CRE

CERTIFIED RELIABILITY ENGINEER

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

asq.org/cert

ASQ

The Global Voice of Quality®

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.

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.

Certified Reliability Engineer

The Certified Reliability Engineer (CRE) understands the principles of performance evaluation and prediction to improve product/systems safety, reliability, and maintainability. This body of knowledge 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 life cycle.

CRE

Computer Delivered – The CRE examination is a one-part, 165-question, four-and-a-half-hour exam and is offered in English only. Of these questions, 150 are scored and 15 are unscored.

Paper and Pencil – The CRE examination is a one-part, 150-question, four-hour exam and is offered in English only.

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

Work 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, Supplier Quality Professional, or Manager of Quality/Organizational Excellence, 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 waived
- Associate's 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 (CRE)

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 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 Fundamentals (25 questions)

A. Leadership Foundations

1. **Benefits of reliability engineering**
   Describe the value that reliability has on achieving company goals and objectives, and how reliability engineering techniques and methods improve programs, processes, products, systems, and services. (Understand)

2. **Interrelationship of safety, quality, and reliability**
   Describe the relationship of and distinguish between reliability and quality, and describe the importance of safety in reliability engineering and how reliability impacts safety. (Understand))

3. **Reliability engineer leadership responsibilities**
   Describe how to be a reliability champion by influencing program decisions and facilitating cross-functional communication. (Understand)

4. **Reliability engineer role and responsibilities in the product life cycle**
   Describe how the reliability engineer influences the product life cycle, and describe a reliability engineer's role in the design review process in order to anticipate how reliability can impact risk and costs, and ensure performance over time. (Understand)

5. **Function of reliability in engineering**
   Describe how reliability techniques can be used to apply best practices in engineering (e.g., measuring reliability early), how industry standards can impact reliability, and how reliability can inform the decision analysis process. (Analyze)

6. **Ethics in reliability engineering**
   Identify appropriate ethical behaviors for a reliability engineer in various situations. (Evaluate)

7. **Supplier reliability assessments**
   Explain how supplier reliability impacts the overall reliability program and describe key reliability concepts that should be included in supplier reliability assessments. (Analyze)

8. **Performance monitoring**
   Describe the importance of performance monitoring to ensure that product reliability or safety requirements continue to be met, and identify life-cycle points in which process and product reliability data are collected and evaluated. (Understand)

B. Reliability Foundations

1. **Basic reliability terminology**
   Explain basic terms related to reliability and the associated metrics (e.g., MTTF, MTBF, MTTR, service interval, maintainability, availability, failure rate, reliability, and bathtub curve). (Apply)

2. **Drivers of reliability requirements and targets**
   Describe how customer expectations and industry standards, safety, liability, and regulatory concerns drive reliability requirements. (Understand)

3. **Corrective and preventive action (CAPA)**
   Identify corrective and preventive actions to take in specific situations and evaluate their measures of effectiveness. (Evaluate)

4. **Root cause analysis**
   Describe root cause analysis, and use a root cause and failure analysis tool to determine the causes of degradation or failure. (Evaluate)

5. **Product life-cycle engineering stages**
   Describe the impact various life-cycle stages (concept/design, development/test, 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)

6. **Economics of product maintainability and availability**
   Describe the cost tradeoffs associated with product maintainability strategies and availability. (Understand)

7. **Cost of poor reliability**
   Describe how poor reliability affects costs over the life cycle. (Understand)

8. **Quality triangle**
   Describe the relationship between cost, time, and quality with respect to reliability. (Understand)

9. **Six Sigma methodologies**
   Describe how Six Sigma principles support reliability engineering. (Understand)

10. **Systems engineering and integration**
    Describe the role of reliability engineering within systems engineering, including the integration of components and their interfaces/interactions within the system. (Understand)

II. Risk Management (25 questions)

A. Identification

1. **Risk management techniques**
   Use risk management tools and processes to identify, document, and track concerns. Identify and prioritize safety, economic, performance, and customer satisfaction concerns utilizing an appropriate risk management framework. (Analyze)

2. **Types of risk**
   Identify the various types of risks, including technical, scheduling, safety, and financial, and describe their relationship to reliability. (Analyze)

B. Analysis

1. **Fault tree analysis (FTA)**
   Use fault tree analysis (FTA) techniques to evaluate product or process failure. (Analyze)

2. **Failure mode and effects analysis (FMEA)**
   Define and distinguish between failure mode and effects analysis (FMEA) and failure mode, effects, and criticality analysis (FMECA) and apply these techniques to systems, products, processes, and designs. (Evaluate)

3. **Common mode failure analysis**
Describe common mode failure (also known as common cause failure) and how it affects risk. (Understand)

4. **Hazard analysis**
Describe how hazard analysis informs the development process, and how information obtained as a result of the hazard analysis is used by the reliability engineer. (Understand)

5. **Risk matrix**
Describe how risk matrices are used in the assessment of risk in regard to likelihood and severity. (Understand)

6. **System safety**
Identify safety-related issues by analyzing customer feedback, design data, field data, and other information. Prioritize safety concerns, and identify steps that will minimize the improper use of equipment, products or processes. (Evaluate)

C. Mitigation
Identify appropriate risk mitigation (treatment) plans to include controls that will minimize risk and subsequent impact in terms of safety, liability, and regulatory compliance. (Evaluate)

III. Probability and Statistics for Reliability (35 questions)

A. Basic Concepts

1. **Basic statistics**
Define various basic statistical terms (e.g., population, parameter, statistic, sample, central limit theorem, parametric and non-parametric), and compute and interpret their values. (Analyze)

2. **Basic probability concepts**
Use basic probability concepts (e.g., independence, mutually exclusive, conditional probability), and compute and interpret the expected values. (Analyze)

3. **Probability distributions**
Compare and contrast various distributions (e.g., binomial, Poisson, exponential, Weibull, normal, and log-normal), and recognize their associated probability plots. (Analyze)

4. **Probability functions**
Compare and contrast various probability functions (e.g., cumulative distribution functions (CDFs), probability density functions (PDFs), and hazard functions), and recognize their application in various situations. (Apply)

5. **Sampling plans for statistics and reliability testing**
Use various theories, tables, and formulas to determine appropriate sample sizes or testing time for statistical and reliability testing. (Apply)

6. **Statistical process control (SPC) and process capability studies (Cp, Cpk)**
Define and describe SPC and process capability studies (Cp, Cpk, etc.), control charts, and how each is related to reliability. (Understand)

7. **Confidence and tolerance intervals**
Compute confidence intervals and tolerance intervals, draw conclusions from the results, and describe how point estimates are used to determine the interval. (Evaluate)

B. Data Management

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. (Analyze)

2. **Types of data**
Identify and distinguish between various types of data (e.g., attributes vs. variable, discrete vs. continuous, censored vs. complete, and univariate vs. multivariate). Select appropriate analysis tools based on the data type. (Evaluate)

3. **Data collection methods**
   Identify and select appropriate data collection methods (e.g., surveys, automated tests, automated monitoring, and reporting tools) in order to meet various data analysis objectives and data quality needs. (Evaluate)

4. **Data summary and reporting**
   Examine collected data for accuracy and usefulness. Analyze, interpret, and summarize data for presentation using various techniques, based on data types, sources, and required output. (Create)

5. **Failure analysis methods**
   Describe failure analysis tools and methods (e.g., mechanical, materials, physical analysis, and scanning electron microscopy (SEM)) that are used to identify failure mechanisms. (Understand)

6. **Failure reporting, analysis, and corrective action system (FRACAS)**
   Identify elements necessary for FRACAS, and demonstrate the importance of a closed-loop process. (Evaluate)

IV. Reliability Planning, Testing, and Modeling (35 questions)

A. Planning

1. **Reliability test strategies**
   Develop and apply the appropriate test strategies (e.g., truncation, test-to-failure, degradation, growth plan, and test, analyze, and fix (TAAF)) for various product development phases. (Evaluate)

2. **Environmental and conditions of use factors**
   Identify environmental and use factors (e.g., temperature, humidity, and vibration) and stresses (e.g., severity of service, electrostatic discharge (ESD), throughput, and duty cycle) to which a product may be subjected. (Analyze)

3. **Failure consequence**
   Describe the importance of identifying the consequences of failure modes when establishing reliability acceptance criteria. (Understand)

4. **Failure criteria**
   Define and describe failure criteria based on system requirements and warranty terms and conditions. (Understand)

5. **Test environment**
   Appraise the environment in terms of system location and operational conditions, and designate the environment in the test plan to ensure an appropriate test strategy is implemented. (Evaluate)

B. Testing

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**
   (single-stress, multiple-stress, sequential stress, step-stress, HALT, margin tests)

2. **Stress screening**
   (ESS, HASS, burn-in tests)

3. **Qualification/ Demonstration testing**
   (sequential tests, fixed-length tests)

4. **Degradation (wear-to-failure) testing**

5. **Software testing**
   (white-box, black-box, operational profile, and fault-injection)

C. Modeling

1. **Reliability block diagrams and models**
   Generate and analyze various types of block diagrams and models, including series, parallel, partial redundancy, and time-dependent. (Evaluate)

2. **Physics of failure and failure mechanisms**
   Identify various potential failure mechanisms (e.g., fracture, corrosion, memory corruption) and describe the physical process of these failures. (Apply)

3. **Failure models**
   Select appropriate theoretical models (e.g., Arrhenius, S-N curve) to assess or predict failure rates. (Analyze)

4. **Reliability prediction methods**
   Use various reliability prediction methods (e.g., Monte Carlo simulation, part stress analysis, and parts count prediction) for both repairable and nonrepairable components and systems, and describe the inputs into the model. (Apply)

5. **Design prototyping**
   Describe the advantages and limitations of prototyping to enhance product reliability. (Understand)

V. Life-Cycle Reliability (30 questions)

A. Reliability Design Techniques

1. **Design evaluation techniques (validation and verification)**
   Explain how validation, verification, and other review techniques are used to assess the reliability of a product's design at various life-cycle stages. (Apply)

2. **Stress-strength analysis**
   Apply the stress-strength analysis method of calculating probability of failure, and interpret the results. (Analyze)

3. **Design of experiments (DOE)**
   Develop and interpret the results of a standard design of experiments (DOE) (e.g., full-factorial and fractional factorial). (Analyze)

4. **Reliability optimization**
   Use various approaches to optimize reliability within the constraints of cost, schedule, weight, and other design requirements. (Apply)

5. **Human factors**
   Describe the relationship between human factors and reliability engineering, including user safety, user and usage profiles, failure modes, and mechanisms. (Understand)

6. **Design for X (DFX)**
   Apply DFX techniques such as design for manufacturability, testability, and maintainability. (Apply)

7. **Design for Reliability (DFR)**
   Apply DFR in order to meet reliability requirements throughout the product or system life cycle. Understand how built-in reliability and fault tolerance/avoidance are key goals for design for reliability. (Evaluate)

B. Parts and Systems Development

1. **Materials and components selection techniques**
   Apply techniques (e.g., derating and commercial off-the-shelf (COTS)) for selecting materials and components to meet reliability goals and requirements. (Analyze)

2. **Parts standardization and system simplification**
   Describe the importance of standardization, simplification, and parts reuse to meet reliability goals and requirements. (Apply)

C. Maintainability

1. **Maintenance strategies**
   Develop a maintenance plan incorporating various strategies (e.g., predictive maintenance, repair or replace decision making, spare parts analysis/forecasting, and equipment warranties). (Apply)

2. **Preventive maintenance (PM) analysis**
   Define and use PM tasks, optimum PM intervals, and other elements of this analysis. Identify situations when PM is not effective. (Apply)

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

Visit **asq.org/cert** for comprehensive exam information.

Enhance your career with ASQ certification today!

Visit **asq.org/cert** for additional certification information including:

- Applications
- Available certifications and international language options
- Reference materials
- Study guides and test-taking tips
- Comprehensive exam information
- ASQ sections
- International contacts
- Endorsements

Item B0060

ASQ

600 N. Plankinton Ave.
Milwaukee, WI 53203-2914