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 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 (Understand)**
   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.

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

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

4. **Reliability engineer role and responsibilities in the product lifecycle (Understand)**
   Describe how the reliability engineer influences the product lifecycle, 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.

5. **Function of reliability in engineering (Analyze)**
   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.

CRE BOK (Continued)

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

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

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

B. Reliability Foundations

1. **Basic reliability terminology** **(Apply)**
   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.).

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

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

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

5. **Product lifecycle engineering stages** **(Understand)**
   Describe the impact various lifecycle 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.

CRE BOK (Continued)

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

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

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

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

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

II. Risk Management (25 questions)

A. Identification

1. **Risk management techniques (Analyze)**
   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.

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

B. Analysis

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

CRE BOK (Continued)

2. **Failure mode and effects analysis (FMEA)** **(Evaluate)**
   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.

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

4. **Hazard analysis** **(Understand)**
   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.

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

6. **System safety** **(Evaluate)**
   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.

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

III. Probability and Statistics for Reliability (35 questions)

A. Basic Concepts

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

CRE BOK (Continued)

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

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

4. **Probability functions (Apply)**
   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.

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

6. **Statistical process control (SPC) and process capability studies (C_p, C_{pk}) (Understand)**
   Define and describe SPC and process capability studies (C_p, C_{pk}, etc.), control charts, and how each is related to reliability.

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

B. Data Management

1. **Sources and uses of reliability data (Analyze)**
   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.

2. **Types of data (Evaluate)**
   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.

CRE BOK (Continued)

3. **Data collection methods (Evaluate)**
   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.

4. **Data summary and reporting (Create)**
   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.

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

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

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

A. Planning

1. **Reliability test strategies (Evaluate)**
   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.

2. **Environmental and conditions of use factors (Analyze)**
   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.

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

CRE BOK (Continued)

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

5. **Test environment** **(Evaluate)**
   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.

B. Testing **(Evaluate)**
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.

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

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

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

CRE BOK (Continued)

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

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

V. Lifecycle Reliability (30 questions)

A. Reliability Design Techniques

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

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

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

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

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

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

CRE BOK (Continued)

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

B. Parts and Systems Development

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

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

C. Maintainability

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

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

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

