Certified Reliability Engineer

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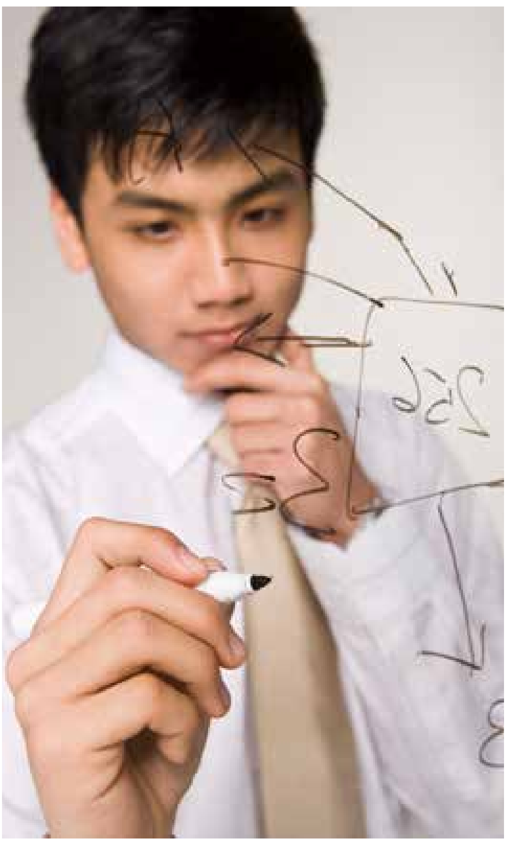
Certification from ASQ is considered a mark of quality excellence in many industries. It helps you advance your career, and boosts your organization's bottom line through your mastery of quality skills. Becoming certified as a Reliability Engineer confirms your commitment to quality and the positive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

Information

Certified Reliability Engineer (CRE)

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 and effects 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 lifecycle.



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.

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

Minimum Expectations for a Reliability Engineer

- Will understand strategic management aspects of reliability engineering, its relationship to safety and quality, its impact on warranty programs and customer satisfaction, the consequences of failure, and the potential for liability. Will understand requirements planning for reliability programs and how various engineering and operational systems must be integrated to achieve overall program goals and alignment with organizational goals. Will use risk analysis tools and techniques to evaluate product and system safety issues. Will abide by the ASQ Code of Ethics.
- Will use probability and statistical tools to analyze product lifecycle, conduct hypothesis testing, understand appropriate statistical models, tolerance and confidence intervals, sample size determination, and regression analysis.
- Will develop product and process reliability requirements using reliability and design techniques such as FMEA, fault tolerance, optimization, and DOE. Will develop systems for material selection, derating methods, and manufacturing control.
- Will develop models to analyze and predict reliability performance using block diagrams, physics of failure, apportionment, dynamic reliability, and simulations.
- Will develop reliability test plans that represent the expected use environment and operational conditions. Will select, analyze, and interpret the results of various test methods to be used during product development and end product testing.
- Will apply the principles of maintainability and availability over the lifecycle of the product, process, or system and will identify and support appropriate testability methods and maintenance activities.
- Will identify, collect, analyze, and manage various types of data to minimize failures and improve performance, and will use failure analysis, FRACAS, and other types of root cause analysis in support of reliability.

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.*

Body of Knowledge

Certified Reliability Engineer

Topics in this Body of Knowledge 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 Examination Development Committee and the candidates 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 intended 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 highest cognitive level at which the topic will be tested. A more comprehensive description of cognitive levels is provided at the end of this document.

I Reliability Management
(18 Questions)

A. Strategic Management

1. **Benefits of reliability engineering**
   Describe how reliability engineering techniques and methods improve programs, processes, products, systems, and services. (Understand)
2. **Interrelationship of safety, quality, and reliability**
   Define and describe the relationships among safety, reliability, and quality. (Understand)
3. **Role of the reliability function in the organization**
   Describe how reliability techniques can be applied in other functional areas of the organization, such as marketing, engineering, customer/product support, safety and product liability, etc. (Apply)
4. **Reliability in product and process development**
   Integrate reliability engineering techniques with other development activities, concurrent engineering, corporate improvement initiatives such as lean and Six Sigma methodologies, and emerging technologies. (Apply)
5. **Failure consequence and liability management**
   Describe the importance of these concepts in determining reliability acceptance criteria. (Understand)
6. **Warranty management**
   Define and describe warranty terms and conditions, including warranty period, conditions of use, failure criteria, etc., and identify the uses and limitations of warranty data. (Understand)

7. **Customer needs assessment**
   Use various feedback methods (e.g., quality function deployment (QFD), prototyping, beta testing) to determine customer needs in relation to reliability requirements for products and services. (Apply)
8. **Supplier reliability**
   Define and describe supplier reliability assessments that can be monitored in support of the overall reliability program. (Understand)

B. Reliability Program Management

1. **Terminology**
   Explain basic reliability terms (e.g., MTTF, MTBF, MTTR, availability, failure rate, reliability, maintainability). (Understand)
2. **Elements of a reliability program**
   Explain how planning, testing, tracking, and using customer needs and requirements are used to develop a reliability program, and identify various drivers of reliability requirements, including market expectations and standards, as well as safety, liability, and regulatory concerns. (Understand)
3. **Types of risk**
   Describe the relationship between reliability and various types of risk, including technical, scheduling, safety, financial, etc. (Understand)
4. **Product lifecycle engineering**
   Describe the impact various lifecycle stages (concept/design, introduction, growth, maturity, decline) have on reliability, and the cost issues (product maintenance, life expectation, software defect phase containment, etc.) associated with those stages. (Understand)
5. **Design evaluation**
   Use validation, verification, and other review techniques to assess the reliability of a product's design at various lifecycle stages. (Analyze)
6. **Systems engineering and integration**
   Describe how these processes are used to create requirements and prioritize design and development activities. (Understand)

C. Ethics, Safety, and Liability

1. **Ethical issues**
   Identify appropriate ethical behaviors for a reliability engineer in various situations. (Evaluate)
2. **Roles and responsibilities**
   Describe the roles and responsibilities of a reliability engineer in relation to product safety and liability. (Understand)
3. **System safety**
   Identify safety-related issues by analyzing customer feedback, design data, field data, and other information. Use risk management tools (e.g., hazard analysis, FMEA, FTA, risk matrix) to identify and prioritize safety concerns, and identify steps that will minimize the misuse of products and processes. (Analyze)

II Probability and Statistics for Reliability (27 Questions)

A. Basic Concepts

1. **Statistical terms**
   Define and use terms such as population, parameter, statistic, sample, the central limit theorem, etc., and compute their values. (Apply)
2. **Basic probability concepts**
   Use basic probability concepts (e.g., independence, mutually exclusive, conditional probability) and compute expected values. (Apply)
3. **Discrete and continuous probability distributions**
   Compare and contrast various distributions (binomial, Poisson, exponential, Weibull, normal, log-normal, etc.) and their functions (e.g., cumulative distribution functions (CDFs), probability density functions (PDFs), hazard functions), and relate them to the bathtub curve. (Analyze)
4. **Poisson process models**
   Define and describe homogeneous and non-homogeneous Poisson process models (HPP and NHPP). (Understand)

5. **Non-parametric statistical methods**
   Apply non-parametric statistical methods, including median, Kaplan-Meier, Mann-Whitney, etc., in various situations. (Apply)
6. **Sample size determination**
   Use various theories, tables, and formulas to determine appropriate sample sizes for statistical and reliability testing. (Apply)
7. **Statistical process control (SPC) and process capability**
   Define and describe SPC and process capability studies (Cp, Cpk, etc.), their control charts, and how they are all related to reliability. (Understand)

B. Statistical Inference

1. **Point estimates of parameters**
   Obtain point estimates of model parameters using probability plots, maximum likelihood methods, etc. Analyze the efficiency and bias of the estimators. (Evaluate)
2. **Statistical interval estimates**
   Compute confidence intervals, tolerance intervals, etc., and draw conclusions from the results. (Evaluate)
3. **Hypothesis testing (parametric and non-parametric)**
   Apply hypothesis testing for parameters such as means, variance, proportions, and distribution parameters. Interpret significance levels and Type I and Type II errors for accepting/rejecting the null hypothesis. (Evaluate)

III Reliability in Design and Development (26 Questions)

A. Reliability Design Techniques

1. **Environmental and use factors**
   Identify environmental and use factors (e.g., temperature, humidity, vibration) and stresses (e.g., severity of service, electrostatic discharge (ESD), throughput) to which a product may be subjected. (Apply)
2. **Stress-strength analysis**
   Apply stress-strength analysis method of computing probability of failure, and interpret the results. (Evaluate)
3. **FMEA and FMECA**
   Define and distinguish between failure mode and effects analysis and failure mode, effects, and criticality analysis and apply these techniques in products, processes, and designs. (Analyze)
4. **Common mode failure analysis**
   Describe this type of failure (also known as common cause mode failure) and how it affects design for reliability. (Understand)
5. **Fault tree analysis (FTA) and success tree analysis (STA)**
   Apply these techniques to develop models that can be used to evaluate undesirable (FTA) and desirable (STA) events. (Analyze)
6. **Tolerance and worst-case analyses**
   Describe how tolerance and worst-case analyses (e.g., root of sum of squares, extreme value) can be used to characterize variation that affects reliability. (Understand)
7. **Design of experiments**
   Plan and conduct standard design of experiments (DOE) (e.g., full-factorial, fractional factorial, Latin square design). Implement robust-design approaches (e.g., Taguchi design, parametric design, DOE incorporating noise factors) to improve or optimize design. (Analyze)
8. **Fault tolerance**
   Define and describe fault tolerance and the reliability methods used to maintain system functionality. (Understand)

9. **Reliability optimization**
   Use various approaches, including redundancy, derating, trade studies, etc., to optimize reliability within the constraints of cost, schedule, weight, design requirements, etc. (Apply)
10. **Human factors**
   Describe the relationship between human factors and reliability engineering. (Understand)
11. **Design for X (DFX)**
   Apply DFX techniques such as design for assembly, testability, maintainability environment (recycling and disposal), etc., to enhance a product's producibility and serviceability. (Apply)
12. **Reliability apportionment (allocation) techniques**
   Use these techniques to specify subsystem and component reliability requirements. (Analyze)

B. Parts and Systems Management

1. **Selection, standardization, and reuse**
   Apply techniques for materials selection, parts standardization and reduction, parallel modeling, software reuse, including commercial off-the-shelf (COTS) software, etc. (Apply)
2. **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, and to improve design. (Analyze)
3. **Parts obsolescence management**
   Explain the implications of parts obsolescence and requirements for parts or system requalification. Develop risk mitigation plans such as lifetime buy, backwards compatibility, etc. (Apply)
4. **Establishing specifications**
   Develop metrics for reliability, maintainability, and serviceability (e.g., MTBF, MTBR, MTBUMA, service interval) for product specifications. (Create)

IV Reliability Modeling and Predictions (22 Questions)

A. Reliability Modeling

1. **Sources and uses of reliability data**
   Describe sources of reliability data (prototype, development, test, field, warranty, published, etc.), their advantages and limitations, and how the data can be used to measure and enhance product reliability. (Apply)
2. **Reliability block diagrams and models**
   Generate and analyze various types of block diagrams and models, including series, parallel, partial redundancy, time-dependent, etc. (Create)
3. **Physics of failure models**
   Identify various failure mechanisms (e.g., fracture, corrosion, memory corruption) and select appropriate theoretical models (e.g., Arrhenius, S-N curve) to assess their impact. (Apply)
4. **Simulation techniques**
   Describe the advantages and limitations of the Monte Carlo and Markov models. (Apply)
5. **Dynamic reliability**
   Describe dynamic reliability as it relates to failure criteria that change over time or under different conditions. (Understand)

B. Reliability Predictions

1. **Part count predictions and part stress analysis**
   Use parts failure rate data to estimate system- and subsystem-level reliability. (Apply)
2. **Reliability prediction methods**
   Use various reliability prediction methods for both repairable and non-repairable components and systems, incorporating test and field reliability data when available (Apply)

V Reliability Testing (24 Questions)

A. Reliability Test Planning

1. **Reliability test strategies**
   Create and apply the appropriate test strategies (e.g., truncation, test–to-failure, degradation) for various product development phases. (Create)
2. **Test environment**
   Evaluate the environment in terms of system location and operational conditions to determine the most appropriate reliability test. (Evaluate)

B. Testing During Development
Describe 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. (Evaluate)

1. **Accelerated life tests** (e.g., single-stress, multiple-stress, sequential stress, step-stress)
2. **Discovery testing** (e.g., HALT, margin tests, sample size of 1)
3. **Reliability growth testing** (e.g., test, analyze, and fix (TAAF), Duane)
4. **Software testing** (e.g., white-box, black-box, operational profile, and fault-injection)

C. Product Testing
Describe the purpose, advantages, and limitations of each of the following types of tests, and use common models to develop product test plans, evaluate risks, and interpret test results. (Evaluate)

1. **Qualification/demonstration testing** (e.g., sequential tests, fixed-length tests)
2. **Product reliability acceptance testing** (PRAT)
3. **Ongoing reliability testing** (e.g., sequential probability ratio test [SPRT])
4. **Stress screening** (e.g., ESS, HASS, burn-in tests)
5. **Attribute testing** (e.g., binomial, hypergeometric)
6. **Degradation** (wear–to-failure) **testing**

VI Maintainability and Availability (15 Questions)

A. Management Strategies

1. **Planning**
   Develop plans for maintainability and availability that support reliability goals and objectives. (Create)
2. **Maintenance strategies**
   Identify the advantages and limitations of various maintenance strategies (e.g., reliability-centered maintenance (RCM), predictive maintenance, repair or replace decision making), and determine which strategy to use in specific situations. (Apply).
3. **Availability tradeoffs**
   Describe various types of availability (e.g., inherent, operational), and the tradeoffs in reliability and maintainability that might be required to achieve availability goals. (Apply)

B. Maintenance and Testing Analysis

1. **Preventive maintenance (PM) analysis**
   Define and use PM tasks, optimum PM intervals, and other elements of this analysis, and identify situations in which PM analysis is not appropriate. (Apply)
2. **Corrective maintenance analysis**
   Describe the elements of corrective maintenance analysis (e.g., fault-isolation time, repair/replace time, skill level, crew hours) and apply them in specific situations. (Apply)
3. **Non-destructive evaluation**
   Describe the types and uses of these tools (e.g., fatigue, delamination, vibration signature analysis) to look for potential defects. (Understand)
4. **Testability**
   Use various testability requirements and methods (e.g., built in tests (BITs), false-alarm rates, diagnostics, error codes, fault tolerance) to achieve reliability goals (Apply)

5. **Spare parts analysis**
   Describe the relationship between spare parts requirements and reliability, maintainability, and availability requirements. Forecast spare parts requirements using field data, production lead time data, inventory and other prediction tools, etc. (Analyze)

VII Data Collection and Use
(18 Questions)

A. Data Collection

1. **Types of data**
   Identify and distinguish between various types of data (e.g., attributes vs. variable, discrete vs. continuous, censored vs. complete, univariate vs. multivariate). Select appropriate data types to meet various analysis objectives. (Evaluate)
2. **Collection methods**
   Identify appropriate methods and evaluate the results from surveys, automated tests, automated monitoring and reporting tools, etc., that are used to meet various data analysis objectives. (Evaluate)
3. **Data management**
   Describe key characteristics of a database (e.g., accuracy, completeness, update frequency). Specify the requirements for reliability-driven measurement systems and database plans, including consideration of the data collectors and users, and their functional responsibilities. (Evaluate)

B. Data Use

1. **Data summary and reporting**
   Examine collected data for accuracy and usefulness. Analyze, interpret, and summarize data for presentation using techniques such as trend analysis, Weibull, graphic representation, etc., based on data types, sources, and required output. (Create)

2. **Preventive and corrective action**
   Select and use various root cause and failure analysis tools to determine the causes of degradation or failure, and identify appropriate preventive or corrective actions to take in specific situations. (Evaluate)
3. **Measures of effectiveness**
   Use various data analysis tools to evaluate the effectiveness of preventive and corrective actions in improving reliability. (Evaluate)

C. Failure Analysis and Correction

1. **Failure analysis methods**
   Describe methods such as mechanical, materials, and physical analysis, scanning electron microscopy (SEM), etc., that are used to identify failure mechanisms. (Understand)
2. **Failure reporting, analysis, and corrective action system (FRACAS)**
   Identify the elements necessary for a FRACAS to be effective, and demonstrate the importance of a closed-loop process that includes root cause investigation and follow up. (Apply)

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.

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