

## **Evaluation of uncertainty of coordinate measurements treated as indirect measurements**

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Measurement uncertainty is an important component of the measuring result statement of which is required by the quality management systems. The common measuring technique used in the widely understood machine industry is measurement with use of coordinate measuring machines, and fundamental characteristics used in the geometrical product specification are dimensions and geometrical deviations.

Coordinate measurements are often treated as direct measurements, because the results presented in the measuring report do not require additional calculations. However, measurement models used for uncertainty evaluation should consider the fact that coordinate measurements are actually indirect measurements – directly measured are coordinates of points, which are then used to calculate necessary characteristics, i.e. dimensions and geometrical deviations. In case of probing the workpiece with minimum number of points (from the mathematical point of view), the equations for particular deviation can be expressed as functions of differences of coordinates of pairs of points.

The paper presents methodology for deriving formulae being measurement models of different characteristics. Among fundamental examples are: measurement of circle diameter, measurement of flatness. Minimum number of probing points for measuring circle diameter is 3 and for flatness it's 4. The derivation of the formula for circle diameter may be based on the characteristic that the centre point of the circle is the intersection point of the bisectors of the two chords of the circle. The flatness deviation can be calculated as the distance between the plane defined on 3 points (A, B, C) and a point S (laying in the middle of the plane).