AMERICAN SOCIETY FOR QUALITY
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: meter, kilogram, second, ampere, kelvin, candela, and mole. (Comprehension) **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. (Analysis)

C. SI multipliers and conversions

Define and apply various multipliers (e.g., zeta, kilo, deci, centi, milli) and convert between them (e.g., mega to kilo, micro to milli). (Application)

D. Fundamental constants

Recognize various fundamental constants and identify their standard symbols and common applications, such as *c* (velocity or speed of light in a vacuum), *g* (gravitational constant), *R* (universal gas constant), etc. (Knowledge) **NOTE:** The values or formulas for calculating these constants will NOT be tested.

E. Common measurements

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

F. Principles and practices of traceability

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

G. Types of measurement standards

Recognize and distinguish between various types of standards, including primary, reference, working, intrinsic, derived, consensus, transfer, etc. (Application)

H. Substitution of calibration standards

Determine when and how calibration standards are substituted based on measurement requirements, equipment availability, equipment specifications, etc. (Application)

II. Measurement Systems [25 Questions]

A. Measurement methods

Describe and use various measurement methods, including direct, indirect, ratio, transfer, differential, and substitution – i.e., replacing a reference standard device with a unit under test (UUT). (Evaluation)

B. Measurement data

Identify and respond to various measurement data considerations, including readability, integrity, confidentiality, resolution, format, suitability for use, etc. (Analysis)

C. Characteristics of measurements

Define and distinguish between various measurement characteristics, including variability, sensitivity, repeatability, bias, linearity, stability, reproducibility, etc. (Comprehension)
NOTE: The application of these characteristics is covered in VI.A.3. and VI.B.

D. IM&TE specifications

Describe and use IM&TE specifications in terms of common descriptors (e.g., percent of full scale (FS), percent of range, parts per million (ppm) of reading, number of counts). (Application)

E. Primary error sources

Identify and correct for various types of error sources that can affect measurement uncertainty, including drift, bias, operator error, environment, etc. (Evaluation)

F. Measurement systems and capabilities

Describe and distinguish between measurement systems and measurement capabilities. (Comprehension)

G. Measurement assurance programs (MAPs)

Identify and describe basic concepts of MAPs, including inter-laboratory comparisons, proficiency tests, gage R&R studies, etc. (Comprehension)

III. Calibration Systems [25 Questions]

A. Calibration procedures

Identify and define common components of calibration procedures, such as required equipment, ambient conditions, revisions, equipment listing, environmental restraints, etc. (Comprehension)

B. Calibration methods

Define and use common calibration methods, including spanning, nulling, zeroing, linearization, etc. (Application)

C. Industry practices and regulations

1. Industry-accepted practices

Recognize various sources of industry-accepted metrology and calibration practices (e.g., published, manufacturer, ANSI). (Comprehension)

2. Directives and mandates

Define and describe different types of calibration directives such as state and federal regulations, traceability and other requirements mandated by legal metrology, and guidance from national or international standards, and identify which rules or conventions take precedence in various situations. (Application)

D. Control of the calibration environment

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

E. Calibration processes for IM&TE

1. Process flow

Identify and describe the basic flow of IM&TE throughout the calibration process. (Comprehension)

2. Logistical information

Identify various aspects of IM&TE logistical information, such as equipment identification, ownership, service history, process tracking, etc. (Comprehension)

3. Roles and responsibilities

Identify various roles and responsibilities of staff such as technical manager, scheduler, quality manager, technician, etc. (Comprehension)

4. Scheduling

Describe various IM&TE scheduling considerations, including calibration intervals, recalls, how overdue schedules are determined, steps in the notification process, etc. (Knowledge)

F. Manual and automated calibration

Recognize various issues related to developing, validating, and using both manual and automated calibration processes, including software-driven processes. (Comprehension)

G. Systems records and records management

Identify the importance of maintaining document control, confidentiality, and integrity in relation to various records (e.g., training records, audit results, uncertainty budgets, customer data) in both electronic and hard-copy formats. (Comprehension)

H. Reporting results

Identify and distinguish between various types of calibration results reports, including certificates, test reports, labels, reports of nonconforming calibration, etc. (Application)

IV. Applied Math and Statistics [20 Questions]

A. Technical and applied mathematics (Application)

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 parts per million (ppm), 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. Number bases

   Convert numbers between various number bases (e.g., decimal, binary, octal, hexadecimal).

7. Volume and area

   Calculate volume and area of various geometric shapes (e.g., cube, sphere, pyramid, cylinder).

8. Angular conversions

   Convert between various angular units (e.g., degrees, radians).

9. Graphs and plots

   Determine the slope, intercept, and linearity of data sets.

B. Applied statistics

1. Basic statistical tools

   Define and use basic statistics such as measures of central tendency (mean, standard deviation, etc.), sample vs. population, degrees of freedom, etc. (Application)

2. Common distributions

   Classify data distributions as being normal, rectangular, triangular, or U-shaped. (Application)

3. Descriptive statistics

   Calculate the variance, root mean square (rms), root sum square (rss), and standard error of the mean (SEM) for a data set. (Application)

4. Sampling issues

   Recognize various terms, including acceptance sampling, sample size, sufficient number of points, etc. (Knowledge)

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 organizational leadership, market and customer focus, organizational performance measures and analysis, employee training and development, continuous improvement models, etc. (Application)

2. Procedures

   Identify various methods and tools used in the development, validation, improvement, and review of a quality system, including mission and goals, strategic planning, cross-functional teams, etc. (Comprehension)

B. The seven quality control tools

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

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). (Comprehension)

D. Preventive and corrective action

1. Process improvement techniques

   Determine and select areas for improvement using various quality tools (e.g., PDCA, confidence checks, brainstorming, mistake-proofing, fishbone diagram). (Application)

2. Nonconforming material identification

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

3. Impact assessment of nonconformances

   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. (Application)

E. Supplier qualification and monitoring

Identify various activities used to qualify, monitor, and sustain approved suppliers. (Knowledge)

F. Professional conduct and ethics

Identify appropriate behaviors, such as those listed in the ASQ Code of Ethics, for various situations requiring ethical decisions. (Application)

G. Occupational safety requirements

1. Hazards and safety equipment

Identify potential hazards within the working environment (e.g., ventilation, mercury, lighting, soldering) and describe the proper use of personal protective equipment (PPE). (Knowledge)

2. Hazardous communications (HAZ-COM)

   Identify and interpret various HAZ-COM directives (e.g., right-to-know (RTK), material safety data sheet (MSDS), material labeling). (Comprehension)

3. Housekeeping

   Describe the importance of good housekeeping tools and methods (e.g., maintenance, cleaning). (Knowledge)

H. Quality standards and guides

Explain the benefits and importance of the following in relation to calibration: Quality standards such as ISO/IEC 17025, ANSI/NCSL Z540-1-1994, ISO/IC 10012, ISO 9000-2000, etc.; Quality guides such as GUM, ANSI/NCSL Z540-2-1997, VIM, etc.; Accreditation and registration boards such as NVLAP, A2LA, IAS, LAB, RAB, IRCA, etc. (Comprehension)

VI. Uncertainty [10 Questions]

A. 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 of developing an uncertainty budget. (Application)

B. Uncertainty management

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

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, etc. (Application)

Six Levels of Cognition
based on Bloom's Taxonomy (1956)

In addition to *content* specifics, the subtext detail 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, 195and are presented below in rank order, from least complex to most complex.

Knowledge Level
(Also commonly referred to as recognition, recall, or rote knowledge.) Able to remember or recognize terminology, definitions, facts, ideas, materials, patterns, sequences, methodologies, principles, etc.

Comprehension Level
Able to read and understand descriptions, communications, reports, tables, diagrams, directions, regulations, etc.

Application Level
Able to apply ideas, procedures, methods, formulas, principles, theories, etc., in job-related situations

Analysis
Able to break down information into its constituent parts and recognize the parts' relationship to one another and how they are organized; identify sublevel factors or salient data from a complex scenario

Synthesis
Able to put parts or elements together in such a way as to show 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

Evaluation
Able to make judgments regarding the value of proposed ideas, solutions, methodologies, etc., by using appropriate criteria or standards to estimate accuracy, effectiveness, economic benefits, etc.