

MEASUREMENT UNCERTAINTY IN TENSION BETWEEN CUSTOMERS AND SUPPLIERS

## Reduce Costs with Precise Coordinate Metrology

**Flexible multisensor coordinate metrology is finding increased use in incoming inspection and production monitoring for complex workpieces. There is always a choice to be made between faster or more precise sensors and machines. As a result, the evaluation of measurement uncertainty is increasingly significant. Customers and suppliers need to consider the interaction of tolerances and measurement uncertainty when defining a working relationship.**

The use of coordinate metrology provides detailed dimensional information about the production process, providing process control based on component tolerances. More precise measurements make it possible to reduce production costs through better utilization of the available tolerances.

### **Precise metrology reduces production costs**

The more precise and reliable the measurements are, the lower the occurrence of interventions in the process, which reduces production costs. The use of a precise measuring machine can even allow

production equipment to be less precise. Better knowledge of the actual current state means that the component tolerances can be better utilized. The cost savings that this generates in the production area can far exceed the price of such a measuring machine. The measurement uncertainty involved in every measurement plays a significant role. It depends on the type of feature, the material and surface finish of the component, the operator, the environment, and above all the measuring machine.

If the difference between the measurement results for shipment release and the drawing tolerances is equal to the uncertainty of the measurement itself, then the workpiece may actually be within (Fig. 1, top, Part A) or outside of the tolerance. The greater the measurement uncertainty, the greater the number of correct parts that must be classified as scrap due to the uncertainty. To prevent this, the supplier must set intervention limits and define production tolerances by subtracting the measurement uncertainty from the drawing tolerance.

This procedure is critically essential, because it is the only way to be sure that

the supplied workpieces are within the tolerance. The lower value for the production tolerance comes at a cost of more complex and expensive production processes (more precise production equipment, less utilization of tool life). As the measurement uncertainty increases, the production area must deal with tighter and tighter tolerances.

The purchase of a more precise measuring machine is therefore often the better option, because more precise production is almost always more expensive than measuring workpieces with a sufficient level of precision. It is particularly cost-effective if as many different measurement tasks as possible can be accomplished in one setup with modern multisensor coordinate measuring machines.

### Precise metrology reduces material costs

The measurement uncertainty at both the producer's and the receiver's incoming inspection must be taken into consideration. The receiver cannot refuse to accept workpieces if the amount by which they exceed

the drawing tolerance is only as great as the uncertainty of his own measurement, because the parts could still be correct (Fig. 1, bottom, Part B). As the measurement uncertainty increases, more workpieces need to be accepted and paid for that have measurement results outside of the drawing tolerance, and therefore cannot be used. Even if the amount that the part is within tolerance is the same as the measurement uncertainty, a part that is measured as good could actually be scrap. These workpieces must be accepted and paid for but cannot be used afterwards.

This means that the receiver incurs material costs for unusable workpieces, or takes the risk of consequential costs caused by using defective parts. A precise measuring machine on the receiving side can reduce the number of workpieces that are paid for but cannot be used, thus reducing material costs.

### Different tolerances for supplier and receiver

Appropriate precision and awareness of the measurement uncertainty that can be

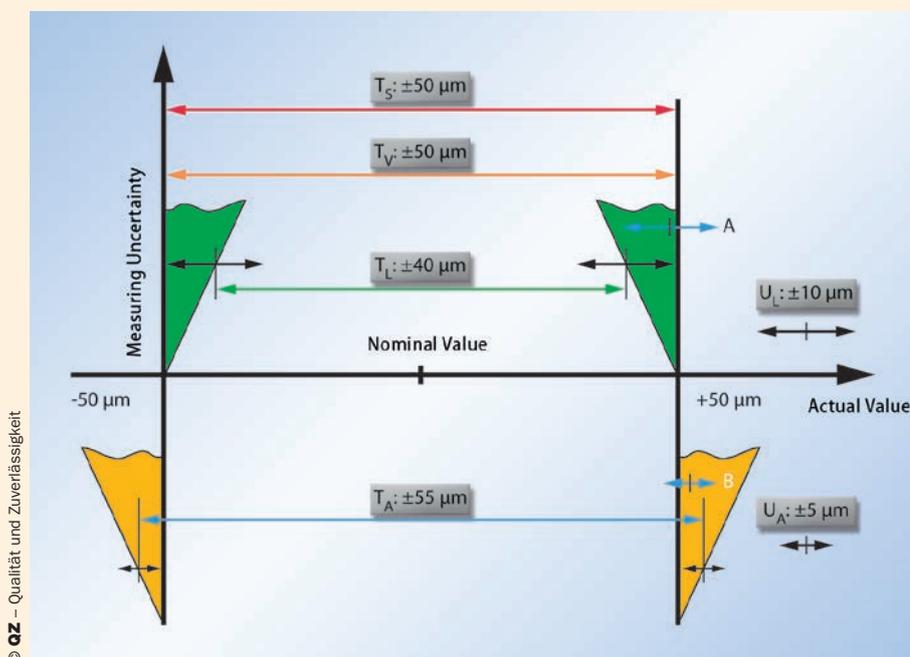
achieved are also very important to the relationship between customer and supplier. The interaction of production inspection and incoming inspection requires that acceptance criteria be defined in terms of the measuring systems used. This also applies to downstream use of parts within a company.

Contractual conditions are often based on the tolerances defined in the drawings. The supplier must meet them. For the receiver, however, the applicable receiving tolerance is increased by their measurement uncertainty. Parts that are close to the drawing tolerance must therefore be rejected, or the risk of using defective parts must be accepted. Economic efficiency and responsible quality assurance demand that the drawing tolerance not be used as the contractual tolerance.

### Agreeing on separate contractual tolerances

More logical limits can be produced by introducing separate contractual tolerances. These are established by subtracting the measurement uncertainty in the receiver's incoming inspection from the drawing tolerances. This contractually establishes that parts with actual values that are outside of the contractual tolerance during incoming inspection (Fig. 2, Parts B and C) do not have to be accepted. Parts that are measured by the receiver as being within the contractual tolerance are thus certain to be within the drawing tolerance. The receiver therefore pays only for those parts that they can actually use.

To ensure compliance with the contractual tolerance, the supplier in turn must reduce his production tolerance based on the measurement uncertainty of their outgoing inspection with respect to the contractual tolerance. Parts that are outside of the production tolerance must be rejected, even if they are measured to be within the contractual tolerance (Fig. 2, Part A). Assuming that the supplier uses this responsible criteria for shipment approval, the receiver no longer receives any parts measured by the receiver's incoming inspection as being outside of the contractual tolerance (Fig. 2, Part B), or even outside of the drawing tolerance (Fig. 2, Part C). This makes it possible for the supplier and customer to work together without disagreement. »



**Figure 1.** Effect of measurement uncertainty on the residual tolerance for shipment approval and receiving acceptance:  $T_S$  Specified drawing tolerance,  $U_L$  Uncertainty of the supplier's measuring machine,  $T_L$  Tolerance for release for shipment,  $U_A$  Uncertainty of the measuring machine at receiving,  $T_A$  Tolerance for release of incoming goods

**A:** Parts with an actual value within the drawing tolerance must be discarded by the supplier due to measurement uncertainty. The tolerance  $T_L$  for release of incoming goods is different from the drawing tolerance  $T_S$ .

**B:** Parts with actual values outside the drawing tolerance must be accepted by the customer due to their measurement uncertainty, although they are not allowed to be used. The tolerance  $T_A$  for release of incoming goods is different from the drawing tolerance  $T_S$ , because the drawing tolerance  $T_S$  is used as the contractual tolerance  $T_V$ .

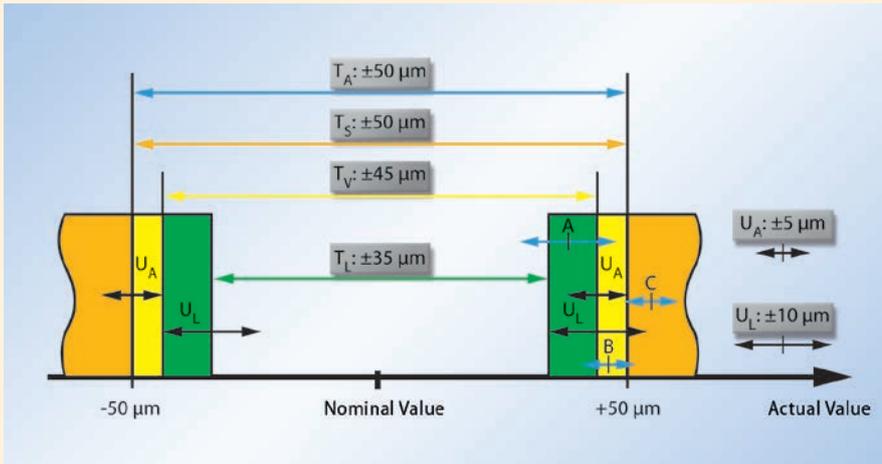


Figure 2. Contractual tolerances ensure that the contractual conditions are unambiguous:  $T_S$  Drawing tolerance,  $U_A$  Uncertainty of the measuring machine upon receipt by the customer,  $T_V$  Contractual tolerance,  $U_L$  Uncertainty of the supplier's measuring machine,  $T_L$  Tolerance for release for shipment.

**A:** Parts with an actual value within the contractual tolerance, but outside of the tolerance for release for shipment, must be discarded by the supplier due to their measurement uncertainty  $U_L$ .

**B:** Parts with an actual value outside of the contractual tolerance are not required to be accepted by the receiver. The measurement uncertainty is already covered in the contractual tolerance.

**C:** Parts with an actual value outside of the drawing tolerance are definitely outside of the contractual tolerance, and also are not required to be accepted.

The tolerance  $T_A$  for acceptance and the drawing tolerance  $T_S$  are equal. All accepted parts can be used.

The fundamental principle that lower measurement uncertainty allows greater production tolerances and lower material costs applies to both the manufacturer and the receiver of workpieces. The supplier and the receiver thereby save time and money. The “Golden Rule of Metrology” and many factory standards that are based on it (e.g., “measurement process suitability” of  $c_g \geq 1,33$ ), correctly state that measurement equipment should be about ten times as precise as the tolerance to be inspected. □

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