AMERICAN SOCIETY FOR QUALITY
SIX SIGMA BLACK BELT
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 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. Enterprise-Wide Deployment (9 Questions)

A. Enterprise view

1. Value of six sigma

Understand the organizational value of six sigma, its philosophy, goals, and definition. (Comprehension)

2. Business systems and processes

Understand and distinguish interrelationships between business systems and processes. (Comprehension)

3. Process inputs, outputs, and feedback

Describe how process inputs, outputs, and feedback of the system impact the enterprise system as a whole. (Comprehension)

B. Leadership

1. Enterprise leadership

Understand leadership roles in the deployment of six sigma (e.g., resources, organizational structure). (Comprehension)

2. Six sigma roles and responsibilities

Understand the roles and responsibilities of black belt, master black belt, green belt, champion, executive, process owners. (Comprehension)

C. Organizational goals and objectives

Understanding key drivers for business; understand key metrics and scorecards

1. Linking projects to organizational goals

Describe the project selection process including knowing when to use six sigma improvement methodology (DMAIC) as opposed to other problem-solving tools, and confirm link back to organizational goals. (Comprehension)

2. Risk analysis

Describe the purpose and benefit of strategic risk analysis (e.g., strengths, weaknesses, opportunities, threats (SWOT), scenario planning), including the risk of optimizing elements in a project or process resulting in suboptimizing the whole. (Comprehension)

3. Closed-loop assessment / knowledge management

Document the objectives achieved and manage the lessons learned to identify additional opportunities. (Comprehension)

D. History of organizational improvement/foundations of six sigma

Understand the origin of continuous improvement tools used in six sigma (e.g., Deming, Juran, Shewhart, Ishikawa, Taguchi). (Comprehension)

II. Business Process Management (9 Questions)

A. Process vs. functional view

1. Process elements

Understand process components and boundaries. (analysis)

2. Owners and stakeholders

Identify process owners, internal and external customers, and other stakeholders. (analysis)

3. Project management and benefits

Understand the difference between managing projects and maximizing their benefits to the business. (analysis)

4. Project measures

Establish key performance metrics and appropriate project documentation. (analysis)

B. Voice of the customer

1. Identify customer

Segment customers as applicable to a particular project; list specific customers impacted by project within each segment; show how a project impacts internal and external customers; recognize the financial impact of customer loyalty. (analysis)

2. Collect customer data

Use various methods to collect customer feedback (surveys, focus groups, interviews, observation, etc.) and understand the strengths and weaknesses of each approach; recognize the key elements that make surveys, interviews, and other feedback tools effective; review questions for integrity (bias, vagueness, etc.). (Application)

3. Analyze customer data

Use graphical, statistical, and qualitative tools to understand customer feedback. (analysis)

4. Determine critical customer requirements

Translate customer feedback into strategic project focus areas using quality function deployment (QFD) or similar tools, and establish key project metrics that relate to the voice of the customer and yield process insights. (analysis) (NOTE: The analysis of QFD matrices is covered in section X. A.)

C. Business results

1. Process performance metrics

Calculate defects per unit (DPU), rolled throughput yield (RTY), and defects per million opportunities (DPMO) sigma levels; understand how metrics propagate upward and allocate downward; compare and contrast capability, complexity, and control; manage the use of sigma performance measures (e.g., cost of poor quality (COPQ), parts per million (PPM), DPMO, DPU, RTY) to drive enterprise decisions. (analysis)

2. Benchmarking

Understand the importance of benchmarking. (Knowledge)

3. **Financial benefits**

Understand and present financial measures and other benefits (soft and hard) of a project; understand and use basic financial models (e.g., net present value (NPV), return on investment (ROI)); describe, apply, evaluate, and interpret cost of quality concepts, including quality cost categories, data collection, reporting, etc. (Application)

III. Project Management (15 Questions)

A. Project charter and plan

1. **Charter and plan elements**

Compare, select, and explain elements of a project's charter and plan. (analysis)

2. **Planning tools**

Plan the project using tools such as Gantt chart, program evaluation and review technique (PERT) chart, planning trees, etc. (Application)

3. **Project documentation**

Create data-driven and fact-driven project documentation using spreadsheets, storyboards, phased reviews, management reviews, presentations to the executive team, etc. (Synthesis)

4. **Charter negotiation**

Create and negotiate the charter, including objectives, scope, boundaries, resources, project transition, and project closure. (analysis)

B. Team leadership

1. **Initiating teams**

Know the elements of launching a team and why they are important: clear purpose, goals, commitment, ground rules, roles and responsibilities of team members, schedules, support from management, and team empowerment. (Application)

2. **Selecting team members**

Select team members who have appropriate skills sets (e.g., self-facilitation, technical/subject-matter expertise), and create teams with appropriate numbers of members and representation. (Application)

3. **Team stages**

Facilitate the stages of team evolution, including forming, storming, norming, performing, adjourning, and recognition. (Application)

C. Team dynamics and performance

1. **Team-building techniques**

Recognize and apply the basic steps in team building: goals, roles and responsibilities, introductions, and both stated and hidden agendas. (Synthesis)

2. **Team facilitation techniques**

Apply coaching, mentoring, and facilitation techniques to guide a team and overcome problems such as overbearing, dominant, or reluctant participants, the unquestioned acceptance of opinions as facts, groupthink, feuding, floundering, the rush to accomplishment, attribution, discounts and plops, digressions and tangents, etc. (Application)

3. **Team performance evaluation**

Measure team progress in relation to goals, objectives, and metrics that support team success. (analysis)

4. **Team tools**

Define, select, and apply team tools such as nominal group technique, force field analysis, multivoting, conversion/diversion. (Application)

D. Change agent

1. **Managing change**

Understand and apply techniques for facilitating or managing organizational change through change agent methodologies. (Application)

2. **Organizational roadblocks**

Understand the inherent structures of an organization (e.g., its cultures and constructs) that present basic barriers to improvement; select and apply techniques to overcome them. (Application)

3. **Negotiation and conflict resolution techniques**

Define, select, and apply tools such as consensus techniques, brainstorming, effort/impact, interest-based bargaining to help conflicting parties (e.g., departments, groups, leaders, staff) recognize common goals and how to work together to achieve them. (Application)

4. **Motivation techniques**

Define, select, and apply techniques that support and sustain team member participation and commitment. (Application)

5. **Communication**

Use effective and appropriate communication techniques for different situations to overcome organizational barriers to success. (Application)

E. Management and planning Tools

Define, select, and use 1) affinity diagrams, 2) interrelationship digraphs, 3) tree diagrams, 4) prioritization matrices, 5) matrix diagrams, 6) process decision program (PDPC) charts, and 7) activity network diagrams. (Application)

IV. Six Sigma Improvement Methodology and Tools – *Define* (9 Questions)

A. Project scope

Determine project definition/scope using Pareto charts, top-level (macro) process maps, etc. (Synthesis)

B. Metrics

Establish primary and consequential metrics (e.g., quality, cycle time, cost). (Analysis)

C. Problem statement

Develop a problem statement, including baseline and improvement goals. (Synthesis)

V. Six Sigma Improvement Methodology and Tools – *Measure* (30 Questions)

A. Process analysis and documentation

1. **Tools**

Develop and review process maps, written procedures, work instructions, flowcharts, etc. (analysis)

2. **Process inputs and outputs**

Identify process input variables and process output variables, and document their relationships through cause and effect diagrams, relational matrices, etc. (Evaluation)

B. Probability and statistics

1. **Drawing valid statistical conclusions**

Distinguish between enumerative (descriptive) and analytical (inferential) studies, and distinguish between a population parameter and a sample statistic. (Evaluation)

2. **Central limit theorem and sampling distribution of the mean**

Define the central limit theorem and understand its significance in the application of inferential statistics for confidence intervals, control charts, etc. (Application)

3. **Basic probability concepts**

Describe and apply concepts such as independence, mutually exclusive, multiplication rules, complementary probability, joint occurrence of events, etc. (Application)

C. Collecting and summarizing data

1. **Types of data**

Identify, define, classify and compare continuous (variables) and discrete (attributes) data, and recognize opportunities to convert attributes data to variables measures. (Evaluation)

2. **Measurement scales**

Define and apply nominal, ordinal, interval, and ratio measurement scales. (Application)

3. **Methods for collecting data**

Define and apply methods for collecting data such as check sheets, coding data, automatic gaging, etc. (Evaluation)

4. **Techniques for assuring data accuracy and integrity**

Define and apply techniques for assuring data accuracy and integrity such as random sampling, stratified sampling, sample homogeneity, etc. (Evaluation)

5. **Descriptive statistics**

Define, compute, and interpret measures of dispersion and central tendency, and construct and interpret frequency distributions and cumulative frequency distributions. (Evaluation) (NOTE: Measures of the geometric and harmonic mean will not be tested.)

6. **Graphical methods**

Depict relationships by constructing, applying and interpreting diagrams and charts such as stem-and-leaf plots, box-and-whisker plots, run charts, scatter diagrams, etc. Depict distributions by constructing, applying and interpreting diagrams such as histograms, normal probability plots, Weibull plots, etc. (Evaluation)

D. Properties and applications of probability distributions

1. **Distributions commonly used by black belts**

Describe and apply the following distributions commonly used by black belts
1) binomial, 2) Poisson, 3) normal, 4) chi-square, 5) Student's t, and 6) F distributions (Evaluation)

2. **Other distributions**

Recognize when and how to use the following, less frequently used distributions: (Application)
7) hypergeometric, 8) bivariate, 9) exponential, 10) lognormal, and 11) Weibull

E. Measurement systems

1. **Measurement methods**

Describe and review measurement methods such as attribute screens, gauge blocks, calipers, micrometers, optical comparators, tensile strength, titration, etc. (Comprehension)

2. **Measurement system analysis**

Calculate, analyze, and interpret measurement system capability using repeatability and reproducibility, measurement correlation, bias, linearity, percent agreement, precision/tolerance (P/T), precision/total variation (P/TV), and use both ANOVA and control chart methods for non-destructive, destructive, and attribute systems. (Evaluation)

3. **Metrology**

Understand traceability to calibration standards, measurement error, calibration systems, control and integrity of standards and measurement devices (Comprehension)

F. Analyzing process capability

1. **Designing and conducting process capability studies**

Identify, describe, and apply the elements of designing and conducting process capability studies, including identifying characteristics, identifying specifications and tolerances, developing sampling plans, and verifying stability and normality (Evaluation)

2. **Calculating process performance vs. specification**

Distinguish between natural process limits and specification limits, and calculate process performance metrics such as percent defective. (Evaluation)

3. **Process capability indices**

Define, select, and calculate C_p and C_{pk}, and assess process capability (Evaluation)

4. **Process performance indices**

Define, select, and calculate P_p, P_{pk}, C_{pm}, and assess process performance (Evaluation)

5. **Short-term vs. long-term capability**

Understand the assumptions and conventions appropriate when only short-term data are collected and when only attributes data are available; understand the changes in relationships that occur when long-term data are used; interpret relationships between long-term and short-term capability as it relates to technology and/or control problems. (Evaluation)

6. **Non-normal data transformations (process capability for non-normal data)**

Understand the cause of non-normal data and determine when it is appropriate to transform. (Application)

7. **Process capability for attributes data**

Compute sigma level and understand its relationship to P_{pk}. (Application)

VI. Six Sigma Improvement Methodology and Tools – *Analyze* (23 Questions)

A. Exploratory data analysis

1. **Multi-vari studies**

Use multi-vari studies to interpret the difference between positional, cyclical, and temporal variation; design sampling plans to investigate the largest sources of variation; create and interpret multi-vari charts. (Application)

2. **Measuring and modeling relationships between variables**

a. **Simple and multiple least-squares linear regression**
Calculate the regression equation; apply and interpret hypothesis tests for regression statistics; use the regression model for estimation and prediction, and analyze the uncertainty in the estimate. (NOTE: Models that have non-linear parameters will not be tested.) (Evaluation)

b. **Simple linear correlation**
Calculate and interpret the correlation coefficient and its confidence interval; apply and interpret a hypothesis test for the correlation coefficient; understand the difference between correlation and causation. (NOTE: Serial correlation will not be tested.) (Evaluation)

c. **Diagnostics**
Analyze residuals of the model. (analysis)

B. Hypothesis testing

1. **Fundamental concepts of hypothesis testing**

a. **Statistical vs. practical significance**
Define, compare, and contrast statistical and practical significance. (Evaluation)

b. **Significance level, power, type I and type II errors**
Apply and interpret the significance level, power, type I, and type II errors of statistical tests. (Evaluation)

c. **Sample Size**
Understand how to calculate sample size for any given hypothesis test. (Application)

2. **Point and interval estimation**

Define and interpret the efficiency and bias of estimators; compute, interpret and draw conclusions from statistics such as standard error, tolerance intervals, and confidence intervals; understand the distinction between confidence intervals and prediction intervals.(analysis)

3. **Tests for means, variances, and proportions**

Apply hypothesis tests for means, variances, and proportions, and interpret the results. (Evaluation)

4. **Paired-comparison tests**

Define, determine applicability, apply, and interpret paired-comparison parametric hypothesis tests. (Evaluation)

5. **Goodness-of-fit tests**

Define, determine applicability, apply, and interpret chi-square tests. (Evaluation)

6. **Analysis of variance (ANOVA)**

Define, determine applicability, apply, and interpret ANOVAs. (Evaluation)

7. **Contingency tables**

Define, determine applicability, and construct a contingency table and use it to determine statistical significance. (Evaluation)

8. **Non-parametric tests**

Define, determine applicability, and construct various non-parametric tests including Mood's Median, Levene's test, Kruskal-Wallis, Mann-Whitney, etc. (analysis)

VII. Six Sigma Improvement Methodology and Tools – *Improve* (22 Questions)

A. Design of experiments (DOE)

1. **Terminology**

Define independent and dependent variables, factors and levels, response, treatment, error, and replication (Comprehension)

2. **Planning and organizing experiments**

Describe and apply the basic elements of experiment planning and organizing, including determining the experiment objective, selecting factors, responses, and measurement methods, choosing the appropriate design, etc. (Evaluation)

3. **Design principles**

Define and apply the principles of power and sample size, balance, replication, order, efficiency, randomization and blocking, interaction, and confounding. (Application)

4. **Design and analysis of one-factor experiments**

Construct experiments such as completely randomized, randomized block, and Latin square designs, and apply computational and graphical methods to analyze and evaluate the significance of results. (Evaluation)

5. **Design and analysis of full-factorial experiments**

Construct these experiments and apply computational and graphical methods to analyze and evaluate the significance of results. (Evaluation)

6. **Design and analysis of two-level fractional factorial experiments**

Construct these experiments (including Taguchi designs) and apply computational and graphical methods to analyze and evaluate the significance of results; understand the limitations of fractional factorials caused by confounding. (Evaluation)

7. **Taguchi robustness concepts**

Apply Taguchi robustness concepts and techniques such as signal-to-noise ratio, controllable and noise factors, and robustness to external sources of variability. (analysis)

8. **Mixture experiments**

Construct these experiments and apply computational and graphical methods to analyze and evaluate the significance of results. (analysis)

B. Response surface methodology

1. **Steepest ascent/descent experiments**

Construct these experiments and apply computational and graphical methods to analyze the significance of results. (analysis)

2. **Higher-order experiments**

Construct experiments such as central composite design (CCD), Box-Behnken, etc., and apply computational and graphical methods to analyze the significance of results. (analysis)

C. Evolutionary operations (EVOP)

Understand the application and strategy of EVOP. (Comprehension)

VIII. Six Sigma Improvement Methodology and Tools – *Control* (15 Questions)

A. Statistical process control (SPC)

1. **Objectives and benefits**

Understand objectives and benefits of SPC (e.g., controlling process performance, distinguishing special from common causes). (Comprehension)

2. **Selection of variable**

Select critical characteristics for monitoring by control chart. (Application)

3. **Rational subgrouping**

Define and apply the principle of rational subgrouping. (Application)

4. **Selection and application of control charts**

Identify, select, construct, and apply the following types of control charts: x-bar and R, x-bar and s, individual and moving range (ImR / XmR), median, p, np, c, and u. (Application)

5. **Analysis of control charts**

Interpret control charts and distinguish between common and special causes using rules for determining statistical control. (analysis)

6. **PRE-control**

Define and explain PRE-control and perform PRE-control calculations and analysis. (analysis)

B. Advanced statistical process control

Understand appropriate uses of short-run SPC, exponentially weighted moving average (EWMA), cusum charts, and moving average. (Comprehension)

C. Lean tools for control

Apply appropriate lean tools (e.g., 5S (sorting, storage, shining, standardizing, sustaining), visual factory, kaizen, kanban, poka-yoke, total productive maintenance, standard work) as they relate to the control phase of DMAIC. (Application) (NOTE: The use of lean tools in other areas of DMAIC is covered in section IX. B.)

D. Measurement system re-analysis

Understand the need to improve measurement system capability as process capability improves; evaluate the use of control measurement systems (e.g., attributes, variables, destructive), and ensure that measurement capability is sufficient for its intended use. (Evaluation)

IX. Lean Enterprise (9 Questions)

A. Lean concepts

1. **Theory of constraints**

Describe the theory of constraints. (Comprehension)

2. **Lean thinking**

Describe concepts such as value, value chain, flow, pull, perfection, etc. (Comprehension)

3. **Continuous flow manufacturing (CFM)**

Describe the CFM concept. (Comprehension)

4. **Non-value-added activities**

Identify these activities in terms inventory, space, test inspection, rework, transportation, storage, etc. (Application)

5. **Cycle-time reduction**

Describe how cycle-time reduction can be used to identify defects and non-value-added activities using kaizen-type methods to reduce waste of space, inventory, labor, and distance. (Comprehension)

B. Lean tools

Define, select, and apply tools such as visual factory, kanban, poka-yoke, standard work, SMED, etc., in areas outside of DMAIC-Control. (Application) (NOTE: The use of lean tools in DMAIC-Control is covered in section VIII. C.)

C. Total productive maintenance (TPM)

Understand the concept of TPM. (Comprehension)

X. Design for Six Sigma (DFSS) (9 Questions)

A. Quality function deployment (QFD)

Analyze a completed QFD matrix. (analysis)

B. Robust design and process

1. **Functional requirements**

Understand functional requirements of a design. (Comprehension)

2. **Noise strategies**

Develop a robust design using noise strategies. (Application)

3. **Tolerance design**

Understand the concepts of tolerance design and statistical tolerancing. (analysis)

4. **Tolerance and process capability**

Calculate tolerances using process capability data. (analysis)

C. Failure mode and effects analysis (FMEA)

Understand the terminology, purpose, and use of scale criteria (including risk priority number (RPN)) for FMEA, and apply to processes, products, or services; understand the distinction between and interpret data associated with design FMEA (DFMEA) and process FMEA (PFMEA). (analysis)

D. Design for X (DFX)

Understand design constraints such as design for cost, design for manufacturability and producibility, design for test, design for maintainability, etc. (Comprehension)

E. Special design tools

Understand the concept of special design tools such as the theory of inventive problem-solving (TRIZ), axiomatic design (conceptual structure robustness), etc. (Knowledge)

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.) 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 is 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.