Professionalizing Quality Education - Certified Quality Engineer Exam

Preface

This text is designed to be a Primer for those interested in taking the certification examination offered twice a year by the American Society for Quality. Test questions are provided at the end of each Section. Test questions and answers must not be used as a reference during the certification examination.

Objective

To provide recognized quality engineer fundamental training and to prepare persons interested in taking the CQE examination.

Certification

Certification is the independently verified prescribed level of knowledge as defined through a combination of experience, education and examination.

The Certified Quality Engineer

Is a professional who can carry out in a responsible manner proven technique which make up the body of knowledge recognized by those who are experts in quality technology.

Eligibility

CQE participants must register with ASQ headquarters. Eligibility entails a combination of eight years work experience and/or higher education. Three years of this requirement must be in a decision making position.

The national test fee is determined by ASQ and is detailed in the CQE brochure.

Location

Exams are given at Prometric Test Centre's at dates and times scheduled by the test taker within the given exam dates, and at selected conferences and other locations.

Duration

The written test lasts 5 hours and will begin at an advised time (typically 8 A.M.).
The Prometric version lasts 5.5 hours because of 15 additional questions.

Other Details

Can be obtained by calling ASQ headquarters at (800) 248-1946 or (414) 272-8575. They will send a CQE brochure free of charge.

Bibliography Sources

The reference sources recommended in the ASQ brochure are excellent. Four of the author's favourites are:

(1) *Juran's Quality Handbook*

(2) Western Electric's Statistical *Quality Control Handbook*

(3) Gryna's *Quality Planning and Analysis*

(4) Grant & Leavenworth's Statistical *Quality Control*

ANSI/ASQ 21.4 should be reviewed and taken into the exam. The author also recommends the following (not on the ASQ list):

(1) *Quality Dictionary* - T. Omdahl for definitions of more than 2,500 quality terms. Available from QCI, (800) 660-4215.

(2) *Business Statistics* - Triola & Franklin - Addison Wesley (800) 822-6339 or any statistics book by Mendenhall.

(3) *AS/ DataMyte Handbook,* available on CD from ASI DataMyte, Plymouth, MN, Tel: (800) 207-5631 or (763) 553-1040, for control charts, capability, quality tools, sampling, and definitions.

Study

The author recommends that this Primer be taught by a qualified CQE using classroom lecture, study assignments and a review of test questions. Training may vary from 27 hours to 48 hours. Additionally, the student should spend about 90 hours of individual study on the Primer, test questions, and other bibliography sources. If the student studies unaided, a minimum of 130 hours of preparation is suggested.

Exam Hints

The CQE applicant should take into the exam:

- Several #2 pencils
- A calculator (capable of determining standard deviation and natural log)
- The *CQE Primer* (without test questions)

- A recommended quality references
- **ANSI/ASQ** 21.4 (latest edition)
- A good statistical reference (one the student knows)
- Scratch paper

Arrive early, get a good seat, organize your materials.

Answer all questions. There's no penalty for wrong answers.

Save difficult questions until the end.

Use good time management. Both the written version of the 160 questions (in 5 hours) and the Prometric version of 175 questions in 5.5 hours requires approximately 1.88 minutes per question.

Some tests begin with difficult questions, avoid panic.

Keep test question numbers and the answer sheet aligned.

Bring any exam errata to your proctor's attention.

Mentally note weakness categories in case you have to take the exam again. ASQ will report only flagrant areas.

ASQ Certified Quality Engineer (CQE) Body of Knowledge*

The topics in this Body of Knowledge include 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 that material that will be covered in the exam. It is meant to clarify the type of content that will be included on 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 description of cognitive levels is provided at the end of this document.

I. Management and Leadership (18 Questions)

A. Quality Philosophies and Foundations

1. Evolution of Quality (Understand)

Understand how modern quality has evolved from quality control through statistical process control (SPC) to total quality management and leadership principles (including Deming's 14 points).

2. Continuous improvement tools(Understand)
Describe continuous improvement tools, including lean, six sigmas, theory of constraints, statistical process control, and total quality management.

B. The Quality Management System (QMS)

1. Strategic planning (Apply)
Identify and define top management's responsibility for the **QMS,** including establishing policies and objectives, setting organization-wide goals, and supporting quality initiatives.

2. Deployment techniques
Define, describe, and use various deployment tools in support of the QMS such as:

a. Benchmarking(Remember)
Define the concept of benchmarking and why it may be used.

b. Stakeholder(s) (Apply)
Define, describe and use stakeholder identification and analysis.

c. Performance {Apply)
Define, describe and use performance measurement tools.

d. Project management {Apply)
Define, describe and use project management tools, including PERT charts, Gantt charts, critical path method {CPM), and resource allocation.

3. Quality information system {QIS) {Understand)
Identify and describe the basic elements of a QIS, including who will contribute data, the kind of data to be managed, who will have access to the data, the level of flexibility for future information needs, and data analysis.

C. ASQ Code of Ethics for Professional Conduct {Evaluate)

Determine appropriate behaviour in situations requiring ethical decisions.

D. Leadership Principles and Techniques {Analyse)

Analyse various principles and techniques for developing and organizing teams and leading quality initiatives.

E. Facilitation Principles and Techniques

1. Roles and responsibilities {Understand)
Describe the facilitator's roles and responsibilities on a team.

2. Facilitation tools {Apply)

Apply various tools used with teams, including brainstorming, nominal group technique, conflict resolution, and force-field analysis.

F. Communication Skills {Analyse)

Identify specific communication methods that are used for delivering information and messages in a variety of situations across all levels of the organization.

G. Customer Relations {Analyse)

Define, apply, and analyse the results of customer relation tools such as quality function deployment {QFD) and customer satisfaction surveys.

H. Supplier Management

1. Techniques (Apply)

Apply various supplier management techniques, including supplier qualification, certification, and evaluation.

2. Improvement (Analyse)

Analyse supplier ratings and performance improvement results.

3. Risk (Understand)

Understand business continuity, resiliency, and contingency planning.

I. Barriers to Quality Improvement(Analyse)

Identify barriers to quality improvement, analyse their causes and impact, and implement methods for improvement.

II. The Quality System (16 Questions)

A. Elements of the Quality System

1. Basic elements (Evaluate)

Interpret the basic elements of a quality system, including planning, control, and improvement, from product and process design through quality cost systems and audit programs.

2. Design (Analyse)

Analyse the design and alignment of interrelated processes to the strategic plan and core processes.

B. Documentation of the Quality System

1. Document components (Understand)

Identify and describe quality system documentation components, including quality policies and procedures to support the system.

2. Document control (Evaluate)
Evaluate configuration management, maintenance, and document control to manage work instructions and quality records.

C. Quality Standards and Other Guidelines (Apply)
Apply national and international standards and other requirements and guidelines, including the Malcolm Baldrige National Quality Award (MBNQA), and describe key points of the ISO 9000 series of standards. [Note: Industry-specific standards will not be tested.]

D. Quality Audits

1. Types of audits (Apply)
Describe and distinguish between various types of quality audits such as product, process, management (system), registration (certification), compliance (regulatory), first, second, and third party.

2. Roles and responsibilities in audits (Understand)
Identify and define roles and responsibilities for audit participants such as audit team (leader and members), client, and auditee.

3. Audit planning and implementation (Apply)
Describe and apply the stages of a quality audit, from audit planning through conducting the audit.

4. Audit reporting and follow-up (Apply)
Apply the steps of audit reporting and follow up, including the need to verify corrective action.

E. Cost of Quality (COQ) (Analyse)
Identify and apply COQ concepts, including cost categorization, data collection, reporting, and interpreting results.

F. Quality Training (Apply)
Identify and apply key elements of a training program, including conducting a needs analysis, developing curricula and materials, and determining the program's effectiveness.

III. Product, Process, and Service Design (23 Questions)

A. Classification of Quality Characteristics (Evaluate)
Define, interpret, and classify quality characteristics for new and existing products, processes, and services. [Note: The classification of defects is covered in IV.B.3.]

B. Design Inputs and Review

1. Inputs (Analyse)

Translate design inputs such as customer needs, regulatory requirements, and risk assessment into robust design using techniques such as failure mode and effects analysis (FMEA), quality function deployment (QFD), Design for X (DFX), and Design for Six Sigma (DFSS).

2. Review (Apply)

Identify and apply common elements of the design review process, including roles and responsibilities of participants.

C. Technical Drawings and Specifications (Evaluate)

Interpret specification requirements in relation to product and process characteristics and technical drawings, including characteristics such as views, title blocks, dimensioning and tolerancing, and GD&T symbols.

D. Verification and Validation (Evaluate)

Interpret the results of evaluations and tests used to verify and validate the design of products, processes and services, such as installation qualification (IQ), operational qualification (OQ), and process qualification **(PQ).**

E. Reliability and Maintainability

1. Predictive and preventive maintenance tools (Apply)

Describe and apply the tools and techniques used to maintain and improve process and product reliability.

2. Reliability and maintainability indices (Analyse)

Review and analyse indices such as MTTF, MTBF, MTTR, availability, and failure rate.

3. Reliability models (Apply)

Identify, define, and distinguish between the basic elements of reliability models such as exponential, Weibull, and bathtub curve.

4. Reliability/ Safety / Hazard Assessment Tools (Evaluate)

Define, construct, and interpret the results of failure mode and effects analysis (FMEA), failure mode, effects, and criticality analysis (FMECA), and fault tree analysis (FTA).

IV. Product and Process Control (25 Questions)

A. Methods (Analyse)

Implement product and process control methods such as control plan development, critical control point identification, and work instruction development and validation.

B. Material Control

1. Material identification, status, and traceability (Analyse)
   Define and distinguish between these concepts, and describe methods for applying them in various situations.

2. Material segregation (Evaluate)
   Describe material segregation and its importance, and evaluate appropriate methods for applying it in various situations.

3. Material classification (Evaluate)
   Classify product and process defects and non-conformities.

4. Material review board (MRB) (Evaluate)
   Describe the purpose and function of an MRB and evaluate nonconforming product or material to make a disposition decision in various situations.

C. Acceptance Sampling

1. Sampling concepts (Analyse)
   Interpret the concepts of producer and consumer risk and related terms, including operating characteristic (OC) curves, acceptable quality limit (AQL), lot tolerance percent defective (LTPD), average outgoing quality (AOQ), and average outgoing quality limit (AOQL).

2. Sampling standards and plans (Analyse)
   Identify, interpret, and apply **ANSI/ASQ** 21.4 and 21.9 standards for attributes and variables sampling. Identify and distinguish between single, double, multiple, sequential, and continuous sampling methods. Identify the characteristics of Dodge-Romig sampling tables and when they should be used.

ASQ CQE Body of Knowledge (Continued)

3. Sample integrity (Apply)
   Identify and apply techniques for establishing and maintaining sample integrity.

D. Measurement and Test

1. Measurement tools (Analyse)
   Select and describe appropriate uses of inspection tools such as gage blocks, calipers, micrometers, and optical comparators.

2. Destructive and non-destructive tests (Apply)
   Identify when destructive and non-destructive measurement test methods should be used and apply the methods appropriately.

E. Metrology (Analyse)
Apply metrology techniques such as calibration, traceability to calibration standards, measurement error and its sources, and control and maintenance of measurement standards and devices.

F. Measurement System Analysis **(MSA)** (Evaluate)
Calculate, analyse, and interpret repeatability and reproducibility (Gage R&R) studies, measurement correlation, capability, bias, linearity, precision, stability and accuracy, as well as related MSA quantitative and graphical methods.

V. Continuous Improvement (27 Questions)

A. Quality Control Tools (Analyse)
Select, construct, apply, and interpret the following quality control tools:

1. Flowcharts
2. Pareto charts
3. Cause and effect diagrams
4. Control charts
5. Check sheets
6. Scatter diagrams
7. Histograms

ASQ CQE Body of Knowledge (Continued)

B. Quality Management and Planning Tools (Analyse)
Select, construct, apply, and interpret the following quality management and planning tools:

1. Affinity diagrams and force field analysis
2. Tree diagrams
3. Process decision program charts (PDPC)
4. Matrix diagrams
5. Interrelationship digraphs
6. Prioritization matrices
7. Activity network diagrams

C. Continuous Improvement Methodologies (Evaluate)
Define, describe, and apply the following continuous improvement methodologies:

1. Total quality management (TQM)
2. Kaizen
3. Plan-do-check-act (PDCA)
4. Six sigmas
5. Theory of constraints (TOC)

D. Lean tools (Evaluate)
Define, describe, and apply the following lean tools:

1.5S
2. Value-stream mapping
3. Kanban
4. Visual control
5. Waste (Muda)
6. Standardized work
7. Takt time
8. Single minute exchange of die (SMED)

E. Corrective Action (Evaluate)
Identify, describe, and apply elements of the corrective action process, including problem identification, failure analysis, root cause analysis, problem correction, recurrence control, and verification of effectiveness.

F. Preventive Action (Evaluate)
Identify, describe and apply various preventive action tools such as error-proofing/poka-yoke, robust design and analyse their effectiveness.

ASQ CQE Body of Knowledge {Continued)

VI. Quantitative Methods and Tools (36 Questions)

A. Collecting and Summarizing Data

1. Types of data
Define, classify, and compare te (attributes) and continuous (variables) data.

2. Measurement scales (Understand)
Define and describe nominal, ordinal, interval, and ratio scales.

3. Data collection methods (Apply)
Describe various methods for collecting data, including tally or check sheets, data coding, automatic gaging, and identify the strengths and weaknesses of the methods.

4. Data accuracy and integrity (Apply)
Apply techniques that ensure data accuracy and integrity, and identify factors that can influence data accuracy such as source/resource issues, flexibility, versatility, inconsistency, inappropriate interpretation of data values, and redundancy.

5. Descriptive statistics (Evaluate)
Describe, calculate, and interpret measures of central tendency and dispersion (central limit theorem), and construct and interpret frequency distributions, including simple, categorical, grouped, ungrouped, and cumulative.

6. Graphical methods for depicting relationships (Analyse)
Construct, apply, and interpret diagrams and charts such as stem-and-leaf plots, and box-and-whisker plots. [Note: Scatter diagrams are covered in **V.A.]**

7. Graphical methods for depicting distributions (Analyse)
Construct, apply, and interpret diagrams such as normal and non-normal probability plots. [Note: Histograms are covered in **V.A.]**

B. Quantitative Concepts

C. Terminology (Analyse)
Define and apply quantitative terms, including population, parameter, sample, statistic, random sampling, and expected value.

ASQ CQE Body of Knowledge {Continued)

D. Drawing statistical conclusions (Evaluate)

Distinguish between numeric and analytical studies. Assess the validity of statistical conclusions by analysing the assumptions used and the robustness of the technique used.

E. Probability terms and concepts (Understand)

Describe concepts such as independence, mutually exclusive, multiplication rules, complementary probability, and joint occurrence of events.

C. Probability Distributions

1. Continuous distributions (Analyse)

Define and distinguish between these distributions such as normal, uniform, bivariate normal, exponential, lognormal, Weibull, chi square, Student's t and F.

2. Discrete distributions (Analyse)

Define and distinguish between these distributions such as binomial, Poisson, hypergeometric, and multinomial.

D. Statistical Decision-Making

1. Point estimates and confidence intervals (Evaluate)

Define, describe, and assess the efficiency and bias of estimators. Calculate and interpret standard error, tolerance intervals, and confidence intervals.

2. Hypothesis testing (Evaluate)

Define, interpret, and apply hypothesis tests for means, variances, and proportions. Apply and interpret the concepts of significance level, power, type I and type II errors. Define and distinguish between statistical and practical significance.

3. Paired-comparison tests(Apply)

Define and use paired-comparison (parametric) hypothesis tests, and interpret the results.

4. Goodness-of-fit tests (Understand)

Define chi square and other goodness-of-fit tests, and understand the results.

5. Analysis of variance **(ANOVA)** (Analyse)

Define and use

ANOVAs and interpret the results.

6. Contingency tables (Apply)
   Define and use contingency tables to evaluate statistical significance.

E. Relationships Between Variables

1. Linear regression (Analyse)
   Calculate the regression equation for simple regressions and least squares estimates. Construct and interpret hypothesis tests for regression statistics. Use linear regression models for estimation and prediction.

2. Simple linear correlation(Analyse)
   Calculate the correlation coefficient and its confidence interval, and construct and interpret a hypothesis test for correlation statistics.

3. Time-series analysis (Apply)
   Define, describe, and use time-series analysis, including moving average to identify trends and seasonal or cyclical variation.

F. Statistical Process Control (SPC)

1. Objectives and benefits (Understand)
   Identify and explain the objectives and benefits of SPC.

2. Common and special causes (Analyse)
   Describe, identify, and distinguish between these types of causes.

3. Selection of variable (Analyse)
   Identify and select characteristics for monitoring by control chart.

4. Rational subgrouping (Apply)
   Define and apply the principles of rational subgrouping.

5. Control charts (Analyse)
   Identify, select, construct, and use various control charts, including X bar-R, X bar-s, individuals and moving range (I&R or X&R), moving average and moving range (M&R), p, np, c, and u.

6. Control chart analysis (Evaluate)
   Read and interpret control charts and use rules for determining statistical control.

7. Pre-control charts (Understand)
   Define and describe these charts and how they differ from other control charts.

8. Short-run SPC
   Identify and define short-run SPC rules.

G. Process and Performance Capability (Understand)

1. Process capability studies (Analyse)
   Define, describe, calculate, and use process capability studies, including identifying characteristics, specifications and tolerances, developing sampling plans for such studies, and establishing statistical control.

2. Process performance vs. specifications (Analyse)
   Distinguish between natural process limits and specification limits, and calculate percent defective, defects per million opportunities (DPMO), and parts per million **(PPM).**

3. Process capability indices (Evaluate)
   Define, select, and calculate Cp, CPk' Cpm, and Cr, and evaluate process capability.

4. Process performance indices (Evaluate)
   Define, select, and calculate PP and Ppk, and evaluate process performance.

H. Design and Analysis of Experiments

1. Terminology (Understand)
   Define terms such as dependent and independent variables, factors, levels, response, treatment, error, and replication.

2. Planning and organizing experiments (Analyse)
   Identify the basic elements of designed experiments, including determining the experiment objective, selecting factors, responses, and

measurement methods, and choosing the appropriate design.

3. Design principles (Apply)
   Define and apply the principles of power and sample size, balance, replication, order, efficiency, randomization, blocking, interaction, and confounding.

4. One-factor experiments (Analyse)
   Construct one-factor experiments such as completely randomized, randomized block, and Latin square designs, and use computational and graphical methods to analyse the significance of results.

5. Full-factorial experiments(Analyse)
   Construct full-factorial designs and use computational and graphical methods to analyse the significance of results.

6. Two-level fractional factorial experiments (Analyse)
   Construct two-level fractional factorial designs and apply computational and graphical methods to analyse the significance of results.

VII. Risk Management (15 Questions)

A. Risk Oversight (Apply)

1. Planning and oversight (Understand)
   Understand identification, planning, prioritization, and oversight of risk.

2. Metrics (Apply)
   Identify and apply evaluation metrics.

3. Mitigation planning (Evaluate)
   Apply and interpret risk mitigation plan.

B. Risk Assessment (Analyse)

Apply categorization methods and evaluation tools to assess risk.

C. Risk Control (Analyse)

1. Identification and documentation

   Identify and document risks, gaps and controls.

2. Auditing and Testing (Evaluate)

   Apply auditing techniques and testing of controls.

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.

