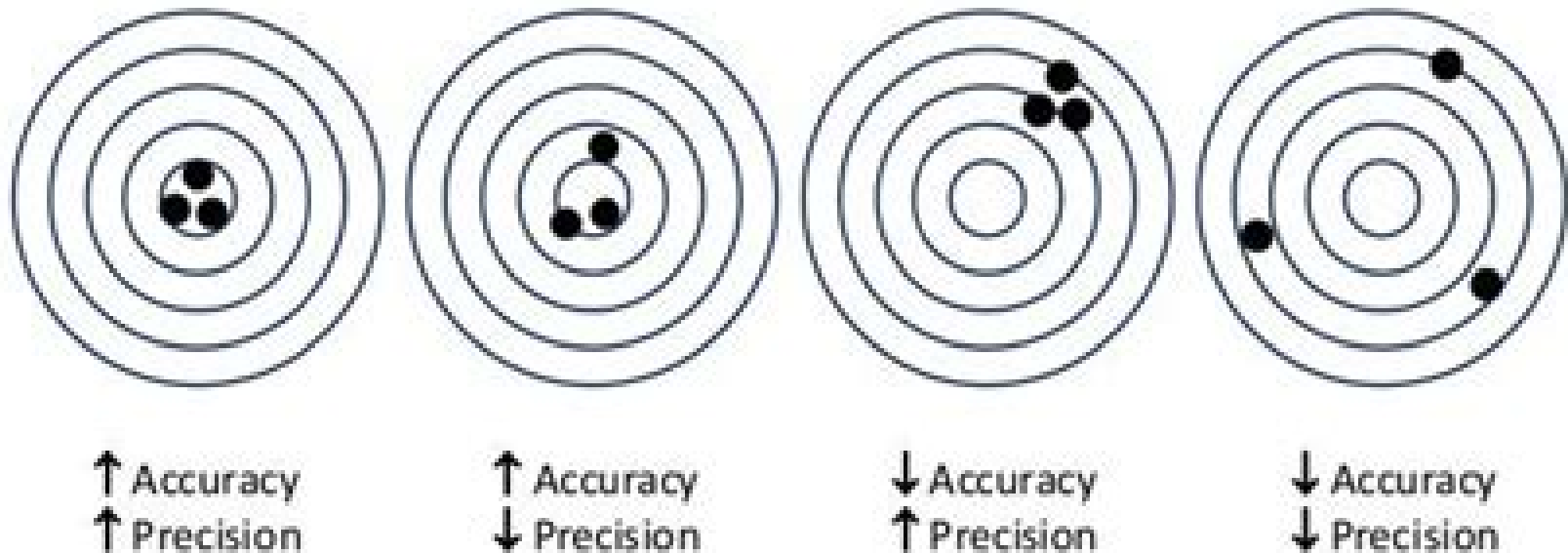


# Measurement Uncertainty

- **Precision** – how small is the variance of the estimates
- **Accuracy** – how close is the estimate to the actual values
- **Bias** – what impacts on precision and accuracy come from the human judgments (or misjudgments)



# Measurement Uncertainty Guide

**Rachel S Tattersall**



## **Measurement Uncertainty Guide:**

*Measurements and their Uncertainties* Ifan Hughes, Thomas Hase, 2010-07-02 This hands on guide is primarily intended to be used in undergraduate laboratories in the physical sciences and engineering It assumes no prior knowledge of statistics It introduces the necessary concepts where needed with key points illustrated with worked examples and graphic illustrations In contrast to traditional mathematical treatments it uses a combination of spreadsheet and calculus based approaches suitable as a quick and easy on the spot reference The emphasis throughout is on practical strategies to be adopted in the laboratory Error analysis is introduced at a level accessible to school leavers and carried through to research level Error calculation and propagation is presented through a series of rules of thumb look up tables and approaches amenable to computer analysis The general approach uses the chi square statistic extensively Particular attention is given to hypothesis testing and extraction of parameters and their uncertainties by fitting mathematical models to experimental data Routines implemented by most contemporary data analysis packages are analysed and explained The book finishes with a discussion of advanced fitting strategies and an introduction to Bayesian analysis

**Evaluating the Measurement Uncertainty** Ignacio Lira, 2002 It is now widely recognized that measurement data should be properly analyzed to include an assessment of their associated uncertainty Since this parameter allows for a meaningful comparison of the measurement results and for an evaluation of their reliability its expression is important not only in the specialized field of scientific metrology but also in industry trade and commerce General rules for evaluating and expressing the uncertainty are given in the internationally accepted ISO Guide to the Expression of Uncertainty in Measurement generally known as the GUM *Evaluating the Measurement Uncertainty* details the theoretical framework on which the GUM is based and provides additional material on more advanced topics such as least squares adjustment and Bayesian statistics The book does not require previous knowledge other than elementary calculus and can be read as a complement to the GUM or as a stand alone reference source It stresses fundamental principles and illustrates their applications through numerous examples taken from many different fields of metrology The book includes practical guidance as well as theoretical aspects resulting in an invaluable resource for metrologists engineers physicists and graduate students involved with measurements in academia and industry

**Evaluating the Measurement Uncertainty** I Lira, 2002-04-09 It is now widely recognized that measurement data should be properly analyzed to include an assessment of their associated uncertainty Since this parameter allows for a meaningful comparison of the measurement results and for an evaluation of their reliability its expression is important not only in the specialized field of scientific metrology but also in industry trade and commerce General rules for evaluating and expressing the uncertainty are given in the internationally accepted ISO Guide to the Expression of Uncertainty in Measurement generally known as the GUM *Evaluating the Measurement Uncertainty* details the theoretical framework on which the GUM is based and provides additional material on more advanced topics such as least squares

adjustment and Bayesian statistics The book does not require previous knowledge other than elementary calculus and can be read as a complement to the GUM or as a stand alone reference source It stresses fundamental principles and illustrates their applications through numerous examples taken from many different fields of metrology The book includes practical guidance as well as theoretical aspects resulting in an invaluable resource for metrologists engineers physicists and graduate students involved with measurements in academia and industry

**Measurement Uncertainty in Chemical Analysis** Paul De Bièvre, Helmut Günzler, 2013-06-29 It is now becoming recognized in the measurement community that it is as important to communicate the uncertainty related to a specific measurement as it is to report the measurement itself Without knowing the uncertainty it is impossible for the users of the result to know what confidence can be placed in it it is also impossible to assess the comparability of different measurements of the same parameter This volume collects 20 outstanding papers on the topic mostly published from 1999-2002 in the journal Accreditation and Quality Assurance They provide the rationale for why it is important to evaluate and report the uncertainty of a result in a consistent manner They also describe the concept of uncertainty the methodology for evaluating uncertainty and the advantages of using suitable reference materials Finally the benefits to both the analytical laboratory and the user of the results are considered

*Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results (rev. Ed. )* Barry N. Taylor, 2009-11 Results of measurements and conclusions derived from them constitute much of the technical information produced by the National Institute of Standards and Technology NIST In July 1992 the Director of NIST appointed an Ad Hoc Committee on Uncertainty Statements and charged it with recommending a policy on this important topic The Committee concluded that the CIPM approach could be used to provide quantitative expression of measurement that would satisfy NIST's customers requirements NIST initially published a Technical Note on this issue in Jan 1993 This 1994 edition addresses the most important questions raised by recipients concerning some of the points it addressed and some it did not

Illustrations

**NIOSH Manual of Analytical Methods: Method finder, user's guide, methods A-D**, 1994

**An Introduction to Uncertainty in Measurement Using the GUM (guide to the Expression of Uncertainty in Measurement)** Les Kirkup, 2006 This book presents the need for clarity consistency and accuracy when making measurements some of the GUM guidelines are presented in this book A background in first year calculus and some basic statistics is necessary for understanding

*The Uncertainty of Measurements* Shri Krishna Kimothi, 2001-11-01 The uncertainty of measurement results is drawing attention of managers metrologists and customers The accuracy of measurements affects all of us in trade commerce safety health care environmental protection and more The quality of these measurements are regulated by a variety of government agencies Measurement also plays an important role in manufacturing and service organizations Use this book to learn more about metrology and the need for reliable measurements You can also learn about measurement system and quality of measurement systems objectives and methods Statistical techniques in metrology are also explained Examples of

measurement data and random variables probability density functions sampling distribution statistical estimation degrees of freedom and regression are included An entire chapter is devoted to measurement errors The book goes in depth into explaining national and international measurement systems and standards and includes a complete chapter on calibration and measurement traceability Measurement Uncertainty will show how to evaluate various uncertainties in measurements using several approaches including international consensus Calibration laboratories can look specifically at the chapter on that profession to guide them in their measurement improvements Kimothi also looks at specific industries and their measurement capabilities and includes examples of R R studies A great resource for the CQE CQT CCT CSSBB certification exams

**Measurement Errors and Uncertainties** S. G. Rabinovich, 2005-08-15 A practical reference on theory and methods of estimating measurement errors and uncertainty for both scientists and engineers in industry and experimental research Building on the fundamentals of measurement theory this book offers a wealth of practical recommendations and procedures It differs from the majority of books in that it balances coverage of probabilistic methods with detailed information on the characterization calibration standardization and limitations of measuring instruments with specific examples from both electrical and mechanical systems In addition to a general updating to reflect current research new material in this edition includes increased coverage of indirect measurements with a new simpler more efficient method for this class of measurements

*Decision Rule Guidance* Henry Zumbrun, Greg Cenker, Dilip Shah , *Decision Rule Guidance* 1st Edition 2024 is written by Henry Zumbrun of Morehouse Instrument Company Greg Cenker of Indysoft and Dilip Shah of E mc3 Solutions It provides foundational knowledge and practical calculations for using decision rules in measurement uncertainty This guidebook is not just a theoretical exploration of measurement uncertainty metrological traceability and decision rules It is a practical tool that transforms complex concepts into actionable insights It guides technicians engineers and decision makers through measurement decision making with examples and calculations Using this guide you can make choices that improve product and service quality safety and reliability The authors bring over 100 years of combined experience in the metrology field They have addressed common challenges in the community with this guide Henry A Zumbrun has over 25 years of industry experience in Metrology specifically in force and torque measurements Greg Cenker has more experience than Henry and is Senior Metrologist and Calibrations Product Manager at IndySoft Dilip A Shah has more experience than Greg and is a Principal of E mc3 Solutions a consulting practice that provides training and consulting solutions in ISO IEC 17025 ISO 9001 measurement uncertainty and computer applications

**Handbook of Mass Measurement** Frank E. Jones, Randall M. Schoonover, 2002-03-26 How much does it weigh seems a simple question To scientists and engineers however the answer is far from simple and determining the answer demands consideration of an almost overwhelming number of factors With an intriguing blend of history fundamentals and technical details the Handbook of Mass Measurement sets forth the details

**Springer Handbook of Metrology and Testing** Horst Czichos, Tetsuya

Saito, Leslie E. Smith, 2011-07-22 This Springer Handbook of Metrology and Testing presents the principles of Metrology the science of measurement and the methods and techniques of Testing determining the characteristics of a given product as they apply to chemical and microstructural analysis and to the measurement and testing of materials properties and performance including modelling and simulation The principal motivation for this Handbook stems from the increasing demands of technology for measurement results that can be used globally Measurements within a local laboratory or manufacturing facility must be able to be reproduced accurately anywhere in the world The book integrates knowledge from basic sciences and engineering disciplines compiled by experts from internationally known metrology and testing institutions and academe as well as from industry and conformity assessment and accreditation bodies The Commission of the European Union has expressed this as there is no science without measurements no quality without testing and no global markets without standards

**The ASQ Metrology Handbook** Heather A. Wade, 2023-01-04 The ever changing fields of science and technology have made huge leaps thanks in part to improvements in measurements Without metrology these areas may not have experienced exponential growth Developed by experts in the field as a comprehensive and practical reference The ASQ Metrology Handbook Third Edition provides a foundation for understanding metrology as well as calibration principles and practices This handbook is ideal for not only metrology professionals but also calibration professionals including calibration technicians and technologists quality professionals workers in testing laboratories consultants and instructors Whether you are entering a new phase of your career field investing in your own continuous improvement journey training your fellow calibration practitioners or preparing for ASQ's Certified Calibration Technician CCT exam this handbook provides the information guidance and knowledge to help you achieve your goals New to this Third Edition A thorough explanation of ISO IEC 17025 2017 The 2019 Redefinition of the International System of Units Updated and expanded chapters including information about training and competency software validation statistics decision rules and risk uncertainty in measurement mass and weighing force and chemical and biological measurements and uncertainties

**A Practical Guide to Basic Laboratory Andrology** David Mortimer, Lars Björndahl, C. L. R. Barratt, José Antonio Castilla, Roelof Menkveld, 2022-03-10 Preceded by A practical guide to basic laboratory andrology Lars Björndahl et al 2010 *NIST Handbook*, 1989 **NIST Technical Note**, 1992

**Plant Flow Measurement and Control Handbook** Swapan Basu, 2018-08-22 Plant Flow Measurement and Control Handbook is a comprehensive reference source for practicing engineers in the field of instrumentation and controls It covers many practical topics such as installation maintenance and potential issues giving an overview of available techniques along with recommendations for application In addition it covers available flow sensors such as automation and control The author brings his 35 years of experience in working in instrumentation and control within the industry to this title with a focus on fluid flow measurement its importance in plant design and the appropriate control of processes The book provides a good balance between practical issues and theory and is fully supported with industry case

studies and a high level of illustrations to assist learning It is unique in its coverage of multiphase flow solid flow process connection to the plant flow computation and control Readers will not only further understand design but they will also further comprehend integration tactics that can be applied to the plant through a step by step design process that goes from installation to operation Provides specification sheets engineering drawings calibration procedures and installation practices for each type of measurement Presents the correct flow meter that is suitable for a particular application Includes a selection table and step by step guide to help users make the best decision Cover examples and applications from engineering practice that will aid in understanding and application **Techniques and Topics in Flow Measurement** Frank E.

Jones,2020-09-11 **Techniques and Topics in Flow Measurement** covers the applications and techniques of flow measurement This definitive book provides guidelines for choosing appropriate techniques and assuring valid measurements as well as describes methods for treatment of calibration data in fluid flow under various conditions The book also covers three systems of units the SI system the English Absolute Dimensional system and the English Engineering system Commonly used and often misused variables such as force weight and pressure are defined and the relationships between the systems for these common variables are summarized One of the many unique features of **Techniques and Topics in Flow Measurement** is the number of ready to use tables included throughout the text Tables are provided for such commonly encountered variables as the saturation vapor pressure of water the composition of dry air the compressibility factor for air air free and air saturated water density viscosity of dry air nitrogen and other gases and specific heat specific volume ratios for dry air water vapor and moist air Another unique feature of this book is the number of highly relevant examples The author includes examples exercises that demonstrate applications for density calculations water vapor mixing ratio determination gas viscosity interpolation NIST guideline applications buoyancy corrections and more **Microbiological Guidelines**

Collective,2018-04-04 Food plays an essential part in everyday life Food should be tasty healthy sustainable and preferably not too expensive But food should also be safe and with sufficient guarantees on maintaining good quality aspects until the end of shelf life The various actors in the food supply chain have an interest in verifying the expected quality and safety by means of microbiological analyses of food Measurement brings knowledge and microbiological guidelines help in the decision making process for judging the acceptability of food or food production processes The present handbook provides microbiological guidelines and current applicable EU legal criteria status 1 1 2018 for a wide range of food categories dairy meat seafoods plant based foods bakery products composite foods shelf stable food water and subcategories therein based upon the type of food processing and intrinsic characteristics of the foods This book can be consulted to provide quick answers on the expected microbiological contamination of foodstuff It can help in interpretation of test results in assessing good hygienic practices in the production of food determining the shelf life and ensuring food safety The handbook also presents definitions of the wide variety of foodstuffs available and some reflections on in particular food safety issues or the

on going debate for some food items in assessing microbial quality This book provides crucial information about food safety for the use of students and professionals

**EXTRACT** First we eat then we do everything else M F K Fisher Food plays an important part in everyday life But when being a food scientist or in the food business food gets to be an even bigger part of your life Our team at the Food Microbiology and Food Preservation research group FMFP UGent at Ghent University during its academic tasks in education research scientific activities at committees but also in interaction with many food companies and stakeholders in the food supply chain in projects or contract work has built up considerable expertise on the microbiological analysis of a large variety of foodstuffs Being situated in Ghent and thus close to Brussels the heart of Europe we intrinsically have to understand and deal with legal EU criteria or action limits The latter is the reason why this book is mainly oriented towards inclusion or making reference to EU legal microbiological criteria for foodstuffs as well

**ABOUT THE AUTHORS** The main author Prof Mieke Uyttendaele leads together with Prof Frank Devlieghere the Food Microbiology and Food Preservation Research Group FMFP UGent at Ghent University Belgium Her teaching and research area covers aspects of microbiological analysis of foods food safety and food hygiene She has built over twenty years of experience by executing initiating and coordinating various projects in this research discipline dealing with sampling and testing to collect baseline data on the microbial contamination of foods looking into the virulence of food borne pathogens elaborating challenge testing to study the behavior of food borne pathogens All this information serves as an input for quality assurance and microbial risk assessment to support food safety decision making and setting microbiological criteria She was is the promotor of more than 25 Ph D students including EU and non EU citizens Throughout her career Prof Uyttendaele has published more than 270 peer reviewed scientific papers authored several book chapters and presented at numerous international Conferences Workshops Throughout the years she has also used her scientific expertise in interpretation of test results for analyses obtained in routine monitoring or analysis executed at the food service lab at FMFP UGent

**An Introduction to Uncertainty in Measurement Using the GUM (Guide to the Expression of Uncertainty in Measurement)** Kirkup Les Frenkel R B, Les Kirkup, Robert B. Frenkel, 2014-05-14 This book presents the need for clarity consistency and accuracy when making measurements some of the GUM guidelines are presented in this book A background in first year calculus and some basic statistics is necessary for understanding



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