ISO/IEC Guide 98-5:2026-07 (E)

Guide to the expression of uncertainty in measurement - Part 5: Examples

Contents

Page

Foreword vii
Introduction viii
0 Scope 1
1 Measurement of pH: linear interpolation 2
1.1 Preamble . . . 2
1.2 pH of a test solution . . . 2
1.3 Specification of the measurand . . . 3
1.4 Measurement model . . . 3
1.4.1 General . . . 3
1.4.2 Generic approach to two-point calibration . . . 3
1.4.3 Generic approach to multi-point calibration . . . 5
1.4.4 Metrological extension . . . 5
1.5 pH measured at a stipulated temperature . . . 5
1.6 pH measurement accounting for temperature . . . 6
1.7 Uncertainty propagation . . . 7
1.8 pH estimation at a stipulated temperature and associated uncertainty evaluation . . . 8
1.9 pH estimation accounting for temperature and associated uncertainty evaluation . . . 9
1.10 Interpretation of results . . . 10
1.10.1 Validation of results . . . 10
1.10.2 Resolution . . . 10
1.10.3 Correlation . . . 10
2 Determination of benzo[a]pyrene 13
2.1 Preamble . . . 13
2.2 Specification of the measurand . . . 13
2.3 Measurement model . . . 14
2.4 Uncertainty propagation . . . 15
2.4.1 JCGM 100:2008 uncertainty framework (GUF) . . . 15
2.4.2 Monte Carlo method (MCM) . . . 16
2.5 Reporting the result . . . 17
2.6 Interpretation of results . . . 17
3 Relative molecular mass of glucose 20
3.1 Preamble . . . 20
3.2 Measurement model . . . 20
3.3 Calculation and uncertainty evaluation . . . 21
3.4 Discussion . . . 22
4 Gravimetric mixture preparation and calculation of composition 23
4.1 Preamble . . . 23
4.2 Measurement model . . . 23
4.3 Uncertainty evaluation . . . 26
4.3.1 Correlations . . . 26
4.3.2 General considerations . . . 26
4.3.3 Weighing data . . . 26
4.3.4 Molar masses . . . 27
4.3.5 Composition of the parent gases . . . 29
4.3.6 Composition of the gas mixture . . . 29
4.4 Discussion . . . 32
5 Greenhouse gas emission inventories 33
5.1 Preamble . . . 33
5.1.1 General . . . 33
5.1.2 Greenhouse gas inventories . . . 33
5.1.3 Combination and correlation . . . 35
5.1.4 IPCC and JCGM reporting guidelines . . . 35

5.2 Specification of the measurand . . . 36
5.3 Measurement model . . . 36
5.4 Uncertainty propagation . . . 36
5.5 Interpretation of results . . . 40
5.6 Uncertainty guidance promoted by the IPCC and the JCGM . . . 40
6 Simple linear measurement models 42
6.1 Preamble . . . 42
6.2 Normally distributed input quantities . . . 42
6.3 Rectangularly distributed input quantities with the same width . . . 44
6.4 Rectangularly distributed input quantities with different widths . . . 46
7 Second-order effects in a nonlinear measurement model: calibration of weights 48
7.1 Preamble . . . 48
7.2 Measurement model . . . 48
7.3 Measurand estimate and associated uncertainty . . . 49
7.4 Uncertainty budget . . . 51
7.4.1 GUF . . . 51
7.4.2 MCM . . . 52
8 Gauge block calibration 53
8.1 Preamble . . . 53
8.2 Measurement model . . . 53
8.3 GUF . . . 55
8.4 MCM . . . 55
8.5 Results . . . 57
9 GUM uncertainty evaluation for least-squares versus Bayesian inference - Calibration of a torque measuring system 59
9.1 Preamble . . . 59
9.2 Experimental . . . 59
9.3 Specification of the measurand . . . 59
9.4 Measurement model . . . 60
9.4.1 General . . . 60
9.4.2 Ordinary and weighted least-squares . . . 60
9.4.3 Statistical model . . . 61
9.5 Uncertainty evaluation . . . 61
9.5.1 Law of propagation of uncertainty . . . 61
9.5.2 Bayesian uncertainty analysis . . . 62
9.6 Reporting the result . . . 64
9.7 Discussion . . . 64
10 Conformity assessment of mass concentration of total suspended particulate matter in air 67
10.1 Preamble . . . 67
10.2 Objective and data . . . 67
10.3 Specification of the measurand . . . 67
10.4 Measured values and associated measurement uncertainty . . . 67
10.5 Tolerance limits . . . 68
10.6 Decision rule and conformity assessment . . . 68
10.6.1 General . . . 68
10.6.2 Bayesian framework . . . 69
10.6.3 Global risks . . . 69
10.6.4 Specific risks . . . 71
10.7 Interpretation of results . . . 71
11 Effect of considering a 2D image as a set of pixels on a computed quantity 73
11.1 Preamble . . . 73
11.2 Estimation of organ or tumour mass . . . 73
11.3 Measurement model . . . 74
11.4 Model selection . . . 76

11.5 Area estimation and associated uncertainty evaluation . . . 78
11.6 Reporting the result . . . 80
11.7 Interpretation of results . . . 80
12 Between-bottle homogeneity of reference materials 82
12.1 Preamble . . . 82
12.2 Specification of the measurand . . . 82
12.3 Measurement model . . . 83
12.4 Implementation . . . 85
12.5 Reporting the result . . . 88
13 Measurement of Celsius temperature using a resistance thermometer 90
13.1 Preamble . . . 90
13.2 Measurement of a single Celsius temperature . . . 90
13.3 Measurement of several Celsius temperatures . . . 92
14 Activity of a radioactive source corrected for decay 96
14.1 Preamble . . . 96
14.2 Measurement model . . . 96
14.3 Uncertainty evaluation . . . 96
14.4 Discussion . . . 98
15 Breaking force of steel wire rope 99
15.1 Preamble . . . 99
15.2 Measurement model . . . 99
15.3 Assignment of PDFs . . . 100
15.3.1 Breaking force observations . . . 100
15.3.2 Correction effects . . . 100
15.4 GUF . . . 101
15.5 MCM . . . 101
15.6 Discussion . . . 102
16 Comparison loss in microwave power meter calibration 104
16.1 Preamble . . . 104
16.2 Formulation . . . 104
16.3 Propagation and summarizing: uncorrelated case . . . 106
16.3.1 General . . . 106
16.3.2 Input estimate $x_1 = 0$ . . . 106
16.3.3 Input estimate $x_1 = 0.010$ . . . 108
16.3.4 Input estimate $x_1 = 0.050$ . . . 109
16.3.5 Discussion . . . 109
16.4 Propagation and summarizing: correlated case . . . 110
16.4.1 General . . . 110
16.4.2 Input estimates $x_1 = 0$, 0.010 and 0.050 . . . 111
16.4.3 Discussion . . . 112
16.5 Analytic calculations . . . 112
16.5.1 General . . . 112
16.5.2 Expectation and standard deviation . . . 112
16.5.3 Analytic solution for zero estimate of the voltage reflection coefficient having associated zero covariance . . . 113
16.5.4 GUF — Uncorrelated input quantities . . . 115
16.5.5 GUF — Correlated input quantities . . . 115
16.6 Conclusion . . . 116
Annexes 117
Annex A Conventions and notation 117
Annex B Glossary of principal symbols 119
B.1 Generic variables and functions . . . 119
B.2 Probability distributions . . . 119
References 120
Alphabetical index 131
Abbreviations 134