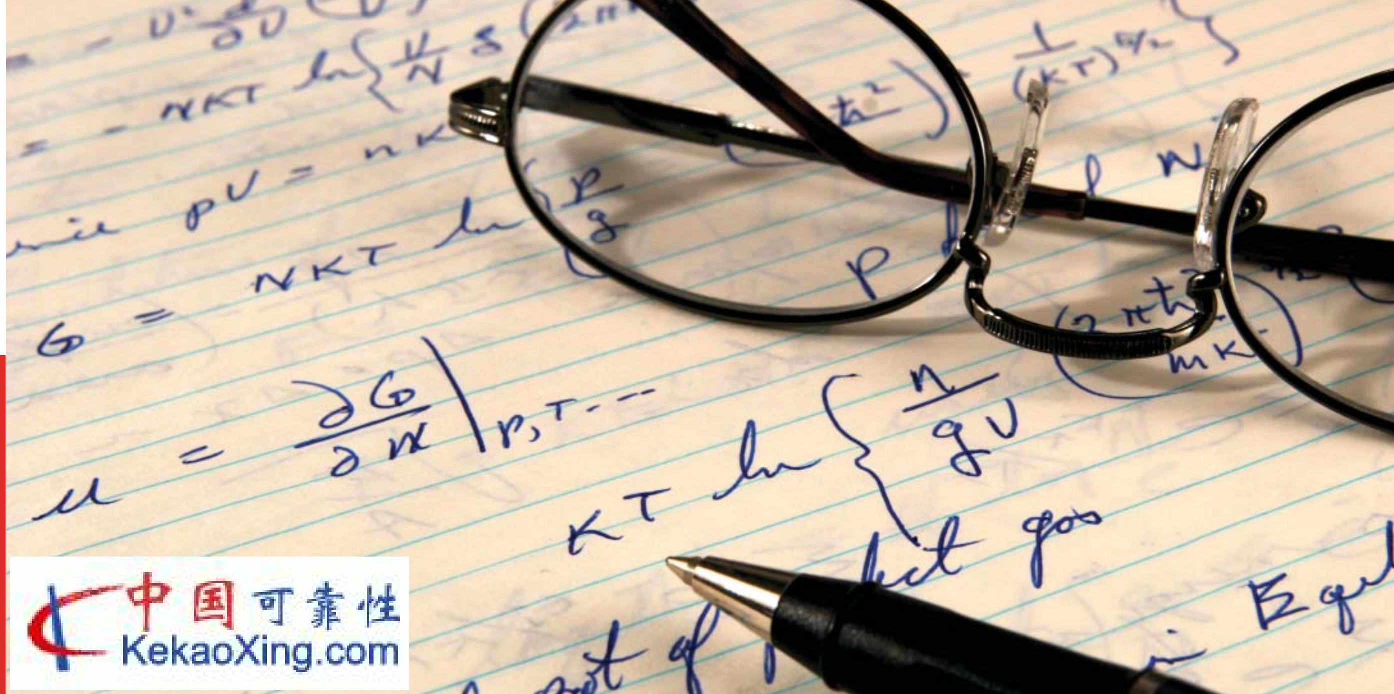
ASQ

AMERICAN SOCIETY FOR QUALITY™

CERTIFIED RELIABILITY ENGINEER



Certified Reliability Engineer

Quality excellence to enhance your career and boost your organization's bottom line

Certification from ASQ is considered a mark of quality excellence in many industries. It helps you advance your career, and boosts your organization's bottom line through your mastery of quality skills. Becoming certified as a Reliability Engineer confirms your commitment to quality and the positive impact it will have on your organization.

Information

Certified Reliability Engineer

The Certified Reliability Engineer is a professional who understands the principles of performance evaluation and prediction to improve product/systems safety, reliability, and maintainability. This Body of Knowledge (BOK) and applied technologies include, but are not limited to, design review and control; prediction, estimation, and apportionment methodology; failure mode effects and analysis; the planning, operation, and analysis of reliability testing and field failures, including mathematical modeling; understanding human factors in reliability; and the ability to develop and administer reliability information systems for failure analysis, design, and performance improvement and reliability program management over the entire product life cycle.

Proof of Professionalism

Proof of professionalism can be demonstrated in one of three ways:

- Membership in ASQ, an international affiliate society of ASQ, or another society that is a member of the American Association of Engineering Societies or the Accreditation Board for Engineering and Technology.
- Registration as a Professional Engineer.
- The signatures of two persons—ASQ members, members of an international affiliate society, or members of another recognized professional society—verifying that you are a qualified practitioner of the quality sciences.

Examination

Each certification candidate is required to pass a written examination that consists of multiple-choice questions that measure comprehension of the Body of Knowledge. The Reliability Engineer examination is a one-part, 150-question, four-hour exam and is offered in English.

Certified Reliability Engineer Expectations

Reliability Management—Have basic knowledge and skills to understand reliability program requirements, planning, definitions, training, and organizational resources to achieve those requirements within the constraints of life-cycle issues and costs.

Probability and Statistical Tools—Have an understanding of basic probability and statistical tools to analyze product life cycle. This includes the proper application of probability distributions, Pareto concepts, tolerance and confidence intervals, sample-size determination, and regression analysis.

Modeling and Prediction—Be able to develop models and predict, analyze, and interpret the reliability system using block diagrams, apportionment, and simulations to compare results with available field data.

Data Collection, Analysis, and Corrective Action—Collect appropriate data to define, identify, analyze, correct, and prevent potential system failures. Be able to implement FRACAS (failure reporting, analysis, and corrective-action system), root cause, and trend analysis.

Reliability Tools in Design and Development—Be able to establish product reliability requirements; be able to understand and use the reliability tools listed in the BOK. Be able to identify and control critical parts, services, and products.

Maintainability and Availability—Understand the principles of maintainability and availability over the life cycle of the product or system. Demonstrate a basic knowledge of testability, human factor, and maintenance activities.

Reliability Testing—Develop reliability test plans that cover the expected customer use environment and operational conditions. Identify appropriate acceleration stresses and methods, analyze and interpret the results of these development tests. Understand the cost-effective use of production screening methods.

Product Safety and Liability—Uphold ASQ code of ethics. Use reliability analysis tools and customer feedback to identify and analyze potential safety issues for a product. Recommend the appropriate action necessary to resolve safety issues. Have a knowledge of applicable regulatory requirements and the implementation of closed-loop corrective/preventive-action systems.

Education and/or Experience
You must have eight years of on-the-job experience in one or more of the areas of the Certified Reliability Engineer Body of Knowledge. A minimum of three years of this experience must be in a decision-making position. "Decision-making" is defined as the authority to define, execute, or control projects/processes and to be responsible for the outcome. This may or may not include management or supervisory positions.

If you are now or were previously certified by ASQ as a Quality Engineer, Quality Auditor, Software Quality Engineer, or Quality Manager, experience used to qualify for certification in these fields often applies to certification as a Reliability Engineer.

If you have completed a degree* from a college, university, or technical school with accreditation accepted by ASQ, part of the eight-year experience requirement will be waived, as follows (only one of these waivers may be claimed):

- Diploma from a technical or trade school—one year will be waived
- Associate degree—two years waived
- Bachelor's degree—four years waived
- Master's or doctorate—five years waived

*Degrees or diplomas from educational institutions outside the United States must be equivalent to degrees from U.S. educational institutions.

For comprehensive exam information on Reliability Engineer certification, visit **www.asq.org/certification**.

Body of Knowledge

Certified Reliability Engineer

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 complete description of cognitive levels is provided at the end of this document.

I Reliability Management (19 Questions)

A. Strategic Management

1. **Benefits of reliability engineering**
   Demonstrate how reliability engineering techniques and methods improve programs, processes, products, and services. (Synthesis)
2. **Interrelationship of quality and reliability**
   Define and describe quality and reliability and how they relate to each other. (Comprehension)
3. **Role of the reliability function in the organization**
   Demonstrate how reliability professionals can apply their techniques and interact effectively with marketing, safety and product liability, engineering, manufacturing, logistics, etc. (Analysis)
4. **Reliability in product and process development**
   Integrate reliability engineering techniques with other development activities (e.g., concurrent engineering). (Synthesis)
5. **Failure consequence and liability management**
   Use liability and consequence limitation objectives to determine reliability acceptance criteria, and identify development and test methods that verify and validate these criteria. (Application)
6. **Life-cycle cost planning**
   Determine the impact of failures in terms of service and cost (both tangible and intangible) throughout a product's life cycle. (Analysis)
7. **Customer needs assessment**
   Describe how various feedback mechanisms (e.g., QFD, prototyping, beta testing) help determine customer needs and specify product and service requirements. (Comprehension)
8. **Project management**
   Interpret basic project management tools and techniques, such as Gantt chart, PERT chart, critical path, resource planning, etc. (Comprehension)

B. Reliability Program Management

1. **Terminology**
   Identify and define basic reliability terms such as MTTF, MTBF, MTTR, availability, failure rate, dependability, maintainability, etc. (Analysis)
2. **Elements of a reliability program**
   Use customer requirements and other inputs to develop a reliability program including elements such as design for reliability, progress assessment, FRACAS, monitoring and tracking components, customer satisfaction and other feedback, etc. (Evaluation)
3. **Product life cycle and costs**
   Identify the various life-cycle stages and their relationship to reliability, and analyze various cost-related issues including product maintenance, life expectation, duty cycle, software defect phase containment, etc. (Analysis)
4. **Design evaluation**
   Plan and implement product and process design evaluations to assess reliability at various life-cycle stages using validation, verification, or other review techniques. (Evaluation)
5. **Requirements management**
   Describe how requirements management methods are used to help prioritize design and development activities. (Comprehension)
6. **Reliability training programs**
   Demonstrate the need for training, develop a training plan, and evaluate training effectiveness. (Application)

C. Product Safety and Liability

1. **Roles and responsibilities**
   Define and describe the roles and responsibilities of a reliability engineer in terms of safety and product liability. (Application)
2. **Ethical issues**
   Identify appropriate ethical behaviors for a reliability engineer in various situations. (Evaluation)
3. **System safety program**
   Identify safety-related issues by analyzing customer feedback, design data, field data, and other information sources. Use risk assessment tools such as hazard analysis, FMEA, FMECA, PRAT, FTA, etc., to identify and prioritize safety concerns, and identify steps to idiot-proofing products and processes to minimize risk exposure. (Analysis)

II Probability and Statistics for Reliability (25 Questions)

A. Basic Concepts

1. **Statistical terms**
   Define and use basic terms such as population, parameter, statistic, random sample, the central limit theorem, etc., and compute expected values. (Application)
2. **Basic probability concepts**
   Define and use basic probability concepts such as independence, mutually exclusive, complementary and conditional probability, joint occurrence of events, etc., and compute expected values. (Application)
3. **Discrete and continuous probability distributions**
   Describe, apply, and distinguish between various distributions (binomial, Poisson, exponential, Weibull, normal, log-normal, etc.) and their functions (cumulative distribution functions (CDFs), probability density functions (PDFs), hazard functions, etc.). Apply these distributions and functions to related concepts such as the bathtub curve. (Evaluation)
4. **Statistical process control (SPC)**
   Define various SPC terms and describe how SPC is related to reliability. (Comprehension)

B. Statistical Inference

1. **Point and interval estimates of parameters**
   Define and interpret these estimates. Obtain them using probability plots, maximum likelihood methods, etc. Analyze the efficiency and bias of the estimators. (Evaluation)
2. **Statistical interval estimates**
   Compute confidence intervals, tolerance intervals, etc., and draw conclusions from the results. (Analysis)

3. **Hypothesis testing (parametric and non-parametric)**
Apply hypothesis testing for parameters such as means, variance, and proportions. Apply and interpret significance levels and Type I and Type II errors for accepting/rejecting the null hypothesis. (Analysis)

4. **Bayesian technique**
Describe the advantages and limitations of this technique. Define elements including prior, likelihood, and posterior probability distributions, and compute values using the Bayes formula. (Application)

III Reliability in Design and Development (25 Questions)

A. Reliability Design Techniques

1. **Use factors**
Identify and characterize various use factors (e.g., temperature, humidity, vibration, corrosives, pollutants) and stresses (e.g., severity of service, electrostatic discharge (ESD), radio frequency interference (RFI), throughput) to which a product may be subjected. (Synthesis)

2. **Stress-strength analysis**
Apply this technique and interpret the results. (Evaluation)

3. **Failure mode and effects analysis (FMEA) in design**
Apply the techniques and concepts and evaluate the results of FMEA during the design phase. (Evaluation) *[NOTE: Identifying and using this tool for other aspects of reliability are covered in VII.C.1.]*

4. **Failure mode effects and criticality analysis (FMECA) in design**
Apply the techniques and concepts and evaluate the results of FMECA during the design phase. (Evaluation) *[NOTE: Identifying and using this tool for other aspects of reliability are covered in VII.C.2.]*

5. **Fault-tree analysis (FTA) in design**
Apply this technique at the design stage to eliminate or minimize undesired events. (Analysis) *[NOTE: Identifying and using the symbols and rules of FTA are covered in VII.C.3.]*

6. **Tolerance and worst-case analyses**
Use various analysis techniques (e.g., root-sum squared, extreme value, statistical tolerancing) to characterize variation that affects reliability. (Evaluation)

7. **Robust-design approaches**
Define terms such as independent and dependent variables, factors, levels, responses, treatment, error, replication, etc. Plan and conduct design of experiments (full-factorial, fractional factorial, etc.) or other methods. Analyze the results and use them to achieve robustness. (Evaluation)

8. **Human factors reliability**
Describe how human factors influence the use and performance of products and processes. (Comprehension)

9. **Design for X (DFX)**
Apply tools and techniques to enhance a product's producibility and serviceability, including design for assembly, service, manufacturability, testability, etc. (Evaluation)

B. Parts and Systems Management

1. **Parts selection**
Apply techniques such as parts standardization, parts reduction, parallel model, software reuse, etc., to improve reliability in products, systems, and processes. (Application)

2. **Material selection and control**
Apply probabilistic methods for proper selection of materials. (Application)

3. **Derating methods and principles**
Use methods such as S-N diagram, stress-life relationship, etc., to determine the relationship between applied stress and rated value. (Application)

4. **Establishing specifications**
Identify various terms related to reliability, maintainability, and serviceability (e.g., MTBF, MTTF, MTBR, MTBUMA, service interval) as they relate to product specifications. (Analysis)

IV Reliability Modeling and Predictions (23 Questions)

A. Reliability Modeling

1. **Sources of reliability data**
Identify and describe various types of data (e.g., public, common, in-house) and their advantages and limitations, and use data from various sources (prototype, development, test, field, etc.) to measure and enhance product reliability. (Analysis)

2. **Reliability block diagrams and models**
Describe, select, and use various types of block diagrams and models (e.g., series, parallel, partial redundancy, time-dependent modeling) and analyze them for reliability. (Evaluation)

3. **Simulation techniques**
Identify, select, and apply various simulation methods (e.g., Monte Carlo, Markov) and describe their advantages and limitations. (Analysis)

B. Reliability Predictions

1. **Part count predictions and part stress analysis**
Use parts failure rate data to estimate system- and subsystem-level reliability. (Analysis)

2. **Advantages and limitations of reliability predictions**
Demonstrate the advantages and limitations of reliability predictions, how they can be used to maintain or improve reliability, and how they relate to and can be used with field reliability data. (Application)

3. **Reliability prediction methods for repairable and nonrepairable devices**
Identify and use appropriate prediction methods for these types of devices and systems. (Application)

4. **Reliability apportionment/allocation**
Describe the purpose of reliability apportionment/allocation and its relationship to subsystem requirements, and identify when to use equal apportionment or other techniques. (Analysis)

V Reliability Testing (23 Questions)

A. Reliability Test Planning

1. **Elements of a reliability test plan**
Determine the appropriate elements and reliability test strategies for various development phases. (Analysis)

2. **Types and applications of reliability testing**
Identify and evaluate the appropriateness and limitations of various reliability test strategies within available resource constraints. (Evaluation)

3. **Test environment considerations**
Evaluate the application environment (including combinations of stresses) to determine the appropriate reliability test environment. (Evaluation)

B. Development Testing

Assess the purpose, advantages, and limitations of each of the following types of tests, and use common models to develop test plans, evaluate risks, and interpret test results. (Evaluation)

1. **Accelerated life tests** (e.g., single-stress, multiple-stress, sequential stress)
2. **Step-stress testing** (e.g., HALT)
3. **Reliability growth testing** (e.g., Duane, AMSAA, TAAF)
4. **Software testing** (e.g., white-box, fault-injection)

C. Product Testing

Assess the purpose, advantages, and limitations of each of the following types of tests, and use common models to develop test plans, evaluate risks, and interpret test results. (Evaluation)

1. **Qualification/demonstration testing** (e.g., sequential tests, fixed-length tests)
2. **Product reliability acceptance testing** (PRAT)
3. **Stress screening** (e.g., ESS, HASS, burn-in tests)
4. **Attribute testing** (e.g., binomial, hypergeometric)
5. **Degradation testing** (e.g., Arrhenius)
6. **Software testing** (e.g., black-box, operational profile)

VI Maintainability and Availability (17 Questions)

A. Management Strategies

1. **Maintainability and availability planning**
Develop maintainability and availability plans that support reliability goals and objectives. (Application)

2. **Maintenance strategies**
Identify the advantages and limitations of various maintenance strategies (e.g., reliability-centered maintenance (RCM), predictive maintenance, condition-based maintenance), and determine which strategy to use in specific situations. (Analysis)

3. **Maintainability apportionment/allocation**
Describe the purpose of maintainability apportionment/allocation and its relationship to system and subsystem requirements, and determine when to modify the maintainability strategy to achieve maintainability goals. (Synthesis)

4. **Availability tradeoffs**
Identify various types of availability (e.g., inherent availability, operational availability), and evaluate the reliability/maintainability tradeoffs associated with achieving availability goals. (Evaluation)

B. Analyses

1. **Maintenance time distributions**
Determine the applicable distributions (e.g., log-normal, Weibull) for maintenance times. (Analysis)

2. **Preventive maintenance (PM) analysis**
Identify the elements of PM analysis (e.g., types of PM tasks, optimum PM intervals, items for which PM is not applicable) and apply them in specific situations. (Analysis)

3. **Corrective maintenance analysis**
Identify the elements of corrective maintenance analysis (e.g., fault-isolation time, repair/replace time, skill level, crew hours) and apply them in specific situations. (Analysis)

4. **Testability**
Identify testability requirements and use various methods (e.g., built-in tests (BITs), no fault found, retest okay, false-alarm rates, software testability) to achieve reliability goals. (Analysis)

5. **Spare parts strategy**
Evaluate the relationship between spare parts requirements and maintainability and availability. (Evaluation)

VII Data Collection and Use (18 Questions)

A. Data Collection

1. **Types of data**
Identify, define, classify, and compare various data types (e.g., variables vs. attributes, censored vs. uncensored). (Evaluation)

2. **Data sources**
Evaluate the appropriateness of various data sources such as field, in-house, environment, location, test specification, failure modes, failure mechanisms, time at failure, etc. (Evaluation)

3. **Collection method**
Identify elements of data collection methods such as surveys, automated tests, automated monitoring and reporting, etc. (Application)

4. **Data management**
Identify the requirements for an organization-wide product-failure database, including which user groups (e.g., production, research, field service, supplier relations, purchasing, business management/accounting) will use the database and how the information interests and needs of those groups can conflict. Identify and distinguish between the level of detail each user group requires, and explain how reporting formats, coding schemes, and other structural components of the database system can influence the usefulness of the data over time and throughout the organization. (Evaluation)

B. Data Use

1. **Data summarization**
Analyze, evaluate, and summarize data using techniques such as trend analysis, Weibull, graphic representation, etc., based on data types, sources, and required output. (Evaluation)

2. **Preventive and corrective action**
Select and use various root cause and data (failure) analysis tools to determine degradation or failure causes, and identify various preventive or corrective actions to take in specific situations. (Evaluation)

3. **Measures of effectiveness**
Select and use various data analysis tools to evaluate the effectiveness of preventive and corrective actions. (Synthesis)

C. Data and Failure Analysis Tools

1. **Failure mode and effects analysis (FMEA)**
Identify the components and steps used to develop a FMEA, and use this tool to analyze problems found in various situations. (Evaluation)

2. **Failure mode, effects, and criticality analysis (FMECA)**
Distinguish this analysis tool from FMEA, and use it to evaluate the likelihood of certain effects and their criticality (including identifying and applying various levels of severity) in specific situations. (Evaluation)

3. **Fault tree analysis (FTA) and success tree analysis (STA)**
Identify and use the event and logic symbols and rules of these tools to determine the root cause of product failures or the steps necessary to ensure product success. (Evaluation)

4. **Failure reporting, analysis, and corrective action system (FRACAS)**
Identify the elements necessary for a FRACAS to be effective. (Application)

Math Note: Approximately 20% of the CRE exam will require candidates to perform mathematical functions.

Six Levels of Cognition

Based on Bloom's Taxonomy (1956)

In addition to the content specifics, the subtext detail also indicated the intended complexity level of the test questions for that topic. These levels are based on the "Levels of Cognition" (from *Bloom's Taxonomy,* 1956) and are presented below in rank order, from least complex to most complex.

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

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

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

Analysis Be 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 Be 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 are appropriate to examine further or from which supported conclusions can be drawn.

Evaluation Be 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. supported conclusions can be drawn.

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