ISO Guide 98-3:2010-11 (E)

Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)

Contents

Page

Preliminary v

Foreword vi

0 Introduction viii

1 Scope 1

2 Definitions 1
2.1 General metrological terms 2
2.2 The term "uncertainty" 2
2.3 Terms specific to this *Guide* 3

3 Basic concepts 4
3.1 Measurement 4
3.2 Errors, effects, and corrections 5
3.3 Uncertainty 5
3.4 Practical considerations 7

4 Evaluating standard uncertainty 8
4.1 Modelling the measurement 8
4.2 Type A evaluation of standard uncertainty 10
4.3 Type B evaluation of standard uncertainty 11
4.4 Graphical illustration of evaluating standard uncertainty 15

5 Determining combined standard uncertainty 18
5.1 Uncorrelated input quantities 18
5.2 Correlated input quantities 21

6 Determining expanded uncertainty 23
6.1 Introduction 23
6.2 Expanded uncertainty 23
6.3 Choosing a coverage factor 24

7 Reporting uncertainty 24
7.1 General guidance 24
7.2 Specific guidance 25

8 Summary of procedure for evaluating and expressing uncertainty 27

Annex A Recommendations of Working Group and CIPM 28
A.1 Recommendation INC-1 (1980) 28
A.2 Recommendation 1 (CI-1981) 29
A.3 Recommendation 1 (CI-1986) 29

Annex B General metrological terms 31
B.1 Source of definitions 31
B.2 Definitions 31

Annex C Basic statistical terms and concepts 39
C.1 Source of definitions 39
C.2 Definitions 39
C.3 Elaboration of terms and concepts 45

Annex D "True" value, error, and uncertainty 49
D.1 The measurand 49
D.2 The realized quantity 49
D.3 The "true" value and the corrected value 49
D.4 Error 50

D.5 Uncertainty 51
D.6 Graphical representation 51

Annex E Motivation and basis for Recommendation INC-1 (1980) 54
E.1 "Safe", "random", and "systematic" 54
E.2 Justification for realistic uncertainty evaluations 54
E.3 Justification for treating all uncertainty components identically 55
E.4 Standard deviations as measures of uncertainty 58
E.5 A comparison of two views of uncertainty 59

Annex F Practical guidance on evaluating uncertainty components 61
F.1 Components evaluated from repeated observations: Type A evaluation of standard uncertainty 61
F.2 Components evaluated by other means: Type B evaluation of standard uncertainty 64

Annex G Degrees of freedom and levels of confidence 70
G.1 Introduction 70
G.2 Central Limit Theorem 71
G.3 The t-distribution and degrees of freedom 72
G.4 Effective degrees of freedom 73
G.5 Other considerations 75
G.6 Summary and conclusions 76

Annex H Examples 79
H.1 End-gauge calibration 79
H.2 Simultaneous resistance and reactance measurement 85
H.3 Calibration of a thermometer 89
H.4 Measurement of activity 93
H.5 Analysis of variance 98
H.6 Measurements on a reference scale: hardness 104

Annex J Glossary of principal symbols 109

Bibliography 114

Alphabetical index 116