
Metrology Concepts

Course No. 130

FOR WHOM INTENDED This course is for engineers, managers and technicians who are involved in standards and calibration laboratories and for others who want a clear understanding of the wide range of activities involved in metrology.

This course is applicable to individuals from a wide range of industries such as Defense, Manufacturing, Utilities, Electronics, Automotive, Medical, Telecommunications, Computers, Aerospace and Universities.

OBJECTIVES To provide a basic understanding of the wide range of activities encompassed by personnel working in standards and calibration laboratories. It covers the measurement process, types and correct use of measurement and test equipment, and measurement standards. It provides an opportunity for students to learn about measurement uncertainty and risk analysis. The course includes information necessary to set up and operate a calibration program.

BRIEF COURSE DESCRIPTION Students will receive an in-depth understanding of the most effective methods of establishing and running a first class Standards and Calibration Laboratory. They will also receive an insight into dealing and communicating with industry related organizations such as NIST, ASQC, NCSL etc. and implementing procedures required by ISO 9004, ISO 10012 and ANSI/ASQC/ NCSL Z540-1 standards.

Students are expected to participate in classroom discussions, to work out classroom examples, to read the text and perform nightly review problems, and to undergo preliminary and final quizzes.

DIPLOMA PROGRAMS This course is required for TTI's [Environmental Engineering Specialist \(EES\)](#), [Climatic Test Specialist \(CTS\)](#), [Electronic Design Specialist \(EDS\)](#), [Instrumentation Test Specialist \(ITS\)](#) and [Metrology/Calibration Specialist \(MCS\)](#) Diploma programs. It may be used as an optional course for any other TTI [Specialist Diploma program](#).

PREREQUISITES There are no formal prerequisites for this course. Supervisors are invited to contact TTI on prospective attendees' backgrounds and needs.

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 Class hours/days for 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.

ON-DEMAND OnDemand Internet Complete Course 130 features nine hours of video as well as more in-depth reading material. All chapters of course 130 are available as OnDemand Internet Short Topics. See our [on-line course outline](#) for details.

Course Outline

Measurement Process: Definition of Measurement
Definition of Metrology • Measurement System
Units of Measurement • Defined Units • Derived Units
Systems of Units: Absolute system • Gravitational system
Metrication and the Metric System (SI): Metrication • Examples
Reasons for Metrication • Costs/Benefits of Metrication
SI Base/Derived Units • Supplementary Units • Coherence
Calibration Program: Definition / Responsibilities
Standards and Procedures: MIL-STD-45662A • NCSL/ANSI Z540-1-1994 •
Comparing compliance documents • NIST
Management • Quality System/Audit • Personnel/Training/Safety
Facilities/ Environment • Equipment • Reference Materials
Documentation • Traceability • Calibration Procedures •
Records: Certificates and Reports • Subcontracting services
Laboratory Accreditation
Measurement and Test Equipment: Definition and Types
Use and Care • Storage and Transportation
General Purpose/Special Purpose M&TE • Dimensional Gages
Automatic Test Equipment (ATE)
Applicable Standards • ISO 9000 Quality Standards
Measurement Standards and Traceability: Embodiment of Unit
Classification of Standards • Hierarchy of Standards
Traceability / NIST / GPIM • International Definitions
Measurement Uncertainty:
Measurement Error, Accuracy, Precision • Statistics in Metrology
ISO Guide to Expression of Uncertainty in Measurement (GUM)
Standard Uncertainty
Type A Uncertainties (Statistical - Random):
Standard Deviation • Curve Fitting • Analysis of Variance
Estimating • Gage R & R Study
Type B Uncertainties (Analysis - Systematic, Bias):
Instrumental • Environmental • Observational • Procedural
Combined Uncertainty
Expanded Uncertainty: Confidence Level • Coverage Factor
Statements of Uncertainty • Uncertainty Budget
Risk Analysis: Purpose of Measurement
Measurement Decision Risks • Acceptable levels of risk
Simplified Strategies • Low Risk Strategy • Statistical Reasoning
"Implied Risk" in Military and Industry Standards • ISO Standard
Accuracy Ratios • Guardbanding • Equivalent risk
False Reject Risks • Software Applications
Treatment of Data: Significant Figures • Propagation of Precision
Rounding and Precision • Curve Fitting
Drift Elimination—Loop Method and Sequential method
Measurement Assurance Program (MAP)
Data Acquisition and Automation • Software Quality System
Software Verification • Configuration Control • Software Control
Measurement Techniques / Considerations:
Types of Measurement • Dimensional Measurement
Temperature effects • Nominal differential expansion equations
Compensation and Residual Uncertainty • Cosine Error
Abbé offset error • Contact Deformation / Deflections
Vibration Control • Volumetric Expansion • Gravitational Influences
Air Buoyancy • Atmospheric Pressure • Hysteresis
Considerations in Electrical Measurement: Grounding • Shielding • Guarding •
Contact Resistance • Thermal EMFs
Summary • Final Review • Award of Certificates for successful completion



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