

# ISO 14253-2:2011-04 (E)

## Geometrical product specifications (GPS) - Inspection by measurement of workpieces and measuring equipment - Part 2: Guidance for the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification

---

<b>Contents</b>		<b>Page</b>
Foreword .....		v
Introduction .....		vi
1	Scope .....	1
2	Normative references .....	2
3	Terms and definitions .....	2
4	Symbols .....	4
5	Concept of the iterative GUM method for estimation of uncertainty of measurement .....	5
6	Procedure for Uncertainty Management -- PUMA .....	6
6.1	General .....	6
6.2	Uncertainty management for a given measurement process .....	6
6.3	Uncertainty management for design and development of a measurement process/procedure .....	7
7	Sources of errors and uncertainty of measurement .....	10
7.1	Types of errors .....	10
7.2	Environment for the measurement .....	12
7.3	Reference element of measurement equipment .....	12
7.4	Measurement equipment .....	12
7.5	Measurement set-up (excluding the placement and clamping of the workpiece) .....	13
7.6	Software and calculations .....	13
7.7	Metrologist .....	13
7.8	Measurement object, workpiece or measuring instrument characteristic .....	13
7.9	Definition of the GPS characteristic, workpiece or measuring instrument characteristic ...	14
7.10	Measuring procedure .....	14
7.11	Physical constants and conversion factors .....	14
8	Tools for the estimation of uncertainty components, standard uncertainty and expanded uncertainty .....	14
8.1	Estimation of uncertainty components .....	14
8.2	Type A evaluation for uncertainty components .....	15
8.3	Type B evaluation for uncertainty components .....	15
8.4	Common Type A and B evaluation examples .....	17
8.5	Black and transparent box model of uncertainty estimation .....	20
8.6	Black box method of uncertainty estimation -- Summing of uncertainty components into combined standard uncertainty, $u_c$ .....	21
8.7	Transparent box method of uncertainty estimation -- Summing of uncertainty components into combined standard uncertainty, $u_c$ .....	21
8.8	Evaluation of expanded uncertainty, $U$ , from combined standard uncertainty, $u_c$ .....	22
8.9	Nature of the uncertainty of measurement parameters $u_c$ and $U$ .....	22
9	Practical estimation of uncertainty -- Uncertainty budgeting with PUMA .....	23

9.1	General .....	23
9.2	Preconditions for an uncertainty budget .....	23
9.3	Standard procedure for uncertainty budgeting .....	24
10	Applications .....	26
10.1	General .....	26
10.2	Documentation and evaluation of the uncertainty value .....	27
10.3	Design and documentation of the measurement or calibration procedure .....	27
10.4	Design, optimization and documentation of the calibration hierarchy .....	28
10.5	Design and documentation of new measurement equipment .....	29
10.6	Requirements for and qualification of the environment .....	29
10.7	Requirements for and qualification of measurement personnel .....	29
Annex A (informative) Example of uncertainty budgets -- Calibration of a setting ring .....		31
Annex B (informative) Example of uncertainty budgets -- Design of a calibration hierarchy .....		38
Annex C (informative) Example of uncertainty budgets -- Measurement of roundness .....		63
Annex D (informative) Relation to the GPS matrix model .....		69
Bibliography .....		71