

**AMERICAN SOCIETY FOR QUALITY
CERTIFIED RELIABILITY ENGINEER (CRE)
BODY OF KNOWLEDGE**

The 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 Exam Development Committee and the candidate preparing to take the exam. The subtext is not intended to limit the subject matter or be all-inclusive of what might be covered in an exam. It is meant to clarify the type of content to be included in the exam. The descriptor in parentheses at the end of each entry refers to the maximum cognitive level at which the topic will be tested. A more complete description of cognitive levels is provided at the end of this document.

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 data) 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 non-repairable 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 methods

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)

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 *content* specifics, the subtext detail also indicates the intended *complexity level* of the test questions for that topic. These levels are based on "Levels of Cognition" (from Bloom's Taxonomy, 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.) Remember or recognize terminology, definitions, facts, ideas, materials, patterns, sequences, methodologies, principles, etc.

Comprehension Level

Read and understand descriptions, communications, reports, tables, diagrams, directions, regulations, etc.

Application Level

Apply ideas, procedures, methods, formulas, principles, theories, etc., in job-related situations.

Analysis

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

Put parts or elements together in such a way as to show a pattern or structure not clearly there before; identify which data or information from a complex set is appropriate to examine further or from which supported conclusions can be drawn.

Evaluation

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