Preface

I have been associated with uncertainty calculations for quite sometime. Asia Metrology Program (APMP) took interest in unification of expressing the measurement results along with uncertainty. In those days the uncertainty components were divided according to source of errors. The errors were named as random and systematic errors. Hence components of uncertainty were named random uncertainty and systematic uncertainty. Around 1980, BIPM took initiative by circulating questioners to the countries who were members of Metre Convention. Every member showed keen interest in expressing the uncertainty in a harmonious way. A small but path-breaking document was produced in 1980, which emphasized that uncertainty is not of different kinds; there are only the ways by which one arrives at the uncertainty value, namely Type A and Type B evaluations of uncertainty. Further the document emphasized that square root of variance or a quantity similar to it is the standard uncertainty.

The book is intended to serve as a guide for expressing the measurement result along with uncertainty. The book conforms to "The Guide to the expression of uncertainty in Measurement" jointly produced by International Organization for Standardization (ISO), International Bureau of Weights and Measures (BIPM), International Federation of Clinical Chemistry (IFCC), International Union of Pure and Applied Chemistry (IUPAC), International Union of Pure and Applied Physics (IUPAP) and International Organization of Legal Metrology (OIML). The book differs from ISO Guide in explaining the basic theory behind relations provided by the Guide. Lots of examples are provided to support the theoretical formulations. All technical and scientific terms used have been explained in the first chapter itself. Various distributions used in uncertainty calculations have been explained in Chaps. 2 and 3. The stress has been given on the properties of Gaussian (Normal) probability distribution. Evaluation of data weather primary or secondary is one special topic discussed in Chap. 4. For each statistical parameter like mean or standard deviation lots of practical examples have been cited. The chapter is highly useful for the nodal laboratories involved in international measurement programmes. Propagation of uncertainty has been discussed by first explaining the Taylor expansion and highlighting the need for the function to be linear. The

process of calibration of the measuring instruments at a few points and expressing the whole calibration result in the form of the function of the input quantity has been discussed by citing several examples in Chap. 6. The functions discussed are linear, exponential, power and polynomials types. Detailed steps for arriving at the uncertainty, starting from the modelling of the measurand as a function of input quantities, have been given in Chap. 7. The advantages and limitations of ISO GUM method have been given. Monte Carlo and Bayesian methods of arriving at the uncertainty have been mentioned. The detailed procedure for calibrating the surface plate and theoretical deductions of height at various points along the various designated lines has been given in Chap. 8. The chapter includes the uncertainty calculations between the points on the same line and also on different lines. The uncertainty calculation as per NABL (National Accreditation Board for Testing and Calibration Laboratories) requirement has also been given in calibration of surface Chap. 8. The uncertainty calculations in mass measurement have been dealt with in Chap. 9. While discussing various sources of errors such as that of buoyancy correction, uncertainty requirements in measurement of various environmental parameters have also been cited. Uncertainty in volume measurements by various methods has been detailed. Uncertainty in the calibration of volumetric glassware by gravimetric method, larger capacity measures by volumetric method and storage tanks by dimensional measurements have been discussed in detail in Chap. 10. The uncertainty calculation in the calibration hydrometers by comparison method has also been given. Chapter 11 deals with the uncertainty calculation in the measurement of and calibration of measuring instruments for length, pressure, temperature and luminous flux. Chapter 12 deals with electrical parameters; uncertainty in measurement of and calibration of measuring instruments has been detailed. Uncertainty calculations of vector measurands which are the function of dependent input quantities have been discussed. Some important Tables for Normal (Gaussian) probability distributions, Student's t distribution, χ^2 and Fisher's F values for different percentage points have been given. The limits for mean and standard deviations for various degrees of freedom have also been tabulated. A bibliography of recent papers, books and documents on uncertainty in measurement has been appended.

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