For more Author information, go to gxpandjvt.com/bios

ABOUT THE AUTHOR
Eugenie Khlebnikova, CQE, is a senior validation specialist at McNeil Consumer Healthcare, a division of Johnson and Johnson. She may be reached at ekhlebni@its.jnj.com.
CQE certification program is a way to maintain and stimulate the profession of quality engineering.

The American Society for Quality (ASQ) was initiated after World War II as a way to continue to use quality techniques developed during the war. Many improvements in product, statistical application, inspection and management were developed and supported by the ASQ. The certification program was initiated by ASQ as a formal recognition that an individual has demonstrated a proficiency within, and comprehension of, a specific body of knowledge.

CQE, the first certification program developed, signifies that an individual can develop, operate, and control a quality control system and use statistical methods to analyze processes. In order to apply to take the CQE exam, the applicant is required to have eight years of on-the-job experience in quality and must be in a decision-making position.

A detailed listing of BOK sections can be found in the Appendix.

APPLICATION TO VALIDATION

Section One, Management and Leadership
The ASQ CQE Body of Knowledge (BoK) provides a broad picture of what quality engineers need to know (1). It starts with a management and leadership section that provides an overview of what quality is and discusses how quality programs evolved from quality control to statistical process control.

Quality means different things to different people. Quality can be defined as a collection of tools and concepts that are proven to work, and it also can be defined by customers through their satisfaction. Joseph Juran, a father of modern quality, defined quality as a fitness for use. His definition of quality was also adopted by GMPs. The GMP regulations require that drug products be produced with a high degree of assurance of meeting all the attributes they are intended to possess (21 CFR 211.100(a) and 211.1109(a)) (2). Pharmaceutical and medical device companies have a quality policy or quality manual in which plans for assuring the quality of products are documented. A quality policy or quality manual in which plans for assuring the quality of product are documented. A quality function deployment (QFD) is described as a planning technique consisting of six key terms such as quality function deployment, the voice of the customer, product quality, quality function, and quality table. The details of each term can be found in any quality management textbook. The validation professionals use some of these elements to define system user requirements in order to develop functional and design specifications prior to qualifying equipment. By applying QFD, we translate customer’s expectations to technical specifications that can be validated to assure quality.

In addition, like quality engineers, validation professionals must be aware of legal rules and regulations. The ASQ Code of Ethics for professional conduct describes the expectations of quality engineers towards the public, their employers, customers, and clients.

Section Two, Quality System
Section two of CQE BoK describes the role of the quality engineer in quality training. Pharmaceutical and medical device companies have a quality policy or quality manual in which plans for assuring the quality of product are documented. A quality manual typically contains four levels. The first level represents a policy statement, which explains the company commitments and objectives to quality. The second level contains procedures that describe
how a company operates and describes responsibility of each department. The third level represents work instructions that describe in detail how quality is achieved. The fourth level represents results obtained by implementing quality system and consists of quality records. The same system is also used in validation. The hierarchy of validation documents consists of the validation policy, standard operating procedures (SOPs), validation master plan, validation protocols, and reports. Because validation is a regulatory requirement, validation follows guidelines and standards. The validation professional must be familiar with many standards including quality standards such as ISO 9000, ISO 90001, and ISO 90004 (4, 5, and 6). These quality standards provide an overview of requirements of how to implement a quality system. A quality system can be described as a mechanism of how quality will be achieved to satisfy a customer. It consists of inputs, outputs, and quality related activities. In a pharmaceutical industry these activities can be environmental monitoring, process validation, process control, qualification of facilities and equipment, cleaning validation, control of inspection, measuring and test equipment, and control of nonconforming product—all activities need to be implemented in order to meet product quality.

Section two of the CQE BoK also covers quality audits. Audits and inspections occur commonly in pharmaceutical and medical device companies; therefore, a basic understanding of auditing is essential for a validation professional to help ensure a favorable outcome for the company.

Another important topic covered by the CQE BoK is the cost of quality. The quality costs are categorized into prevention, appraisal, internal failure, and external failure costs. Prevention costs are the costs of activities performed to prevent poor quality. Prevention activities are quality planning, training, and quality improvement projects. Appraisal costs include activities associated with quality assurance such as inspection, testing, calibration, validation, and auditing. Failure costs result when product does not meet requirements. Internal failure costs occur before the product is released to customer. For example, a packaging line produces packaging defects that are noticed during the operation and the batch is scraped. External failure costs occur after delivery of the product; examples include customer complaints and recalls. Quality engineers develop plans and activities to reduce the internal and external failures. Therefore, validation activities play a major role in reducing scrap, preventing defects, and customer complaints. If the validation activities are properly carried out, they should reduce or eliminate product recalls and trouble shooting. Validated processes should require less process support, less down time, and should operate more efficiently. In other words, validation improves quality assurances, reduces cost by process optimization, allows better system control, and provides a high degree of assurance that a validated process will consistently produce a product that meets its predetermined specifications.

In addition, section two of the CQE BoK discusses quality training. The role of quality engineer is not only to assure quality but also to be a leader and trainer. Validation professionals often communicate quality and regulatory expectations to manufacturing plant operations. They are often the first ones to learn new technology and train other people; therefore, this section of the BoK is applicable to the work done by validation professionals.

Section Three, Product and Process Design
Section three of the CQE BoK discusses the elements of process design such as process design phases, quality characteristics, measurement of quality characteristics, and evaluation of failure risk.

Process design is the activity of defining the commercial manufacturing process. Process design is performed by the research and development (R&D) department. During the process design key product inputs and outputs are identified, process controls are established, and process knowledge and understanding is gained. Strategies for process control are designed to reduce variation. The process design is then evaluated to determine if it can consistently reproduce results. In some companies, validation professionals perform process design and process validation. In other companies, R&D performs process design, and validation professionals perform process validation. Regardless of the organizational structure, validation professionals should have a fundamental knowledge of process design elements.

Section Four, Product and Process Control
Section four of the CQE BoK is dedicated to product and process control. The purpose of process controls is to ensure product quality. Controls can consist of material analysis and equipment monitoring at significant processing points (§211.110(c)). It is an expectation of FDA that these controls will be implemented and validated, which makes this section of
Section Five, Continuous Improvement
Section five of the CQE BoK is focused on continued improvement initiatives. The success of organizations depends on improvement of the processes. FDA’s view on validation does not end at the completion of the process qualification. Rather, after the validation study is completed, the process is monitored and evaluated to see if it remains in a state of control. An ongoing program should be established to collect and analyze product and process data (§211.180 (e)). It is a responsibility of validation professionals to review and evaluate data, identify trends, or undesirable process variation. Guidance for Industry Process Validation General Principles and Practices recommends “a statistician or person with adequate training in statistical process control techniques develop the data collection plan and statistical methods and procedures used in measuring and evaluating process stability and process capability” (3). A validation professional who is also a CQE-certified has demonstrated knowledge in this competency and has sufficient training evidence to oversee these activities.

Section Six, Statistical Analysis
Validation professionals often use statistical tools. Statistical data analysis is recommended by many regulatory documents. The FDA process validation guidance recommends that a statistician should develop the data collection plan and statistical methods and procedures to evaluate data (3). The guidance defines process validation as the collection and evaluation of data from the process design state through commercial production, which establishes scientific evidence that a process is capable of consistently delivering product quality. The guidance emphasizes that manufacturers should study process variation, identify sources of variation, and understand the impact on product attributes.

The applications of statistics for validation are data sampling, data analysis, capabilities studies, etc. Sampling is an important consideration during process validation. The validation professional often must make a decision where, when, and how to take samples, as well as how many samples to take. These decisions are not always easy; therefore, a scientific and statistically sound approach must be taken. In addition, statistical methods should be used to aid in an understanding of data. Machine capabilities studies can be performed during the pre-validation phase to get a firm understanding of the baseline capability of the machine. Process capability is an often over-looked aspect of validation. For instance, when a new product is moved from one tablet press to another, it is often a good idea to conduct a process capability study to determine whether the new press is capable.

Statistical tools must be used appropriately to be effective. It is essential to know where and when to use each tool and more importantly, when not to use it. A CQE certification demonstrates that a validation professional possesses an adequate training in statistics, and therefore, meets the training requirement to perform statistical analysis as mentioned in the process validation guidance.

SUMMARY
In conclusion, a CQE certification represents the attainment of quality engineering competencies that can be used in multiple applications of quality engineering, especially in validation. The CQE credential is a major boost to professional development and is recognized by many corporations. Numerous companies have implemented a requirement for employees who work in the quality department to be certified. Even in cases where it is not a requirement, professional certification demonstrates a certain level of expertise and is a credential that may set an individual apart from others in the field. Several validation professionals who have become certified quality engineers continue to further develop skills as technical specialists, applied statisticians, validation and quality trainers, and quality assurance managers.
REFERENCES
2. FDA, 21 CFR 211, Title 21--Food and Drugs Chapter I--Food and Drug Administration Department of Health and Human Services, Subchapter C--Drugs: General Part 211, Current Good Manufacturing Practice for Finished Pharmaceuticals, 43 Federal Register 45077, Sept. 29, 1978.
7. FDA, 21 CFR §820.70.

ARTICLE ACRONYM LISTING
ANOVA Analysis of Variance
AOQL Average Outgoing Quality Limit
AQL Acceptable Quality Limit
ASQ American Society of Quality
CQE Certified Quality Engineer
GMP Good Manufacturing Practices
LTPD Lot Tolerance Percent Defective
MBNQA Malcolm Baldridge National Quality Award
MRB Material Review Board
MSA Measurement System Analysis
OC Operational Curve
QFD Quality Functional Deployment
QIS Quality Information System
QMS Quality Management System
SPC Statistical Process Control

APPENDIX
CQE BODY OF KNOWLEDGE (BOK)
The CQE BoK covers the following areas:

1. Management and Leadership
   • Quality Philosophies and Foundations
     Evolvement of modern quality from quality control through statistical process control (SPC) to total quality management and leadership principles, and quality evolution from various continuous improvement tools including lean, six sigma, theory of constraints, etc.
   • The Quality Management System (QMS)
     • Strategic planning
       Top management’s responsibility for the QMS, including establishing policies and objectives, setting organization-wide goals, supporting quality initiatives, etc.
     • Deployment techniques
       Various deployment tools in support of the QMS: benchmarking, stakeholder identification and analysis, performance measurement tools, and project management tools such as PERT charts, Gantt charts, critical path method (CPM), resource allocation, etc.
   • Quality information system (QIS)
     Basic elements of a QIS, including who will contribute data, the kind of data to be managed, who will have access to the data, the level of flexibility for future information needs, data analysis, etc.
   • ASQ Code of Ethics for Professional Conduct
     Appropriate behavior in situations requiring ethical decisions.
   • Leadership Principles and Techniques
     Various principles and techniques for developing and organizing teams and leading quality initiatives.
   • Facilitation Principles and Techniques
     The facilitator’s role and responsibilities on a team. Various tools used with teams, including brainstorming, nominal group technique, conflict resolution, force-field analysis, etc.
   • Communication Skills
     Various communication methods for delivering information and messages in a variety of situations across all levels of the organization.
   • Customer Relations
     Customer relation measures such as quality function deployment (QFD), customer satisfaction surveys, etc.
• Supplier Management
  Various techniques including supplier qualification, certification, evaluation, ratings, performance improvement, etc.

• Barriers to Quality Improvement
  Barriers to quality improvement, their causes and impact, and describe methods for overcoming them.

2. The Quality System

• Elements of the Quality System
  The basic elements of a quality system, including planning, control, and improvement, from product and process design through quality cost systems, audit programs, etc.

• Documentation of the Quality System
  Quality system documentation components, including quality policies, procedures to support the system, configuration management, and document control to manage work instructions, quality records, etc.

• Quality Standards and Other Guidelines
  National and international standards and other requirements and guidelines, including the Malcolm Baldrige National Quality Award (MBNQA), and describe key points of the ISO 9000 series of standards and how they are used.

• Quality Audits
  • Types of audits
    Various types of quality audits such as product, process, management (system), registration (certification), compliance (regulatory), first, second, and third party, etc.
  • Roles and responsibilities in audits
    Roles and responsibilities for audit participants such as audit team (leader and members), client, auditee, etc.
  • Audit planning and implementation
    Steps of a quality audit, from the audit planning stage through conducting the audit, from the perspective of an audit team member.
  • Audit reporting and follow up
    Steps of audit reporting and follow up, including the need to verify corrective action.

• Cost of Quality (COQ)
  COQ concepts, including cost categories, data collection methods and classification, and reporting and interpreting results.

• Quality Training
  Key elements of a training program, including conducting a needs analysis, developing curricula and materials, and determining the program’s effectiveness.

3. Product and Process Design

• Classification of Quality Characteristics
  Characteristics for new products and processes.

• Design Inputs and Review
  Sources of design inputs such as customer needs, regulatory requirements, etc. and how they translate into design concepts. Common elements of the design review process, including roles and responsibilities of participants.

• Technical Drawings and Specifications
  Interpretation of technical drawings and specification requirements in relation to product and process characteristics.

• Design Verification
  Various evaluations and tests to qualify and validate the design of new products and processes to ensure their fitness for use.

• Reliability and Maintainability
  • Predictive and preventive maintenance tools
  • Reliability and maintainability indices
  • Basic elements of the bathtub curve
  • Reliability, safety, and hazard assessment tools
  • Failure mode and effects analysis

4. Product and Process Control

• Tools
  Product and process control methods such as developing control plans, identifying critical control points, developing and validating work instructions, etc.

• Material Control
  • Material identification, status, and traceability
  • Material segregation
  • Classification of defects
  • Material review board (MRB)

• Acceptance Sampling
  • Sampling concepts
    Concepts of producer and consumer risk and related terms, including operating characteristic (OC) curves, acceptable quality limit (AQL), lot tolerance percent defective (LTPD), average outgoing quality (AOQ), average outgoing quality limit (AOQL), etc.
  • Sampling standards and plans
    ANSI/ASQ Z1.4 and Z1.9 standards for attributes and variables sampling. Dodge-Romig sampling tables.
5. Continuous Improvement

- Quality Control Tools
- Quality Management and Planning Tools
- Continuous Improvement Techniques
- Corrective Action
- Preventive Action

6. Quantitative Methods and Tools

- Collecting and Summarizing Data
  - Types of data
  - Measurement scales
  - Data collection methods
  - Data accuracy
  - Descriptive statistics
  - Graphical methods for depicting relationships
  - Graphical methods for depicting distributions

- Quantitative Concepts
  - Terminology
  - Drawing statistical conclusions
  - Probability terms and concepts

- Probability Distributions
  - Continuous distributions
  - Discrete distributions

- Statistical Decision-Making
  - Point estimates and confidence intervals
  - Hypothesis testing
  - Paired-comparison tests
  - Goodness-of-fit tests
  - Analysis of variance (ANOVA)
  - Contingency tables