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S. V. Gupta

Mass Metrology

The Newly Defined Kilogram

Second Edition

 Springer

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*In loving memory of my wife
Mrs. Prem Gupta*

Preface to the Second Edition

A measurement of quantity leads to the value of the quantity as a product of a pure number and a well-defined invariant unit. The kilogram—the unit of mass was the only unit which was embodied in an artefact (Platinum–Iridium cylinder, placed in specified conditions at the BIPM). This apart from the fact that everybody was to look for the BIPM for evaluation of their prototype, mass of International Prototype kilogram was suspiciously changing. This was in contradiction to the condition of invariance of the unit. The General Conference on Weights and Measures (French acronym CGPM) decided to revise, along with other SI base units, the definition of kilogram. The kilogram is such that the value of Plank constant h is $6.626\ 070\ 040 \times 10^{-34}$ when expressed in terms SI-based units, i.e., $\text{kg m}^2 \text{s}^{-1}$. To explain various aspects of the new definition of the kilogram, a few chapters have been added and one chapter is revised. It may be clear that only definition of kilogram changed, not mass measurement methods below the level of National standards.

Fresh from the University of Allahabad and joining the National Physical Laboratory in 1954, I found myself in an altogether different world. It appeared that what we learnt at M.Sc. level was different than what we need at NPL. There was hardly any detailed literature on mass measurement, except some notes from NPL UK and a Dictionary of Applied Physics. I vow to myself to compile all the available literature on mass metrology. However, it took me another 55 years to complete my dream. My concept was to give every available thing in the literature or my own experience about mass metrology in the form of a book. In the process, I forgot what is required in present times and not necessary for the present generation. For example, I included great details and mathematics about weighing with a two-pan balance. My concept is that very few books are available about mass measurement, so I tried to include a lot of things which might not be needed in the contemporary time. All such superfluous material I have curtailed very much on the recommendation of the Reviewers of the book.

Besides the routine chapters on the unit of mass, mass measurement system in India; two- and single-pan balances their maintenance and testing, I have taken up the various transducers used for weighing and included their testing. I have proved

that maximum permissible error requirements are the same for digital and analogue balances, a great detail of environmental effects on weights from the best material are given. The methods for air density determination have been given in detail. In the process, changed composition of argon in air discovered from the measurement of air density in situ carried out with solid objects and that calculated from BIPM equation has been discussed. The methods of mass determination of different weights in a set in terms of the mass of head weight are described in detail with numerical examples. Optimisation of weighing designs and solution of normal equations are described. A new chapter on the detection of small mass differences to the limit of zeptogram 10^{-21} g (Mass of a quarter of the gold atom) has been produced. Fabrication and detection of frequency using nanotechnology are mentioned with sufficient references. Details of micro-cantilevers used for the purpose are given. The applications of micro-cantilever in other fields are outlined. The methods of redefining the kilogram—the unit of mass in terms of fundamental constants have been described. The chapter is concluded with the present status and future plan to define the kilogram.

Special attention has been paid to the need of Legal Metrology. Special topics such as the maintenance and upkeep of standard balances kept at various levels and effect of gravity on electronic balances have been discussed. The limits of movement of Classes I–III electronic balances in north–south direction have been given in detail for practically all situations.

I acknowledge the help of Dr. R. S. Davis, Head of Mass standards at BIPM. I wish to thank Prof. R. C. Bhudani, Director, National Physical Laboratory and the President of Metrology Society of India, for agreeing to bring out the book. My thanks are also due to my daughter Mrs. Reeta Gupta, Scientist, National Physical Laboratory for her sincere day-to-day help.

I will fail in my duty if I do not express my most sincere thanks to the editors Dr. Zachary Evenson and Dr. Angela Lahee of M/s Springer for their keen interest and suggestions.

Delhi, India

S. V. Gupta

Preface to the First Edition

Fresh from the University of Allahabad and joining National Physical Laboratory in 1954, I found myself in an altogether different world. It appeared that what we learnt at MSc level was different from what we need at NPL. Naturally I started asking many questions as to why we are performing in a particular way. After prolonged discussion, I used to hear the final answer as “NPL UK is doing it this way”. There was hardly any detailed literature on mass measurement, except some notes from NPL UK and a Dictionary of Applied Physics, at that time I vow to myself to compile all the available literature on Mass Metrology. However, it took me another 55 years to complete my dream. My concept was to give every available thing in the literature or my own experience about mass metrology in the form of a book. In the process I forgot what is required in present times and not necessary for present generation. For example I included great details and mathematics about weighing with a two-pan balance. My concept is that a very few books are available about mass measurement so I tried to include a lot of things which might not be needed in the contemporary time. All such superfluous materials have been curtailed on the recommendation of the reviewer of the book.

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New Delhi

S. V. Gupta

Contents

1	Unit of Mass and Standards of Mass	1
1.1	Concepts of Mass	1
1.1.1	Gravitational Mass	2
1.1.2	Inertial Mass	2
1.1.3	Equality of Inertial and Gravitational Mass	3
1.2	Mass and Weight of a Body	3
1.2.1	Conventional Mass	4
1.2.2	Variation of the Weight of a Body on Surface of Earth	4
1.3	Unit of Mass	7
1.3.1	History of the Units of Metre and Kilogram	7
1.3.2	Unit of Length	8
1.3.3	Kilogram de Archives	8
1.4	Metric Convention	9
1.4.1	International Kilogram	9
1.4.2	National Standard of Kilogram	10
1.4.3	National Kilogram and Other Standards in India	11
1.4.4	Calibration of Transfer Standards of Mass	12
1.5	Hierarchy of Mass Standards	13
1.5.1	Nomenclature	13
1.5.2	Measurement Chain	15
1.5.3	Tracking the Mass Values of Standards	15
1.5.4	Period of Verification or Calibration	16
1.5.5	Maximum Permissible Errors	16
1.6	Traceability of Measurements	17
1.6.1	Traceability	17
1.6.2	CIPM MRA	18
	References	19

2	Two-Pan Equal-Arm Balances	21
2.1	Introduction	21
2.2	Brief History	21
2.3	Other 1-kg Balances	22
2.3.1	Equal-Arm Interchangeable Pan Balance UK	22
2.3.2	Equal Arm with Double Interchangeable Pan Balance	23
2.3.3	Substitution Balance NPL-India	24
2.3.4	Electronic Balance with Automation at NPL-India	26
2.3.5	Hydrostatic Balance	27
2.4	Installation of a Balance	29
2.4.1	Proper Environmental Conditions for Balance Room	29
2.4.2	Requirements for Location of the Balance	29
2.5	Evaluation of Metrological Data for a Balance	32
2.5.1	Need for Evaluation	32
2.5.2	Visual Examination	32
2.5.3	Sensitivity	33
2.5.4	Period of Swing or Time Period	35
2.5.5	Accuracy of Rider Bar	36
2.5.6	Stability/Repeatability	38
2.5.7	Repeatability of Weighing	38
2.5.8	Equality of Arm Lengths	39
2.5.9	Calculation of Arm Ratio, Repeatability of Single and Double Weighing	40
2.5.10	Requirement for Arm Ratio and Repeatability of Weighing	42
2.5.11	Test for Parallelism of Knife Edges	42
2.6	Methods of Weighing	44
2.6.1	Direct Weighing	44
2.6.2	Transposition Weighing	45
2.6.3	Substitution Weighing	45
2.7	Double Transposition and Substitution Weighing	46
2.7.1	Double Transposition Method	46
2.7.2	Double Transposition with Simultaneous Determination of S.R.	47
2.7.3	Double Substitution	48
2.7.4	Double Substitution Weighing with Simultaneous Determination of S.R.	49
2.8	Maintenance of Standard Balances	49
2.8.1	Category of Balances	50
2.8.2	Reference Balances	50

2.8.3	Secondary Standard Balances	50
2.8.4	Working Standard Balances	51
	References	51
3	Single-Pan Mechanical Balances	53
3.1	Introduction	53
3.2	Description of a Single-Pan Balance	53
3.3	Evaluation of Single-Pan Balance	57
3.3.1	Verification Interval	57
3.3.2	General Examination	57
3.3.3	Sensitivity of the Sprit Level of the Balance	58
3.3.4	Hardness of Knife Edges and Bearing Planes	58
3.3.5	Sensitivity Setting	59
3.3.6	Tests	59
3.3.7	Test for Smallest Built-in Weight and Calibration of Illuminated Scale	59
3.3.8	Calibration of Lower Half and Upper Half of the Optical Scale	60
3.3.9	Short Duration Test for Precision of the Balance	62
3.3.10	Calibration of Built-in Weights for All Dial Settings	63
3.3.11	Performance Test	65
3.4	Uncertainty in Calibration of the Balance	67
3.4.1	Uncertainty of Mass Determination by the Balance	68
	References	68
4	Electronic Balances and Effect of Gravity	69
4.1	Introduction	69
4.2	Electromagnetic Force Compensation	70
4.2.1	Principle of EMFC	70
4.2.2	Principle of EMFC Balance	71
4.3	Partially Electromagnetic Force Compensated Balance	72
4.3.1	Partially EMFC Two-Pan Balance	72
4.3.2	Partially EMFC Single-Pan Balance	74
4.4	Fully EMFC Balance	75
4.4.1	Without Lever	75
4.4.2	Balance with Mechanical Levers	75
4.4.3	Working of EMFC Balances	76
4.4.4	Electronic Circuitry	77
4.5	Range of Capacity of EMFC Balance	79
4.6	Availability of EMFC Cells	80

4.7	Effect of Variation in Gravity on Electronic Balances	80
4.7.1	Instruments Affected by Gravity	80
4.7.2	Error Due to Variation in g	82
4.7.3	Variation of g with Respect to Latitude	83
4.7.4	Error Per Degree Change in Latitude at Different Places	83
4.7.5	Significant Error	86
4.7.6	Choice of Values of “ n ” to Calculate Error at Various Latitudes	86
4.7.7	Latitude Differences to Cause Significant Error	86
4.7.8	Intra-state Movement of Electronic Weighing Instruments	92
4.7.9	Error Due to Altitude	92
4.8	Conclusion About the Movement of Electronic Weighing Instruments	94
	References	95
5	Strain Gauge Load Cells	97
5.1	Load Cell	97
5.2	Construction	97
5.2.1	Elastic Spring Element	97
5.2.2	Detector	97
5.2.3	Pasting	98
5.3	Resistance Strain Gauge	98
5.3.1	Change in Resistance	98
5.3.2	Measurement of Resistance	99
5.3.3	Configuration of Strain Gauges on Spring Element	102
5.3.4	Dimensions of the Spring Element	104
5.3.5	Methods of Connecting Several Load Cells	105
5.3.6	Trimming Devices in the Load Cell	106
5.4	Some Important Terms	109
5.4.1	Definitions	109
5.4.2	Notations Used on Load Cells	111
5.5	Classification of Load Cells	112
5.5.1	Accuracy Class	112
5.5.2	Number of Intervals	112
5.5.3	Load Application	113
5.6	Maximum Permissible Errors for Load Cells	113
5.6.1	Maximum Permissible Error at Verification/ Model Approval	113
5.6.2	Maximum Permissible Error at Inspection	114
5.6.3	Determination of Error for Digital Instruments	114

- 5.7 Tests to Be Conducted 114
 - 5.7.1 Performance Tests 115
 - 5.7.2 Influence Factors Tests 115
 - 5.7.3 Test Conditions 115
- 5.8 Performance Tests 117
 - 5.8.1 Permissible Error, Repeatability, Nonlinearity and Hysteresis Tests 117
 - 5.8.2 Creep and Minimum Dead Load Return Tests 117
 - 5.8.3 Performance Tests at Different Temperatures 119
 - 5.8.4 Temperature Effect on Minimum Dead Load Output 120
 - 5.8.5 Effect of Barometric Pressure Test 120
 - 5.8.6 Humidity Test 120
- 5.9 Additional Tests 121
 - 5.9.1 Voltage Variations 122
 - 5.9.2 Short-Time Power Reductions 122
 - 5.9.3 Bursts (Electrical Fast Transients) 123
 - 5.9.4 Electrostatic Discharge 124
 - 5.9.5 Electromagnetic Susceptibility 124
 - 5.9.6 Span Stability 125
- 5.10 Requirements for Load Cells 127
- References 127
- 6 Various Types of Transducers-for Weighing 129**
 - 6.1 Introduction 129
 - 6.1.1 Classification 130
 - 6.1.2 Force Applied by a Body 130
 - 6.2 Vibrating String/Vibrating Strip Devices 130
 - 6.2.1 Single-String Transducer Cell 131
 - 6.2.2 Double-String Transducer Cell 132
 - 6.2.3 S-Shaped Vibrating Strip Transducer 133
 - 6.2.4 Transducer with String Vibrating in Heterodyne Mode 133
 - 6.2.5 Use of Vibrating String Transducers 134
 - 6.3 Tuning Fork Transducer 135
 - 6.4 Gyroscopic Devices 137
 - 6.5 Optical Interference Transducer 139
 - 6.6 Magneto-elastic Transducer (Pressductor) 140
 - 6.6.1 Construction 140
 - 6.6.2 Principle of Magneto-elastic Transducer 141
 - 6.7 Change in Capacitance Transducer 142

6.8	Photoelectric Device	143
6.9	Hydraulic Load Transducer	144
6.10	Piezoelectric Transducer	144
	6.10.1 Longitudinal and Transverse Effect	145
	6.10.2 Piezoelectric Device and Cascading to Increase the Output	146
	6.10.3 Sensitivity in Different Modes	147
	6.10.4 Electronic Measurement Circuits	147
	6.10.5 Particulars of Piezoelectric Transducers	149
6.11	Strain Gauge of Semiconductor Material	149
6.12	Piezo-resistant Force Transducer	149
6.13	Linear Variable Differential Transformer	150
6.14	Inductive Worm-Spring Transducer	153
6.15	Surface Wave Resonator	153
6.16	Nucleonic Weighing	155
	6.16.1 Principle	155
	References	157
7	Testing of Electronic Balances	159
7.1	Introduction	159
7.2	Principle of Digital Indications	159
	7.2.1 Digital and Analogue Instruments	159
	7.2.2 Principle of Digital Indication Device	160
	7.2.3 Equality in Error of Digital and Analogue Instruments	164
	7.2.4 Maximum Permissible Errors	164
	7.2.5 Definitions of Some Important Terms	164
	7.2.6 Practical Determination of the Error of a Digital Machine	166
	7.2.7 Verification of Digital Instruments for Compliance	166
	7.2.8 Rule for Errors of the Combined System	167
7.3	Testing of Electronic Balances/Weighing Machines	168
	7.3.1 Introduction	168
	7.3.2 General Requirements	169
	7.3.3 Descriptive Requirements	169
	7.3.4 Classes of Weighing Instruments	170
	7.3.5 Performance Tests	170
7.4	Type Approval Tests	174
	7.4.1 Tests to Meet the Requirements for the Effect of Influence Quantities	174
	7.4.2 Extreme Temperature Test	175
	7.4.3 Variation in Supply Voltage and Frequency Test	176

7.4.4	Short Time Power Reduction Test	176
7.4.5	Electrical Bursts Test	176
7.4.6	Electrostatic Discharge Test	177
7.4.7	Electromagnetic Susceptibility Test	177
7.5	Nonlinearity	178
7.5.1	Methods of Estimating Nonlinearity	178
7.6	Hysteresis Error	179
7.7	Guidelines for Choosing Balances	179
7.8	Class of Electronic Balances Not Covered by OIML	180
	References	180
8	Air Density and Buoyancy Correction	181
8.1	Introduction	181
8.2	Equation for Density of Air	183
8.2.1	Parameters of the Gas Equation	184
8.2.2	Molar Mass of Water Vapour	185
8.2.3	Constants Involved in p_{sv} , f and Z	187
8.2.4	Variable Parameters	188
8.2.5	Uncertainty Budget of Air Density Evaluation from CIPM Formula	188
8.2.6	Air Density Tables	188
8.3	Air Buoyancy Artefact Method	190
8.3.1	Principle	190
8.3.2	Artefacts	193
8.3.3	Uncertainty Budget	199
8.4	Optical Method for Determination of Air Density	202
8.4.1	Relation of Refractive Index and Density of Air	202
8.4.2	Experimental Work	203
8.4.3	BIPM Refractometer	204
	Appendix	204
	References	210
9	Weights—Standards of Mass	215
9.1	Introduction	215
9.2	OIML Classification of Weights	216
9.3	Maximum Permissible Errors	217
9.3.1	OIML Maximum Permissible Errors	217
9.3.2	Maximum Permissible Errors in Weights in USA	217
9.3.3	Maximum Permissible Errors in Commercial Weights in India	219
9.4	Maximum Permissible Errors for Other Weights	220
9.4.1	Maximum Permissible Errors for Weights Used in Scientific and Industrial Fields	220

9.4.2	Maximum Permissible Errors in Standard Weights for Legal Metrology	221
9.4.3	Special Purpose Reference Standards (Germany)	221
9.5	Material of Weights	222
9.5.1	Property Requirements for Material of Weights	222
9.5.2	Material for Weights of 1 g and Above	224
9.5.3	Material for Fractional Weights	226
9.5.4	Material for Adjustment of Weights	227
9.6	Design and Finish of the Weights	228
9.6.1	Basics of Design of Weights	228
9.6.2	Surface Finish of Gram Weights	231
9.6.3	Fractional Weights	232
9.6.4	Weight Box	233
9.7	Effect of Finite Magnetic Susceptibility	233
9.7.1	Expression for Magnetic Force	234
9.7.2	Measurement of Magnetic Susceptibility of Weights	235
9.8	Electrostatic Charges	238
9.9	Effect of Inequality of Temperature of Weight and Its Surroundings	238
9.9.1	Buoyant Force	239
9.9.2	Change in Mass Due to Convection of Air	239
9.9.3	Change in Indication with Time	240
9.9.4	Change in Mass Due to Adsorption	241
9.10	Effect of Density of Material of Weights	244
9.10.1	Criterion for Density Range of the Weight	245
9.10.2	Determination of Density of a Weight	246
9.11	Physical Properties	249
9.12	Surface Resistance of Platinum–Iridium Mass Standards	249
9.12.1	Effect of Change in Relative Humidity	250
9.12.2	Effect of Change in Temperature	250
9.12.3	Effect of Change in Pressure	250
9.13	Effect of Weighing in Air and Vacuum	251
9.14	Stability of Mass Standards	251
9.14.1	Instability in Mass Standards Due to Mercury Contamination	251
9.14.2	Instability in Mass Standards Due to Atmospheric Carbon and Oxygen	252
	References	253
10	Group Weighing Method	255
10.1	Introduction	255

10.2	Different Sets of Weights	256
10.2.1	Sets of Weights	256
10.2.2	Head Weights	257
10.3	Principal of Group Weighing	257
10.3.1	Linear Equations and Method of Least Squares	258
10.3.2	Design Matrix	259
10.3.3	Variance Covariance Matrix	260
10.3.4	Weighting Factor	261
10.3.5	Improving a Weighing Design	262
10.3.6	Efficiency of a Weighing Design	264
10.3.7	Average of Squares of Residual Errors	264
10.4	Calibration of Set of Weights	264
10.4.1	Series 5, 2, 2, 1	264
10.4.2	Series 5, 2, 1, 1	275
10.4.3	Series 5, 2, 1, 1 (BIPM)	278
10.4.4	Series 4, 3, 2, 1 (BIPM)	281
10.4.5	Series 5, 3, 2, 1	286
10.5	Calculations with Weighing Factors	289
10.6	Multiples of Unit of Mass	294
10.7	Weights of Same Denominations	296
10.7.1	Optimum Value of N	297
10.7.2	Experimental Work	298
10.7.3	Numerical Example	299
	References	300
11	Nanotechnology for Detection of Small Mass Difference	303
11.1	Introduction	303
11.2	Cantilever Vibration	303
11.2.1	Characterisation of Cantilever	304
11.2.2	Dimensions and Mass of an Attogram Cantilever	306
11.3	Nanotechnology	307
11.4	Examples of Fabrication of Micro-cantilevers	308
11.4.1	Etching Process	308
11.4.2	Electron Beam Lithography	310
11.4.3	Various Micro-cantilevers in Use	312
11.5	Principles of Detection of Micro-cantilever Motion	312
11.6	Examples of Detection Micro-cantilever Response	312
11.6.1	Detection by Using an Interferometer	312
11.6.2	Detection by Capacity Measurement	313
11.6.3	Improved Fibre-Optic Interferometer	315
11.7	Mass Sensitivity of Cantilevers	316

11.7.1	No Change in Spring Constant (End-Point Loading)	316
11.7.2	Changing Spring Constant (Uniform Loading)	317
11.8	Mass Detector Cantilevers	317
11.8.1	At Femtogram Level	317
11.8.2	At Attogram Level	318
11.8.3	Sub-attogram Level	319
11.8.4	Zeptogram Level	319
11.8.5	Sub-zeptogram Level (One Gold Atom)	320
11.8.6	At Attonewton Level	320
11.8.7	A Final Goal	321
11.8.8	Viscosity: A Problem	322
11.9	Minimum Detectable Force/Mass	322
11.10	Micro-cantilever Applications	323
11.10.1	Large Surface to Volume Ratio	323
11.10.2	Examination of Surface	323
11.10.3	Thermal/Photo-thermal	324
11.10.4	Low Power Consumption Micro-cantilevers	325
11.10.5	Chemistry	325
11.10.6	Biology	325
11.10.7	Health Care	326
11.10.8	Physics (Viscosity and Density)	327
11.10.9	Magnetometry	328
11.10.10	Data Storage	328
11.10.11	Terrorist Threat Detection	329
	References	329
12	Redefining the Unit of Mass	335
12.1	Introduction	335
12.1.1	Requirements for Defining a Base Unit	336
12.2	History of Kilogram and Its Stability in Mass	336
12.2.1	Brief History of Kilogram de Archive (KA)	336
12.2.2	Preparation of the Artefact Defining kg	337
12.2.3	Fabrication	338
12.2.4	Continuity with the Mass of KA	339
12.2.5	Stability of $m(KA)$ with Respect of $m(IPK)$	339
12.2.6	Stability of $m(IPK)$	340
12.2.7	Outcome of Redefining a Unit of Measurement	341
12.2.8	Meaning of Taking a Measured Value as Exact	342
12.3	Possibilities to Redefine Kilogram	342

12.3.1	N_A by Measurements	343
12.3.2	kg and N_A Relation	343
12.3.3	Relation Between of H and N_A	344
12.4	Values of Avogadro Constant	345
12.5	Other Methods of Defining kg	347
12.5.1	The Kilogram Through Ion Collection Method	347
12.5.2	The Kilogram Through Levitation Method	350
12.5.3	The Kilogram Through Voltage Balance	352
12.5.4	The Kilogram Through Watt Balance	355
12.5.5	The Kilogram, Einstein Energy Equation and Planck Constant	357
12.5.6	Another Way of Redefining the Kilogram	358
12.6	Planck Constant h in Terms of Other Constants	358
12.7	Status of Watt Balance	359
12.8	Practical Standards to Realize Kilogram	360
12.9	Author's Observations	361
	References	361
13	Redefining the Base Units	365
13.1	Preparations for Redefining Base Units	365
13.1.1	A Brief History of the CGPM Decisions	365
13.1.2	Resolution About Redefinitions	366
13.2	Revised Definitions of SI Base Units	371
13.2.1	CODATA Efforts for New Definitions	373
13.3	Fundamental Constants for Kilogram	374
13.4	New Definition of Base Units	374
13.4.1	Base Units in Terms of Fundamental Constants	375
13.5	Inter Dependence of Base Units	376
13.5.1	New SI Units	377
13.5.2	Old SI Units	377
13.6	Relationship Matrix	378
13.6.1	Defining Constants in Terms of Base Units	379
13.6.2	Base Units in Terms of Defining Constants	379
13.6.3	Use of the Tables	379
13.7	Vacuum and Air Dissemination of Kilogram	380
13.7.1	Conclusions and Recommendations	381
13.8	Traceability	382
13.8.1	Traceability and Uncertainty Before Redefinition	382
13.8.2	Traceability and Uncertainty After Redefinition	383
13.9	Hierarchy of Mass	383
	References	384

14	Realisation of Mass Unit	385
14.1	Introduction	385
14.2	Kibble Balance	385
14.2.1	Title of the Balance	385
14.2.2	Importance of Kibble Balance	386
14.2.3	Basic Principle	386
14.3	Kibble Balances at Metrology Institutes	389
14.3.1	Conventional Two-Mode Two Measurement Phase Kibble Balances	390
14.3.2	Korea Research Institute of Standards and Science KRISS, Korea	390
14.3.3	Laboratoire National de Métrologie et d'Essais (LNE), France	390
14.3.4	Federal Institute of Metrology (METAS), Switzerland	390
14.3.5	Measurement Standard Laboratory of New Zealand MSL	391
14.3.6	National Institute of Metrology (NIM), China	391
14.3.7	National Institute of Standards and Technology (NIST), USA	391
14.3.8	National Physical Laboratory (NPL), UK	392
14.3.9	National Research Council (NRC), Canada	392
14.4	The Original Joule Balance	392
14.4.1	National Institute of Metrology (NIM), China	392
14.4.2	Single-Mode One Measurement Phase Kibble Balances	392
14.4.3	Single-Mode Two Measurement Phase Watt Balances	393
14.4.4	Moving Magnet Balance at Ulusal Metroloji Enstitüsü (UME), Turke	393
14.5	Measurement of Velocity of the Pan	394
14.5.1	Interferometers	394
14.5.2	Refractive Index of Air	394
14.5.3	Light Source	395
14.6	Mass of Weight Used (M)	395
14.6.1	Measurement of the Working Masses	395
14.6.2	Substitution Weighing	396
14.6.3	Balances Used in Kibble Balance	396
14.6.4	Alignment of the Mass on the Mass Pan	397
14.6.5	Alignment of the Mass Comparator	397
14.7	Gravity Measurement	398
14.7.1	Instruments for Measurement	398
14.7.2	Corrections	399

14.8	Constant Magnetic Field	402
14.8.1	Magnets	403
14.9	Demagnetization of the Rare Earth Magnets	407
14.10	Change of the Reluctance of the Yoke	408
14.10.1	The Reluctance Force	408
14.10.2	Temperature Change of the Rare Earth Magnet	408
14.10.3	Temperature Change of the Yoke Material	408
14.10.4	Engineering of Magnets with Smaller Temperature Coefficients	409
14.10.5	Actively Controlling the Temperature	410
14.11	Voltage Measurements	410
14.11.1	Measurement Techniques	411
14.11.2	Josephson Reference	411
14.11.3	Hysteretic Arrays	411
14.11.4	Programmable Arrays	412
14.11.5	Voltmeter	412
14.11.6	Amplifiers	413
14.11.7	Synchronisation of the Voltmeter and Counter	413
14.12	Current Generation and Measurement	414
14.12.1	Current Sources	415
14.12.2	The Measurement Resistor	417
14.13	Resistance Determination with the Quantum Hall Effect	418
14.14	Joule Balance Measurements	419
14.15	Environmental Effects	419
14.15.1	Ground Vibration	419
14.15.2	Anti-vibration Systems	420
14.15.3	External Magnetic Fields	420
14.15.4	Temperature Effects	420
14.15.5	Shielding and Electrical Isolation	420
14.16	Reduction in Mass Values of BIPM Working Standards Against IPK	421
14.17	Relation Between R_{K-90} , K_{J-90} and h	421
14.18	Results	423
14.19	XRCD Method	425
14.19.1	Sphere	426
14.19.2	Volume of Sphere	426
14.19.3	Principle	426
14.19.4	Realization of the Kilogram Using Already Characterized Crystals	427
14.19.5	Relation Between IPK and kg (Revised Definition)	427

14.20	Characterization of Silicon Crystal	428
14.20.1	Enrichment of Crystal	428
14.20.2	Single Crystal Growth	429
14.20.3	Isotopic Composition of Silicon	429
14.20.4	Crystal Perfection: Evaluation of Point Defects	429
14.20.5	m_{SL} Layers	431
14.20.6	Molar Mass	433
14.20.7	Lattice Parameter	434
14.20.8	Uncertainty in XRCD Method	437
14.21	Pilot Study for Equivalence of Two Methods	438
14.21.1	New Definition of kg	438
14.21.2	Sponsor	438
14.21.3	Aim	439
14.21.4	Organisation and Participants	439
14.21.5	Comparison Protocol	439
14.21.6	Particulars of Travelling Standard	440
14.21.7	Calculations	441
14.21.8	Conclusions	442
	References for Kibble Balance	442
	References for XRCD	447
	References for Pilot Study	448
	Index	449