Measurement Uncertainty

Course No. 132

FOR WHOM INTENDED Engineers, scientists and managers. This course will be of interest to personnel involved in SPC, Metrology, Biomedical, Aerospace, Automobile, Electronics industries and those making and understanding experimental test measurements in a wide range of other industries.

BRIEF COURSE DESCRIPTION Every measurement is made for a purpose: to make a judgment about something. It can be to judge the accuracy of an instrument or data, to accept or reject a product or to determine the price charged in every day commerce. In order to have confidence that the measurement, which is actually only the best estimate of the quantity considered, is acceptable, an estimate of the uncertainty of the measurement must be undertaken.

The course begins with an introduction to measurement uncertainty and the terms associated with it. Then the accuracy and limitations of statistics are discussed, with examples of the various types of distributions encountered in statistical tests. A discussion of sources of errors and their classification into random and systematic follow, before presenting the details of using traditional versus expanded uncertainty equations.

Equations for calculating the propagation of errors are presented next, along with a "special case" method that avoids the use of calculus in many cases. The course covers control charts and their applicability to uncertainty before covering a step-by-step example of calculating uncertainty for a typical application. Methods of reporting uncertainty, along with how to state or interpret statements of uncertainty, confidence intervals and confidence levels and coverage factors, are covered in some detail.

Bonus Chapter "Examples of Calculating Uncertainty" is not presented in the classroom, and it is not included in the Complete On-Demand Course. However, it is provided in the course materials for self-study by interested students, and may be included in on-site presentations at the client's request.

Successful completion of this course will enable participants to understand, evaluate and express measurement uncertainty.

RELATED COURSES The related Course132/435, Measurement Uncertainty/Engineering Statistics includes all of the content in course 132, along with an introduction to Engineering Statistics, also available as course 435.

DIPLOMA PROGRAMS The related Course 132/435, Measurement Uncertainty/Engineering Statistics, is required for Ti's Metrology/Calibration Specialist (MCS) Diploma Program. Course 132 does not satisfy the MCS requirements but may be used as an elective for any TTi specialist diploma program.

PREREQUISITES There are no definite prerequisites for this course. However, this course is aimed toward individuals involved in a related technical field. An understanding of basic algebra will be useful.

TEXT Each student will receive 180 days access to the on-line electronic course workbook. Renewals and printed textbooks are available for an additional fee.

COURSE HOURS, CERTIFICATE AND CEUs On-site courses can vary from 14–35 hours over 2–5 days, as requested by our clients. Upon successful course completion, each participant receives a certificate of completion and one Continuing Education Unit (CEU) for every ten class hours.

Course Outline

Basic concepts
Measured and Calculated Quantities • Measurement Errors • Absolute Error • Error and Uncertainty

Definitions
Definitions and application examples of terms encountered in measurement uncertainty

Statistical concepts in measurement
Probability • Error types • Distributions • f-test • t-test

Elemental Errors
Type A Random Errors • Type B Systematic Errors
Accuracy • Errors caused by Standard
Measurand Errors • Environmental Condition Errors
Method Errors/Operator Errors • Other External Sources
Gross Errors • Error classification Example

Calculating Uncertainty: The Traditional Approach
Traditional vs expanded formula • Confidence levels
Combining Elemental Uncertainties • Student-t

Calculating Uncertainty: Expanded Equations
Estimating Uncertainty—Principles
Combined Uncertainty • Uncertainty Application

Propagation of errors
Maximum possible error • Cantilever modulus example
Sensitivities • Uncertainty in Calculated Qty. • Best Estimate
Radiation Heat Transfer Example • Rod Example
Warehouse Example • Special Case Equation

Control charts
What is a control chart? • How to build a control chart
Planning • Data Collection • Monitoring • Analysis

Uncertainty calculation
Detailed step by step example

Reporting Uncertainty

(Bonus) Examples of Calculating Uncertainty
Mass: Electronic Scale
Dimensional: Measuring Device (Caliper)
Pressure
Chemical
Electrical
Temperature

Summary • Final Quiz

Award of Certificates for Successful Completion

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