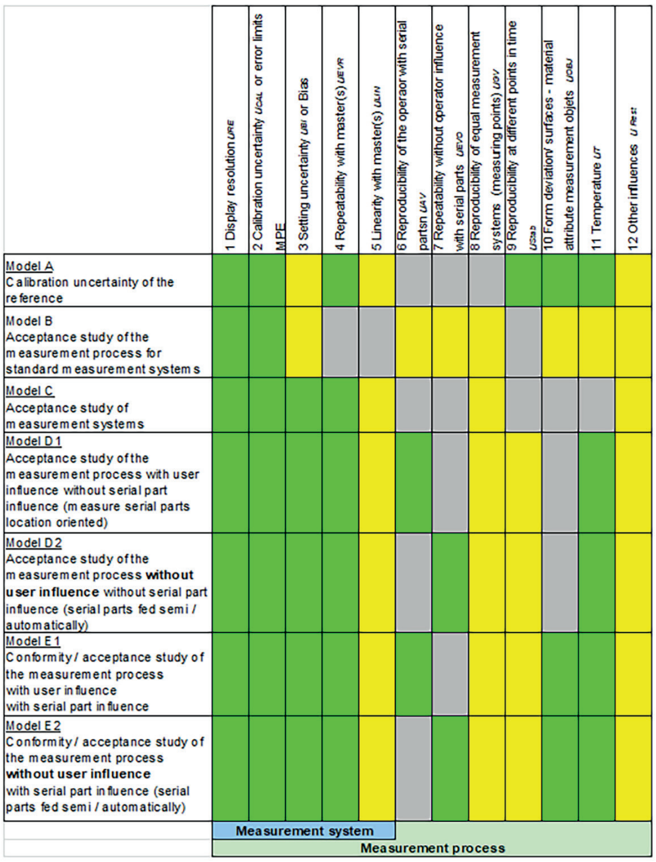


SPECIFY AN APPLICATION-SPECIFIC LIMIT

How shall we deal with this aspect? It is not enough to simply lower the limit since the causes of this problem are complex.

VDA Volume 5 wants to determine the uncertainty of "the measurement process" and thus evaluates all influence quantities affecting the measurement process. The question is whether the same influence quantities affecting a short-term machine capability analysis also affect a long-term analysis in terms of statistical process control. If this is not the case, the performance of a measurement process in a machine capability analysis will not be the same as for the purpose of SPC, even though the technical equipment and the characteristic of the part to be measured are identical.

VDA Volume 5 takes this aspect into account by giving an overview of typical measurement process models and associated typical uncertainty components in chapter 7.1.



We do not know how closely the models given in VDA Volume 5 reflect real requirements, but the concept behind them is brilliant. The only crux is the standardised limit. As an example, when you agree on an acceptance test according to model C with the manufacturer of the measuring system and you are scarcely able to respect the limit, any subsequent acceptance tests for the measurement process affected by the operator and series production parts will be likely to exceed this limit on site. It might thus be reasonable to assign a suitable limit to the measurement process model.

A flexible model might even make it easier to align typical MSA methods with VDA Volume 5. In historical terms, standards and guidelines usually demanded

- a type-1 study based on C_g /C_{gk} ≥ 1.33 and
- a type-2 study based on %GRR ≤ 10%,

however, we could now interpret this requirement as "MSA(V1/V2)" measurement process model based on special limits.

- Applying usual boundary conditions, i.e.
  - RE ≤ 5%T
  - U_{CAL} ≤ 5%T
  - BI ≤ 5%T
  - 99.73% MSA variation range,

we will expect Q_{MS} ≤ 19% and Q_{MP} ≤ 20% .

- Applying e.g. Bosch booklet 10 (2015) and expecting calibrated reference parts having a low measurement uncertainty and a bias that is as small as possible, i.e.
  - RE ≤ 5%T
  - U_{CAL} ≤ 1%T
  - BI = 0
  - 99.73% MSA variation range

the limits shall be adjusted to Q_{MS} ≤ 12% and Q_{MP} ≤ 13%.

- Focusing on Mercedes Benz Cars LF5 (2010) specifying
  - $RE \leq 5\%T$
  - $U_{CAL} \leq 5\%T$
  - $BI = 0$
  - 99.73% MSA variation range

the limits are $Q_{MS} \leq 18\%$ and $Q_{MP} \leq 22\%$.

These simple examples show that the system is highly flexible.

Interested in this topic?

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