
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 forms the foundation of TTI's Metrology Specialist Certificate Program.

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.

CERTIFICATE PROGRAMS This is a required course for the Metrology Specialist Certificate Program. It may be used as an elective for any other TTI specialist certificate 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 a set of [course notes](#) including most of the viewgraphs used in the presentation.

COURSE HOURS, CERTIFICATE AND CEUs Open courses meet seven hours per day. Upcoming presentation dates can be found on our current [open course schedule](#). 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.

For [schedules](#), [general information](#) and [registration forms](#), see TTI's web site.

*Former title: Fundamentals of Metrology.

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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