lished in 2003 already contained the empirical assumption that the combined standard uncertainty of the measuring system amounted to about 50% of the combined standard uncertainty of the entire measurement process. It is more than obvious to define the limit of the QMS value as half of the QMP_max value so that it amounts to 15% in the evaluation of the measuring system.

International Meaning of these Limits

Particularly in a global, economic sense, manufacturers of measuring instruments or measuring systems have a high interest in the definition of standardized and binding procedures and limits. This is also helpful for the exchange of goods between customer and supplier. There is no other way manufacturers of measuring systems can be sure to meet the agreed specifications in selling and later acceptance of their products. The same applies to suppliers since they sign delivery contracts and agree to meet product characteristics. You may only check and evaluate this demand in a reasonable way by using a standardized measurement process capability analysis and by being able to consider the expanded measurement uncertainty as correct and binding at the customer's and the supplier's.

Summary

Measurement process capability analyses for the calculation of capability indices and ratios are important. You decide whether a measurement process is "capable" or "not capable" by comparing capability indices and ratios to specified limits. The better and the more frequently you are able to apply these procedures, the easier it is to perform a capability analysis.

However, you should be aware that you cannot measure everything by the same yardstick. You have to decide in each individual case whether the standards discussed in this article are applicable.

Q-DAS® offers a platform for the evaluation of these special cases.

Reducing the Uncertainty through Suitable Measurement Processes

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In industrial production, the applied measurement processes evaluate and assess the quality of manufacturing and production facilities as well as the produced parts, components and products. The results gained by the measurement processes and the statistical evaluation always include different uncertainties.

Quality Evaluation

Depending on the manufacturing or production process, selected quality characteristics are inspected in or after the different process steps. You may conduct a 100% inspection or an inspection based on a sample. You evaluate the manufacturing or production quality graphically by using various visualizations or numerically by calculating capability indices. The recorded measured values are evaluated statistically and the required statistics are calculated. These data are processed numerically and, depending on the respective application and the responsible user group, graphically, too. Only by succeeding in communicating the results quickly specifically to the respective task and user and in making them easily accessible, these results are applied in order to evaluate and assess processes and certain issues. In this case they contribute to the quality evaluation.

Uncertainty

The results or issues include, amongst others, uncertainties as a result of:

- measurement and test processes
- the application of statistical procedures
- erroneous data recording, transfer and management
- erroneous communication of results

You may solve the problems caused by the last two sources of error with organizational measures and IT support, e.g. by permanently checking the plausibility of data where relevant. The application of Q-DAS® products helps you to describe processes by means of validated statistical procedures specifying the confidence intervals for the single statistics. The uncertainty caused by statistical procedures becomes assessable now. However, the uncertainties from the measurement processes remain and thus we will have a closer look at them in the following.

Uncertainty Caused by the Measurement Process

The assertion "The accuracy of your measurements determines the accuracy of your production!" is more than true as the specifications become smaller. This is the reason why a capability analysis must be conducted before applying a measurement process .

In case a measurement process determines a measured value, this value will be invalid if you do not know the uncertainty of the measurement process. Only the expanded measurement uncertainty U_{MP} added to the measured value x_i leads to the measurement result $y_i = x_i + U_{MP}$.

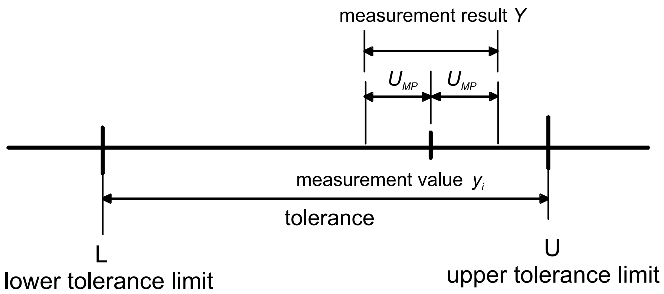

Figure 1: Proof of conformance with the tolerance

Figure 1 shows the measurement result relating to the specification for a quality characteristic. It is easy to understand that the measurement uncertainty U_{MP} must be low compared to the tolerance TOL. Otherwise, wrong decisions in the evaluation of the measured value, particularly near the specification limit, will be inevitable. Such a decision might be responsible for the delivery of defective products to the customer. You avoid this problem by performing capability analyses for your measurement processes.

[1] Definition of measurement process as given in VIM:
Interaction of interrelated operating resources, actions and influences creating a measurement.
Note: Operating resources can be men and materials .

By comparing the capability ratio Q_{MP} to a specified limit you evaluate the capability of the measurement process. VDA 5 or the ISO 22514-7 standard propose a limit of 30% for Q_{MP} 30%. This is only a recommendation that is not obligatory or binding. In some cases, this limit has to be adapted to the respective measuring task.

$$Q_{MP} = \frac{2 \cdot U_{MP}}{TOL} \cdot 100\%$$

Figure 2 displays how the capability index (also referred to as C-value) for the evaluation of machines, manufacturing equipment and processes relates to the capability ratio Q_{MP} of the measurement process. As the uncertainty of the measurement process rises (Q_{MP} rises) this graphic clearly shows that the difference between the observed and actual capability index becomes greater. In case of a Q_{MP} value of 40%, you will observe a C_g value of 1,33 even though it actually amounts to 2,2 due to the uncertainty. In order to calculate the capability ratio Q_{MP}, you have to determine the expanded measurement uncertainty U_{MP} of the measurement process.

You may either use

- GUM (Guide to the Expression of Uncertainty in Measurement) for calibration laboratories or measuring rooms
- or ISO 22514-7 or VDA Volume 5 for measurement processes in manufacturing or production

in order to calculate the expanded measurement uncertainty.

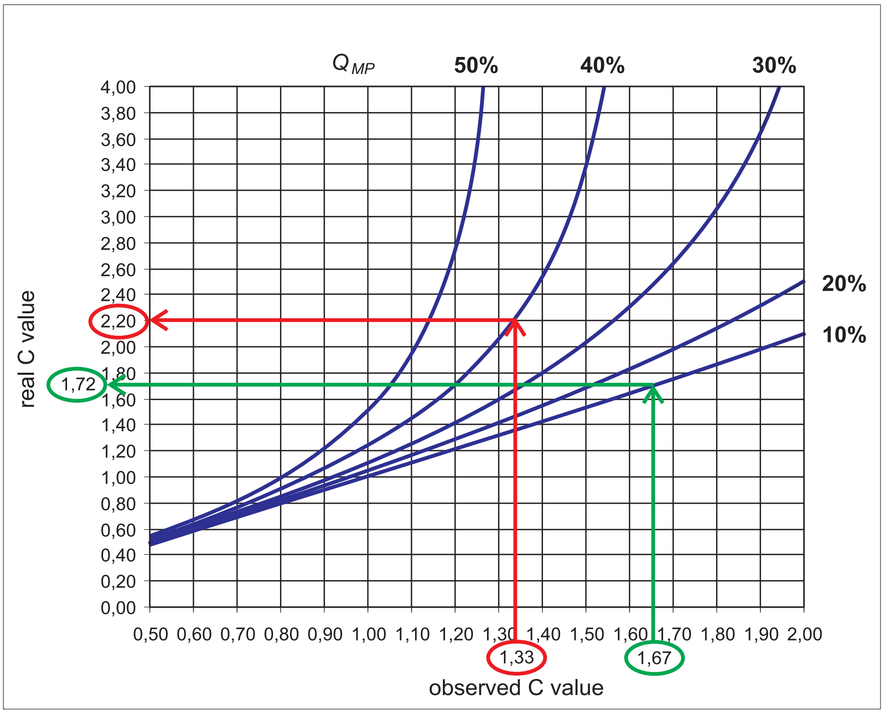

Figure 2: Display of the actual C-value compared to the observed C-value subject to Q_{MP}