CERTIFIED CALIBRATION TECHNICIAN (CCT)
Body of Knowledge – 2009

The topics in this Body of Knowledge (BOK) include additional detail in the form of subtext explanations and the cognitive level at which the questions will be written. This information will provide useful guidance for both the Exam Development Committee and the candidate preparing to take the exam. The subtext is not intended to limit the subject matter or be all-inclusive of what might be covered in an exam. It is meant to clarify the type of content to be included in the exam. The descriptor in parentheses at the end of each entry refers to the maximum cognitive level at which the topic will be tested. A more complete description of cognitive levels is provided at the end of this document.

Note Regarding IM&TE (inspection, measurement, and test equipment)

The Test Specification Committee that created this BOK recognizes that different industries and branches of the military use various descriptors and abbreviations to refer to the units being calibrated. To avoid confusion, the committee decided to use the term IM&TE as the most globally descriptive term. This term will be used in both the BOK and the CCT examination itself.

I. General Metrology [35 Questions]

A. Base SI units

Describe and define the seven base units: meter, kilogram, second, ampere, kelvin, candela, and mole. (Understand) NOTE: The application of these units is covered in I.B., I.C., and I.E.

B. Derived SI units

Define and calculate various derived units, including degree, ohm, pascal, newton, joule, coulomb, hertz, etc. (Apply)

C. SI multipliers and conversions

Define various multipliers, including, kilo, deci, centi, milli, and calculate converted values, such as mega to kilo, micro to milli, etc. (Apply)

D. Fundamental constants

Identify fundamental constants *c* (velocity or speed of light in a vacuum), *g* (gravitational constant), and *R* (universal gas constant), their standard symbols, and their common applications. (Remember) NOTE: The values of these constants and the formulas for calculating them will not be tested.

E. Common measurements

Describe and apply IM&TE in measuring temperature, humidity, pressure, torque, force, mass, voltage/current/resistance, time/frequency, and linear displacement. (Evaluate)

F. Traceability standards and hierarchy

Identify various aspects of traceability, including traceability through commercial and national laboratories and international metrology organizations. (Understand)

G. Measurement standards

Define and distinguish between various types of standards, including primary, reference, working, intrinsic, derived, consensus, and transfer, and identify when to use them in various situations. (Apply)

H. Substitution of standards

Determine when and how calibration standards can be substituted based on measurement requirements, equipment availability, equipment specifications, etc. (Analyze)

II. Measurement Systems [22 Questions]

A. Measurement methods

Describe and use various measurement methods, including direct, indirect, ratio, transfer, differential, and substitution by unit under test (UUT). (Evaluate)

B. Measurement characteristics

Define and distinguish between various measurement characteristics, including variability, sensitivity, repeatability, reproducibility, bias, linearity, stability, etc., as they are used for basic measurements. (Understand) NOTE: The use of these characteristics in uncertainty measurements is covered in IV

C. Measurement data considerations

Identify and analyze various aspects of measurement data, including format, readability, resolution, suitability for use, confidentiality, etc. (Analyze)

D. IM&TE specification terms and characteristics

Define and use common specification descriptions, including percent of full scale (FS), percent of range, percent of reading, and number of counts. Describe and distinguish between characteristics of specifications, including tolerance and specifications, baseline modifies and qualifiers, output, scale and floor terms, etc. (Analyze)

E. Error sources

Identify and correct for error sources that can affect measurement results, including drift, bias, operator error, environment, etc. (Evaluate)

F. Measurement assurance program (MAP)

Define and describe basic MAP concepts, including interlaboratory comparisons and testing schemes, proficiency tests, gage R&R studies, etc. (Understand)

III. Calibration Systems [33 Questions]

A. Calibration procedures

Identify and define common elements of calibration procedures, such as required equipment, revisions, equipment listing, environmental considerations and restraints, etc. (Understand)

B. Standardization and adjustment methods

Use methods such as spanning, nulling, zeroing, linearization, etc., to adjust and standardize IM&TE, and analyze the outcomes. (Analyze)

C. Industry practices and regulations

1. Industry practices

Identify various sources of industry-accepted metrology and calibration practices, including published resources, manufacturer recommendations, ANSI standards, etc. (Understand)

2. Regulations, mandates, and guidance

Define and distinguish between government regulations, traceability and other legally mandated metrology requirements, national or international guidance, etc., and identify which rules or conventions take precedence in various situations. (Apply)

D. Environmental control

Define and describe various environmental parameters for humidity, dust levels, electrostatic discharge (ESD), temperature, vibration, etc., and analyze their influence on calibration activities. (Analyze)

E. Calibration processes for IM&TE

1. Process flow

Describe the basic flow of IM&TE through the calibration process. (Understand)

2. Logistical information

Identify IM&TE logistical information, such as equipment identification, ownership, service history, process tracking systems, etc. (Understand)

3. Roles and responsibilities

Identify roles and responsibilities of calibration staff members, including laboratory manager, technical manager, scheduler, quality manager, technician, etc. (Understand)

4. Scheduling

Describe IM&TE scheduling considerations, including planned calibration intervals, product or equipment recalls, steps in the notification process, overdue lists, staff workloads, etc., and analyze their impact. (Analyze)

F. Validation processes

Identify issues related to validating manual and automated calibration systems, and identify unique validation considerations for software or firmware that is part of IM&TE or calibration processes. (Understand)

G. Records management

Define and describe document control in terms of maintaining the integrity and confidentiality of various calibration records, including audit results, staff training, uncertainty budgets, customer data, etc., in both electronic and paper formats (Apply)

H. Official reports

Describe and distinguish between various types of formal results reporting, including calibration labels, test reports, nonconforming calibration reports, calibration certificates, etc. (Apply)

IV. Measurement Uncertainty and Applied Math [20 questions]

A. Uncertainty terminology

Define basic terms, such as guardbanding, test uncertainty ratio (TUR), test accuracy ratio (TAR), bias, error, percent of tolerance, etc. (Remember)

B. Uncertainty budget components

Identify various type A and type B uncertainty components, including environment, human factors, methods and equipment, item under test, reference standards, materials, etc., and identify the key elements and steps of developing an uncertainty budget. (Apply)

C. Uncertainty determination and reporting

Identify and use various methods to determine and report measurement uncertainty, including combined and expanded uncertainty, weighted factors, explanatory graphics, coverage factors, confidence levels, effective degrees of freedom, uncertainty calculation elements including mean, standard deviation, root sum square (RSS), variance, etc. (Analyze)

D. Technical and applied mathematics (Apply)

1. Scientific and engineering notation

   Express a floating point number in scientific and engineering notation.

2. English/Metric conversions

   Convert various units of measurement between English and metric units, including length, area, volume, capacity, and weight.

3. Ratios

   Express ratios in terms of percentage, decibels (dB), etc.

4. Linear interpolation and extrapolation

   Interpret tables and graphs to determine intermediate and extrapolated values.

5. Rounding, truncation, and significant figures

   Round and truncate a given number to a specified number of digits.

6. Order of mathematical operations

   Identify the correct order for performing mathematical operations and solve equations that contain multiple operations.

7. Algebraic equations

   Use basic algebra to solve for the unknown.

8. Angular conversions

   Convert between various angular units such as degrees, minutes, seconds, grads, radians, etc.

9. Graphs and plots

   Calculate the slope, intercept, and linearity of data sets, and interpret graphs and plots that illustrate these aspects of data.

V. Quality Systems and Standards [15 Questions]

A. Quality management systems

1. System components

   Define and distinguish between various components of a quality system, including management and customer focus, employee training and development, continuous process improvement, etc. (Apply)

2. Strategic and tactical processes

Identify various methods used to develop, improve, and review quality systems, including mission and goals, planning and deployment, cross-functional teams, etc. (Understand)

B. Quality control tools

Select and apply the seven basic quality tools: flowcharts/process maps, check sheets, Pareto diagrams, cause and effect diagrams, scatter diagrams, control charts, and histograms. (Analyze)

C. Quality audits

Define basic audit types (e.g., internal, external, product, process) and roles (e.g., auditor, auditee, client), and identify basic components of an audit (e.g., audit plan, audit purpose, audit standard) and describe various auditing tools (e.g., checklist, final report). (Understand)

D. Corrective action for nonconformances

1. Nonconforming material identification

   Determine conformance status and apply various methods of identifying and segregating nonconforming IM&TE materials. (Evaluate)

2. Impact assessment

   Define and use various tools (e.g., reverse traceability, customer notification, product recall, calibration standard evaluation, root-cause analysis) in response to out-of-tolerance conditions for IM&TE. (Apply)

E. Professional conduct and ethics

Identify appropriate behaviors that are aligned with the ASQ Code of Ethics, for various situations. (Apply)

F. Occupational safety requirements

1. Hazards and safety equipment

   Identify potential hazards in the work environment, including improper ventilation, mercury vapors, soldering fumes, suboptimal workplace lighting, etc., and identify appropriate personal protective equipment (PPE) for various situations. (Understand)

2. Hazardous communication (HazCom) standard

   Identify and interpret various elements of the HazCom standard (also known as the OSHA Right-to-Know Law) including material safety data sheet (MSDS) terms, material labeling requirements, etc. (Understand)

3. Housekeeping

   Describe housekeeping methods in the calibration environment including, maintenance, 5S's, IM&TE and cleaning). (Remember)

G. Quality standards and guides

Explain the benefits and importance of the following documents in relation to calibration.

1. Quality standards and guides such as ANSI/ISO/IEC 17025-2005, ANSI/NCSL Z540.3-2006, ISO 10012:2003(E), ISO 9001-2008, ANSI/NCSL Z540-2-1997, Guide 99:2007, VIM etc.
2. Accreditation and registration boards such as NVLAP, A2LA, IAS, LAB, RABQSA, IRCA, etc. (Understand)

Levels of Cognition
Based on Bloom's Taxonomy – Revised (2001)

In addition to **content** specifics, the subtext for each topic in this BOK also indicates the intended **complexity level** of the test questions for that topic. These levels are based on "Levels of Cognition" (from Bloom's Taxonomy – Revised, 2001) and are presented below in rank order, from least complex to most complex.

Remember
Recall or recognize terms, definitions, facts, ideas, materials, patterns, sequences, methods, principles, etc.

Understand
Read and understand descriptions, communications, reports, tables, diagrams, directions, regulations, etc.

Apply
Know when and how to use ideas, procedures, methods, formulas, principles, theories, etc.

Analyze
Break down information into its constituent parts and recognize their relationship to one another and how they are organized; identify sublevel factors or salient data from a complex scenario.

Evaluate
Make judgments about the value of proposed ideas, solutions, etc., by comparing the proposal to specific criteria or standards.

Create
Put parts or elements together in such a way as to reveal a pattern or structure not clearly there before; identify which data or information from a complex set is appropriate to examine further or from which supported conclusions can be drawn.