CERTIFIED CALIBRATION TECHNICIAN (CCT)
BODY OF KNOWLEDGE

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 (30 questions)

A. Base SI units
Describe and define the seven base units: 1) meter, 2) kilogram, 3) second, 4) ampere, 5) kelvin, 6) candela, and 7) mole. (Understand)
NOTE: The application of these units is covered in I.B., I.C., I.D, and I.E.

B. Derived SI units
Define, calculate, and convert various derived units, such as 1) degree, 2) ohm, 3) pascal, 4) newton, 5) joule, 6) coulomb, 7) hertz, and 8) watt. (Apply)

C. SI multipliers and conversions
Define various multipliers, such as 1) kilo, 2) deci, 3) centi, and 4) milli. Calculate converted values, such as mega to kilo and micro to milli. (Apply)

D. Fundamental constants
Identify the fundamental constants of 1) velocity or speed of light in a vacuum (c), 2) gravitational constant (g), 3) Planck's constant (h), 4) Avogadro constant (N_A), 5) Boltzmann (kB), and 6) elementary charge (e), and their standard symbols and common applications. (Understand)
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 1) temperature, 2) humidity, 3) pressure, 4) torque, 5) force, 6) mass, 7) voltage / current / resistance, 8) time / frequency, 9) linear displacement, 10) power, 11) dimensional, 12) viscosity, 13) volume, 14) luminosity, 15) flow, 16) energy, and 17) density. (Apply)

F. Traceability standards and hierarchy
Identify various aspects of traceability, such as traceability through commercial laboratories, national laboratories, international metrology organizations, and SI units. Understand the realization and dissemination of SI units. (Apply)

G. Measurement standards
Define and distinguish between various types of standards, such as 1) primary, 2) secondary, 3) reference, 4) working, 5) intrinsic, 6) derived, 7) consensus, and 8) transfer, and identify when to use them in various situations. (Analyze)

H. Substitution of standards
Assess when and how calibration standards can be substituted based on 1) measurement requirements, 2) equipment availability, 3) equipment specifications, etc. (Evaluate)

II. Measurement Systems (26 questions)

A. Measurement methods
Describe and employ various measurement methods, such as 1) direct (e.g., absolute and fundamental), 2) indirect, 3) ratio, 4) transfer (e.g., comparison), 5) differential, and 6) substitution by unit under test (UUT). (Evaluate)

B. Measurement characteristics
Define and distinguish various characteristics used for basic measurements, such as 1) variability, 2) sensitivity, 3) repeatability, 4) reproducibility, 5) bias, 6) linearity, 7) stability, and 8) measurand. (Apply)
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, such as 1) format, 2) readability, 3) resolution, 4) suitability for use, and 5) confidentiality. (Analyze)

D. IM&TE specification terms and characteristics
Demonstrate knowledge of common specification descriptions, such as 1) percent of full scale, 2) percent of range, 3) percent of reading, and 4) number of counts. Describe and distinguish between characteristics of specifications, such as 5) tolerance and specifications, 6) baseline modifiers and qualifiers, 7) output, 8) scale, and 9) floor terms. (Analyze)

E. Error sources
Identify, mitigate, and correct error sources that can affect measurement results, such as 1) drift, 2) bias, 3) operator error, 4) measurement process, and 5) environment. (Evaluate)

F. Measurement assurance program (MAP)
Explain basic MAP concepts, such as 1) interlaboratory comparisons and testing schemes, 2) proficiency tests, 3) gage R&R studies, and 4) statistical process control (SPC). (Understand)

III. Calibration Systems (28 questions)

A. Calibration procedures
Identify and apply common elements of calibration procedures, such as 1) required equipment, 2) equipment listing, 3) environmental considerations and restraints, and 4) common procedures. (Analyze)

B. Standardization and adjustment methods
Utilize methods, such as 1) spanning, 2) nulling, 3) zeroing, and 4) linearization, 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, such as published resources, national standards, and international standards. (Understand)

2. Regulations, mandates, and guidance

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

D. Environmental control

Recognize various environmental parameters for 1) humidity, 2) dust levels, 3) electrostatic discharge (ESD), 4) temperature, 5) vibration, 6) pressure, etc., and explain their influence on calibration activities. (Apply)

E. Calibration processes for IM&TE

1. Process flow

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

2. Logistical information

Explain IM&TE logistical information, such as 1) equipment identification, 2) ownership, 3) service history, and 4) process tracking systems. (Understand)

3. Roles and responsibilities

Identify roles and responsibilities of calibration staff members, such as 1) laboratory manager, 2) technical manager, 3) scheduler, 4) quality manager, and 5) technician. (Understand)

4. Scheduling

Determine IM&TE scheduling considerations, such as 1) planned calibration intervals, 2) material or equipment requests, 3) steps in the notification process, 4) overdue lists, and 5) staff workloads, and analyze their impact. (Analyze)

F. Validation processes

Determine 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. Apply verification of standard methods and validation of self-developed processes. (Apply)

G. Records management

Define and describe document control in terms of maintaining the integrity and confidentiality of various calibration records, such as 1) audit results, 2) staff training, 3) uncertainty budgets, 4) customer data, 5) technical records, 6) documented processes, 7) requests, 8) contracts, and 9) tenders. (Apply)

H. Official reports

Describe and distinguish various types of formal results reporting, such as 1) calibration certificates, 2) calibration labels, 3) nonconformance calibration reports, and 4) test reports. (Apply)

IV. Measurement Uncertainty and Applied Math (25 questions)

A. Uncertainty terminology

Define and explain basic terms, such as 1) guard-banding, 2) probability for false rejection (PFR, also known as Type I error), 3) probability for false acceptance (PFA, also known as Type II error), 4) test uncertainty ratio (TUR), 5) test accuracy ratio (TAR), 6) bias, 7) percent of tolerance, and 8) gage R&R. (Apply)

B. Uncertainty budget components

Define and identify various type A and type B uncertainty components, such as 1) environment, 2) methods, 3) unit under test, 4) materials, 5) resolution, and 6) the key elements and steps of developing an uncertainty budget. (Apply)

C. Uncertainty determination and reporting

Define various methods to determine and report measurement uncertainty, such as 1) combined and expanded uncertainty, 2) coverage factors, 3) confidence levels, 4) effective degrees of freedom, 5) distribution factors, 6) uncertainty calculation elements (e.g., mean, standard deviation, root sum square (RSS), and variance), and 7) statement of conformity / decision rule (e.g., simple acceptance). (Apply)

D. Technical and applied mathematics

1. **Scientific and engineering notation**
   Express a floating-point number in scientific and engineering notation. (Apply)
2. **English / Metric conversions**
   Convert various units of measurement between English / U.S. Customary Units and metric units, such as 1) length, 2) area, 3) volume, 4) capacity, and 5) mass. (Apply)
3. **Ratios**
   Express various terms, such as 1) percentage, 2) parts per million (ppm), and 3) decibels (dB). (Apply)
4. **Tables, graphs, and plots**
   Interpret tables and graphs to determine intermediate and extrapolated values. Illustrate the aspects of slope, intercept, and linearity of data sets in relation to graphs and plots. (Analyze**)**
5. **Rounding, truncation, and significant figures**
   Determine the resolution of calculations (e.g., number of digits and least significant digit). Round and truncate to a specified number of digits. (Apply)
6. **Order of mathematical operations**
   Identify the correct order for performing mathematical operations and solve equations that contain multiple operations. (Apply)
7. **Algebraic equations**
   Use basic algebra to solve for the unknown. (Apply)
8. **Angular conversions**
   Convert various angular units, such as degrees, minutes, seconds, grads, and radians. (Apply)

V. Quality Systems and Standards (16 questions)

A. Quality management systems

1. System components
Define and distinguish between various components of a quality system, such as 1) management and customer focus, 2) employee training and development, and 3) continuous process improvement. (Apply)

2. Strategic and tactical processes
Identify various methods used to develop, improve, and review quality systems, such as 1) mission and goals, 2) planning and deployment, and 3) cross-functional teams. (Understand)

B. Quality control tools
Understand the seven basic quality tools: 1) flowcharts / process maps, 2) check sheets, 3) Pareto chart, 4) cause and effect diagrams, 5) scatter diagrams, 6) control charts, and 7) histograms. (Understand)

C. Quality audits
Define and describe the following elements of quality audits. (Understand)

1. Types of audits, such as internal, external, product, and process.
2. Audit components, such as audit plan, audit purpose, and audit standard.

D. Corrective action for nonconformances

1. Nonconformance identification
Determine conformance status and compare methods with the standards. Apply various methods of identifying and segregating nonconforming IM&TE. (Evaluate)

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

E. Professional conduct and ethics
Demonstrate appropriate behaviors that are aligned with the ASQ Code of Ethics for various situations. (Apply)

F. Occupational safety requirements

1. Hazards and safety equipment
Assess potential hazards in the work environment, such as 1) improper ventilation, 2) soldering fumes, and 3) suboptimal workplace lighting. Identify appropriate personal protective equipment (PPE) for various situations. (Apply)

2. Occupational health and safety
Understand when and how to use various elements of occupational health and safety, such as 1) safety data sheet terms, 2) material labeling requirements, and 3) workplace safety. (Apply)

3. Housekeeping
Apply housekeeping methods in the calibration environment, such as 1) maintenance, 2) 6S, 3) IM&TE, and 4) cleaning. (Apply)

4. Pre and post calibration condition

Describe proper set-up prior to calibration and how to return IM&TE to safe, operational set-up upon completion. (Apply)

G. Quality standards and guides

Explain the benefits and importance of the following documents and organizations in relation to calibration. (Understand)

1. Quality standards and guides, including ISO 9001-2015, ISO / IEC 17025-2017, ISO 10012, GUM (JCGM 100:2008), and VIM (JCGM 200:2012).
2. Accreditation bodies such as those recognized by IAF (International Accreditation Forum) and ILAC (International Laboratory Accreditation Cooperation).

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.