2

Statistical Quality Control and Six Sigma

2.1 Introduction

The phrase "**statistical quality control**" (SQC) refers to the application of statistical methods to monitor and evaluate systems and to determine whether changing key input variable (KIV) settings is appropriate. Specifically, SQC is associated with Shewhart's statistical process charting (SPC) methods. These SPC methods include several charting procedures for visually evaluating the consistency of key process outputs (KOVs) and identifying unusual circumstances that might merit attention.

In common usage, however, SQC refers to many problem-solving methods. Some of these methods do not relate to monitoring or controlling processes and do not involve complicated statistical theory. In many places, SQC has become associated with all of the statistics and optimization methods that professionals use in quality improvement projects and in their other job functions. This includes methods for design of experiments (DOE) and optimization. In this book, DOE and optimization methods have been separated out mainly because they are the most complicated quality methods to apply and understand.

In Section 2.2, we preview some of the SQC methods described more fully later in this book. Section 2.3 relates these techniques to possible job descriptions and functions in a highly formalized organization. Next, Section 2.4 discusses the possible roles the different methods can play in the six sigma problem-solving method.

The discussion of organizational roles leads into the operative definition of quality, which we will define as conformance to design engineering's specifications. Section 2.5 explores related issues including the potential difference between non-conforming and defective units. Section 2.6 concludes the chapter by describing how standard operating procedures capture the best practices derived from improvement or design projects.

2.2 Method Names as Buzzwords

The names of problem-solving methods have become "buzzwords" in the corporate world. The methods themselves are diverse; some involve calculating complicated statistics and others are simple charting methods. Some of the activities associated with performing these methods can be accomplished by a single person working alone, and others require multidisciplinary teams. The following is an abbreviated list of the methods to illustrate the breadth and purposes of these methods:

Acceptance Sampling involves collecting and analyzing a relatively small number of KIV measurements to make "accept or reject" decisions about a relatively large number of units. Statistical evidence is generated about the fraction of the units in the lot that are acceptable.

Control Planning is an activity performed by the "owners" of a process to assure that all process KOV variables are being measured in a way that assures a high degree of quality. This effort can involve application of multiple methods.

Design of Experiments (DOE) methods are structured approaches for collecting response data from varying multiple KIVs to a system. After the experimental tests yield the response outputs, specific methods for analyzing the data are performed to establish approximate models for predicting outputs as a function of inputs.

Failure Mode & Effects Analysis (FMEA) is a method for prioritizing response measurements and subsystems addressed with highest priority.

Formal Optimization is itself a diverse set of methods for writing technical problems in a precise way and for developing recommended settings to improve a specific system or product, using input-output models as a starting point.

Gauge Repeatability and Reproducibility (R&R) involves collecting repeated measurements on an engineering system and performing complicated calculations to assess the acceptability of a specific measurement system. ("Gage" is an alternative spelling.)

Process Mapping involves creating a diagram of the steps involved with an engineering system. The exercise can be an important part of waste reduction efforts and lean engineering and can aid in identifying key input variables.

Regression is a curve-fitting method for developing approximate predictions of system KOVs (usually averages) as they depend on key input variable settings. It can also be associated with proving statistically

that changes in KIVs affect changes in KOVs if used as part of a DOE method.

Statistical Process Control (SPC) **charting** includes several methods to assess visually and statistically the quality and consistency of process KOVs and to identify unusual occurrences. Therefore, SPC charting is useful for initially establishing the value and accuracy of current settings and confirming whether recommended changes will consistently improve quality.

Quality Function Deployment (QFD) involves creating several matrices that help decision-makers better understand how their system differs from competitor systems, both in the eyes of their customers and in objective features.

In the chapters that follow, these and many other techniques are described in detail, along with examples of how they have been used in real-world projects to facilitate substantial monetary savings.

Example 2.2.1 Methods and Statistical Evidence

Question: Which of the following methods involve generating statistical evidence?

a. Formal optimization and QFD generally create statistical evidence.
b. Acceptance sampling, DOE, regression, and SPC create evidence.
c. Process mapping and QFD generally create statistical evidence.
d. Answer in parts "a" and "b" are both correct.
e. Answer in parts "a" and "c" are both correct.

Answer: (b) Acceptance sampling, DOE, regression, and SPC can all easily be associated with formal statistical tests and evidence. Formal optimization, process mapping, and QFD generate numbers that can be called statistics, but they generally do not develop formal proof or statistical evidence.

2.3 Where Methods Fit into Projects

In many textbooks, statistical methods are taught as "stand alone" entities and their roles in the various stages of a system improvement or design project are not explained. It is perhaps true that one of the most valuable contributions of the six sigma movement is the association of quality methods with project phases. This association is particularly helpful to people who are learning statistics and optimization methods for the first time. These people often find it helpful to know which methods are supposed to be used at what stage.

In the six sigma literature, system improvement projects are divided into five phases or major activities (e.g., see Harry and Schroeder 1999 and Pande *et al*. 2000):

1. **Define** terminates when specific goals for the system outputs are clarified and the main project participants are identified and committed to project success.
2. **Measure** involves establishing the capability of the technology for measuring system outputs and using the approved techniques to evaluate the state of the system before it is changed.
3. **Analyze** is associated with developing a qualitative and/or quantitative evaluation of how changes to system inputs affect system outputs.
4. **Improve** involves using the information from the analyze phase to develop recommended system design inputs.
5. **Control** is the last phase in which any savings from using the newly recommended inputs is confirmed, lessons learned are documented, and plans are made and implemented to help guarantee that any benefits are truly realized.

Often, six sigma improvement projects last three months, and each phase requires only a few weeks. Note that for new system design projects, the design and verify phases play somewhat similar roles to the improve and control phases in improvement projects. Also, the other phases adjust in intuitive ways to address the reality that in designing a new system, potential customer needs cannot be measured by any current system.

While it is true that experts might successfully use any technique in any phase, novices sometimes find it helpful to have more specific guidance about which techniques should be used in which phase. Table 2.1 is intended to summarize the associations of methods with major project phases most commonly mentioned in the six sigma literature.

Table 2.1. Abbreviated list of methods and their role in improvement projects

Method	Phases
Acceptance Sampling	Define, Measure, Control
Benchmarking	Define, Measure, Analyze
Control Planning	Control, Verify
Design of Experiments	Analyze, Design, Improve
Failure Mode & Effects Analysis (FMEA)	Analyze, Control, Verify
Formal Optimization	Improve, Design
Gauge R&R	Measure, Control
Process Mapping	Define, Analyze
Quality Function Deployment (QFD)	Measure, Analyze, Improve
Regression	Define, Analyze, Design, Improve
SPC Charting	Measure, Control

Example 2.3.1 Basic Method Selection

Question: A team is trying to evaluate the current system inputs and measurement system. List three methods that might naturally be associated with this phase.

Answer: From the above definitions, the question pertains to the "measure" phase. Therefore, according to Table 2.1, relevant methods include Gauge R&R, SPC charting, and QFD.

2.4 Organizational Roles and Methods

Sometimes, methods are used independently from any formal system improvement or design project. In these cases, the methods could be viewed as stand-alone projects. These applications occur in virtually all specialty departments or areas. In this section, the roles of specializations in a typical formalized company are described, together with the methods that people in each area might likely use.

Figure 2.1 shows one possible division of a formalized manufacturing company into specialized areas. Many formalized service companies have similar department divisions. In general, the marketing department helps the design engineering department understand customer needs. Design engineering translates input information from marketing into system designs. Section 2.5 will focus on this step, because design engineers often operationally define quality for other areas of company. Also, the designs generated by these engineers largely determine quality, costs of all types, and profits. Procurement sets up an internal and external supply chain to make the designed products or services. Process engineering sets up any internal processes needed for producing units, including tuning up any machines bought by procurement. Production attempts to build products to conform to the expectations of design engineering, using parts from procurement and machines from process engineering. Sales and logistics work together to sell and ship the units to customers.

Figure 2.1 also shows the methods that people in each area might use. Again, it is true that anyone in any area of an organization might conceivably use any method. However, Figure 2.1 does correctly imply that methods described in this book are potentially relevant throughout formalized organizations. In addition, all areas have potential impacts on quality, since anyone can conceivably influence the performance of units produced and/or the expectations of customers.

Example 2.4.1 Departmental Methods Selection

Question: In addition to the associations in Figure 2.1, list one other department that might use acceptance sampling. Explain in one sentence.

Answer: Production might use acceptance sampling. When the raw materials or other input parts show up in lots (selected by procurement), production might use acceptance sampling to decide whether to reject these lots.

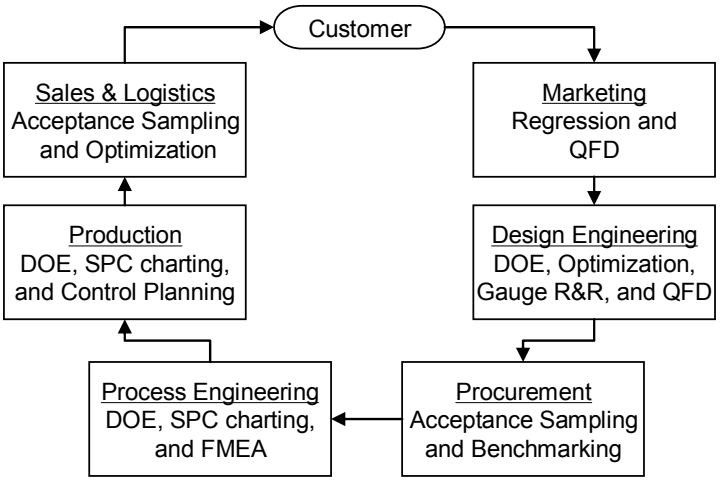


Figure 2.1. Methods which might most likely be used by each department group

2.5 Specifications: Non-conforming vs Defective

In manufacturing, design engineering generates a blueprint. Similar plans could be generated for the parameters of a service operation. Usually, a blueprint contains both target or "**nominal**" settings for each key input variable (KIV) and acceptable ranges. Figure 2.2 shows an example blueprint with three KIVs. The screw diameter is x_1, the percentage carbon in the steel is x_2, and x_3 is the angle associated with the third thread from the screw head.

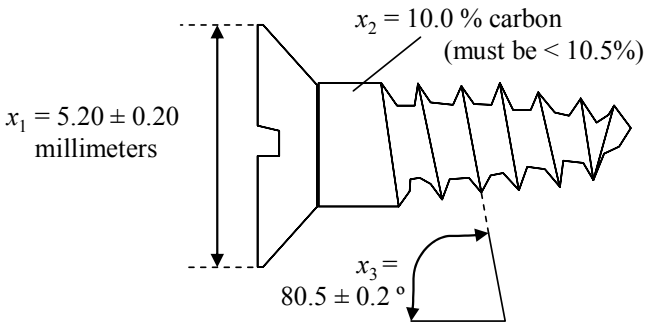


Figure 2.2. Part of blueprint for custom designed screw with two KIVs

Key input variables with acceptable ranges specified on blueprints or similar documents are called "**quality characteristics**." The minimum value allowed on a blueprint for a quality characteristic is called the lower specification limit (LSL). The maximum value allowed on a blueprint for a characteristic is called the upper specification limit (USL). For example, the LSL for x_1 is 5.00 mm for the blueprint

in Figure 2.2 and the USL for x_3 is 80.7º. For certain characteristics, there might be only an LSL or a USL but not both. For example, the characteristic x_2 in Figure 2.2 has USL = 10.5% and no LSL.

Note that nominal settings of quality characteristics are inputs, in the sense that the design engineer can directly control them by changing numbers, usually in an electronic file. However, in manufacturing, the actual corresponding values that can be measured are uncontrollable KOVs. Therefore, quality characteristics are associated with nominals that are KIVs (xs) and actual values that are KIVs (ys).

In many real-world situations, the LSL and USL define quality. Sometimes these values are written by procurement into contracts. A "**conforming**" part or product has all quality characteristic values, within the relevant specification limits. Other parts or products are called "**non-conforming,**" since at least one characteristic fails to conform to specifications. Manufacturers use the term "**non-conformity**" to describe each instance in which a part or product's characteristic value falls outside its associated specification limit. Therefore, a given part or unit might have many non-conformities. A "**defective**" part or product yields performance sufficiently below expectations such that its safe or effective usage is prevented. Manufacturers use the term "**defect**" to describe each instance in which a part or product's characteristic value causes substantially reduced product performance. Clearly, a defective unit is not necessarily non-conforming and *vice versa*. This follows because designers can make specifications without full knowledge of the associated effects on performance.

Table 2.2 shows the four possibilities for any given characteristic of a part or product. The main purpose of Table 2.2 is to call attention to the potential fallibility of specifications and the associated losses. The arguably most serious case occurs when a part or product's characteristic value causes a defect but meets specifications. In this case, a situation could conceivably occur in which the supplier is not contractually obligated to provide an effective part or product. Worse still, this case likely offers the highest chance that the defect might not be detected. The defect could then cause problems for customers.

Table 2.2. Possibilities associated with any given quality characteristic value

	Performance Related Status	
Conformance Status	Defective	Non-defective
Non-conforming	Bad case – if not fixed, the unit could harm the customer	Medium case – unnecessary expense fixing unit might occur
Conforming	Worst case – likely to slip through and harm customer	Best case – unit fosters good performance and meets specs

Another kind of loss occurs when production and/or outside suppliers are forced to meet unnecessarily harsh specifications. In these cases, a product characteristic can be non-conforming, but the product is not defective. This can cause unnecessary expense because efforts to make products consistently conform

to specifications can require additional tooling and personnel expenses. This type of waste, however, is to a great extent unavoidable.

Note that a key input variable (KIV) in the eyes of engineering design can be a key output variable (KOV) for production, because engineering design is attempting to meet customer expectations for designed products or services. To meet these expectations, design engineering directly controls the ideal nominal quality characteristic values and specifications. Production tries to manipulate process settings so that the parts produced meet the expectations of design engineering in terms of the quality characteristic values. Therefore, for production, the controllable inputs are settings on the machines, and the characteristics of units that are generated are KOVs. Therefore, we refer to "quality characteristics" instead of KIVs or KOVs.

Example 2.5.1 Screw Design Specifications

Question: Propose an addititional characteristic and the associated specification limits for the screw example in Figure 2.2. Also, give a value of that characteristic which constituties a non-conformity and a defect.

Answer: Figure 2.3 shows the added characteristic x_4. The LSL is 81.3º and the USL is 81.7º. If x_4 equalled 95.0º, that would constitute both a non-conformity, because 95.0º > 81.7º, and a defect, because the customer would have difficulty inserting the screw.

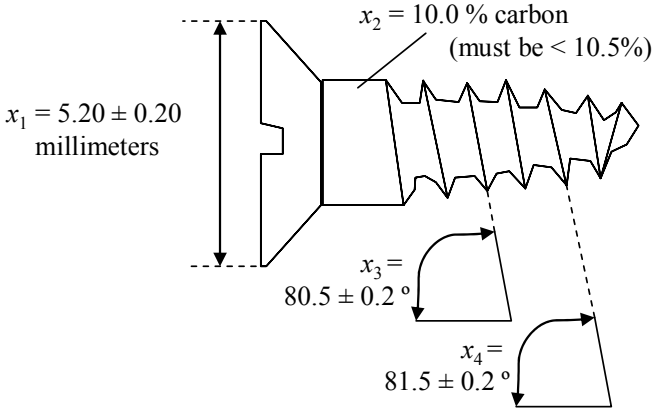


Figure 2.3. Augmented blueprint with the additional characteristic x_4

2.6 Standard Operating Procedures (SOPs)

Currently, potential customers can enter many factories or service facilities and ask to view the International Standards Organization (ISO) manuals and supporting documentation. In general, this documentation is supposed to be easily available to anyone in these companies and to reflect accurately the most current practices.

Creating and maintaing these documents requires significant and ongoing expense. Also, companies generally have specific procedures that govern the practices that must be documented and the requirements for that documentation.

Multiple considerations motivate these documentation efforts. First, customer companies often simply require ISO certifications of various types from all suppliers. Second, for pharmaceutical companies, hospitals, and many other companies where government regulations play a major role, a high level of documentation is legally necessary. Third, even if neither customers nor laws demand it, some managers decide to document business practices simply to improve quality. This documentation can limit product, process, and/or service design changes and facilitate communication and a competition of ideas among the company's best experts.

2.6.1 Proposed SOP Process

There is no universally accepted way to document standard operating procedures (SOPs). This section describes one way that *might* be acceptable for *some* organizations. This method has *no* legal standing in any business sector. Instead, it mainly serves to emphasize the importance of documentation, which is often the practical end-product of a process improvement or design engineering project. In some sense, the precise details in SOPs are the system inputs that project teams can actually control and evaluate. If your company has thorough and well-maintained SOPs, then the goals of SQC and DOE methods are to evaluate and improve the SOPs. There are specific methods for evaluating measurement SOPs, for example, gauge R&R for evaluating manufacturing SOPs such as SPC charts.

In the proposed approach, a team of relevant people assemble and produce the SOP so that there is "buy-in" among those affected. The SOP begins with a "title," designed to help the potential users identify that this is the relevant and needed SOP. Next, a "**scope**" section describes who should follow the documented procedures in which types of situations. Then a "**summary**" gives an overview of the methods in the SOP, with special attention to what is likely to be of greatest interest to readers. Next, the SOP includes the "**training qualifications**" of the people involved in applying the method and the "**equipment and supplies**" needed to perform the SOP. Finally, the "**method**" is detailed, including specific numbered steps. This documentation might include tables and figures. If it does, references to these tables and figures should be included in the text. In general, the primary intent is that the SOP be clear enough to insure the safety of people involved and that the operations be performed consistently enough to ensure good quality. Visual presentation and brevity are preferred when possible.

Example 2.6.1 Detailed Paper Helicopter Manufacturing SOP

Question: Provide a detailed SOP for producing paper helicopters.

Answer: Table 2.3 below contains a SOP for paper helicopter manufacturing.

Table 2.3. Detailed version of a paper helicopter SOP

Title: Detailed SOP for paper helicopter manufacturing
Scope: For use by college and graduate students
Summary: A detailed method to make a "base-line" paper helicopters is provided.
Training Qualifications: None
Equipment and Supplies: Scissors, metric ruler, A4 paper
Method: The steps below refer to Figure 2.4. 1. Make cut ① 23 cm. from lower left paper corner. 2. Make cut ② 10 cm. from bottom. 3. Make cut ③ 5 cm. down from the end of cut 2. 4. Make 2 cuts, both labelled ④ in Figure 2.4, 3 cm long each. 5. Fold both sides of the base inwards along the crease lines labelled ⑤. 6. Fold the bottom up along the crease line labelled ⑥. 7. Fold wings in opposite directions along crease lines labelled ⑦.

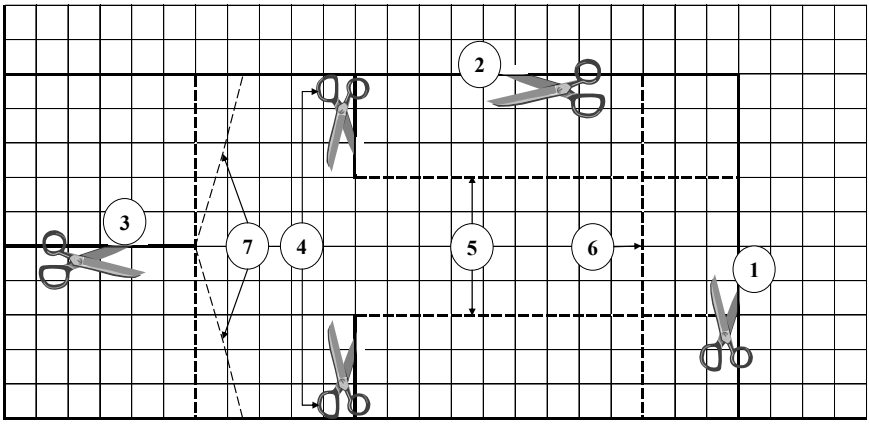


Figure 2.4. Helicopter cut (—) and fold (--) lines (not to scale, grid spacing = 1 cm)

Note that not all information in a blueprint, including specification limits, will necessarily be included in a manufacturing SOP. Still, the goal of the SOP is, in an important sense, to make products that consistently conform to specifications.

The fact that there are multiple possible SOPs for similar purposes is one of the central concepts of this book. The details of the SOPs could be input parameters for a system design problem. For example, the distances 23 cm and 5 cm in the above paper helicopter example could form input parameters x_1 and x_2 in a system design improvement project. It is also true that there are multiple ways to document what is essentially the same SOP. The example below is intended to offer an alternative SOP to make identical helicopters.

Example 2.6.2 Concise Paper Helicopter Manufacturing SOP

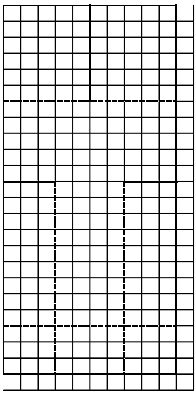
Question: Provide a more concise SOP for producing paper helicopters.

Answer: Table 2.4 below contains a concise SOP for paper helicopter manufacturing.

Table 2.4. The concise version of a paper helicopter SOP

Title: Concise SOP for paper helicopter manufacturing
Scope: For use by college and graduate students
Summary: A concise method to make a "base-line" paper helicopters is provided.
Training Qualifications: None
Equipment and Supplies: Scissors, metric ruler, A4 paper
Method: Cut on the solid lines and fold on the dotted lines as shown in Figure 2.5a to make a helicopter that looks like Figure 2.5b.

(a)



(b)

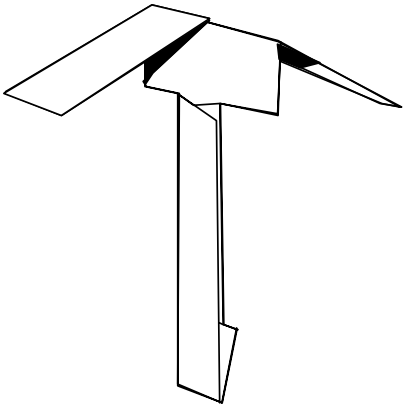


Figure 2.5. (a) Paper with cut and fold lines (grid spacing is 1 cm); **(b)** desired result

With multiple ways to document the same operations, the question arises: what makes a good SOP? Many criteria can be proposed to evaluate SOPs, including cost of preparation, execution, and subjective level of professionalism. Perhaps the most important criteria in a manufacturing context relate to the performance that a given SOP fosters in the field. In particular, if this SOP is implemented in the company divisions, how desirable are the quality outcomes? Readability, conciseness, and level of detail may affect the outcomes in unexpected ways. The next chapters describe how statistical process control (SPC) charting methods provide thorough ways to quantitatively evaluate the quality associated with manufacturing SOPs.

2.6.2 Measurement SOPs

Quite often, SOPs are written to regulate a process for measuring a key output variable (KOV) of interest. For example, a legally relevant SOP might be used by a chemical company to measure the Ph in fluid flows to septic systems. In this book, the term "measurement SOPs" refers to SOPs where the associated output is a number or measurement. This differs from "production SOPs" where the output is a product or service. An example of a measurement SOP is given below. In the next chapters, it is described how gauge R&R methods provide quantitative ways to evaluate the quality of measurement SOPs.

Example 2.6.3 Paper Helicopter Measurement SOP

Question: Provide an SOP for measuring the quality of paper helicopters.

Answer: Table 2.5 describes a measurement SOP for timing paper helicopters.

Table 2.5. Paper helicopter measurement SOP

Title: SOP for measuring paper helicopter for student competition
Scope: For use by college and graduate students
Summary: A method is presented to measure the time in air for a student competition.
Training Qualifications: None
Equipment and Supplies: Chalk, chair, stopwatch, meter stick, and two people
Method: 1. Use meter stick to measure 2.5 m up a wall and mark spot with chalk. 2. Person 1 stands on chair approximately 1 m from wall. 3. Person 1 orients helicopter so that base is down and wings are horizontal. 4. Person 2 says "start" and Person 1 drops helicopter and Person 2 starts timer. 5. Person 2 stops timer when helicopter hits the ground. 6. Steps 2–5 are repeated three times, and average time in seconds is reported.

Problems

In general, pick the correct answer that is most complete or inclusive.

1. A company is trying to design a new product and wants to systematically study its competitor's products. Which methods are obviously helpful (i.e., the method description mentions related goals)?
    a. Gauge R&R
    b. QFD

c. Formal Optimization
d. Answers in parts “a” and “b” are both correct.
e. Answers in parts “a” and “c” are both correct.

2. A company has implemented a new design into production. Now it is interested in prioritizing which inspection areas need more attention and in documenting a complete safety system. Which methods are obviously helpful (i.e., the method description mentions related goals)?
    a. FMEA
    b. QFD
    c. Control planning
    d. Answers in parts “a” and “b” are both correct.
    e. Answers in parts “a” and “c” are both correct.

3. Which methods are obviously helpful for evaluating measurement systems (i.e., the method description mentions related goals)?
    a. Gauge R&R
    b. DOE
    c. Formal Optimization
    d. Answers in parts “a” and “b” are both correct.
    e. Answers in parts “a” and “c” are both correct.

4. A company is trying to design a new product and wants to study input combinations to develop input-output predictive relationships. Which methods are obviously helpful (i.e., the method description mentions related goals)?
    a. Regression
    b. DOE
    c. Control planning
    d. Answers in parts “a” and “b” are both correct.
    e. Answers in parts “a” and “c” are both correct.

5. A team is in a problem-solving phase in which the objectives and responsibilities have been established but the state of the current system has not been measured. According to Chapter 2, which method(s) would be obviously helpful (i.e., the method description mentions related goals)?
    a. SPC charting
    b. Gauge R&R
    c. DOE
    d. Answers in parts “a” and “b” are both correct.
    e. Answers in parts “a” and “c” are both correct.

6. A team has created approximate regression models to predict input-output relationships and now wants to decide which inputs to recommend. According to Chapter 2, which method(s) would be obviously helpful?
    a. SPC charting
    b. Gauge R&R
    c. Formal optimization

d. Answers in parts “a” and “b” are both correct.
e. Answers in parts “a” and “c” are both correct.

7. A team is in a problem-solving phase in which recommendations are ready but have not been fully confirmed and checked. According to Chapter 2, which method(s) would be obviously helpful?
    a. SPC charting
    b. DOE
    c. Formal optimization
    d. Answers in parts “a” and “b” are both correct.
    e. Answers in parts “a” and “c” are both correct.

8. A large number of lots have shown up on a shipping dock, and their quality has not been ascertained. Which method(s) would be obviously helpful?
    a. Acceptance sampling
    b. DOE
    c. Formal optimization
    d. Answers in parts “a” and “b” are both correct.
    e. Answers in parts “a” and “c” are both correct.

9. Based on Table 2.1, which methods are useful in the first phase of a project?

10. Based on Table 2.1, which methods are useful in the last phase of a project?

11. Which department could possibly use DOE?
    a. Design engineering
    b. Production
    c. Process engineering
    d. All of the above are correct.

12. Which department(s) could possibly use SPC charting?
    a. Production
    b. Marketing
    c. Sales and logistics, for monitoring delivery times of truckers
    d. All of the above are correct.

13. According to Chapter 2, which would most likely use acceptance sampling?
    a. Sales and logistics
    b. Design engineering
    c. Procurement
    d. Answers in parts “a” and “b” are both correct.
    e. Answers in parts “a” and “c” are both correct.

14. According to the chapter, which would most likely use formal optimization?
    a. Design engineering
    b. Production engineering

c. Process engineering
d. All of the above are correct.

15. Which of the following is true about engineering specification limits?
    a. They are associated with the "±" given on blueprints.
    b. They can fail to reflect actual performance in that non-conforming ≠ defective.
    c. They are always written in dimensionless units.
    d. Answers in parts "a" and "b" are both correct.
    e. Answers in parts "a" and "c" are both correct.

16. Which of the following is correct about engineering specifications?
    a. They are sometimes made up by engineers who do not know the implications.
    b. They are often used in contracts between procurement and suppliers.
    c. They could be so wide as to raise no production concerns.
    d. All of the above are correct.
    e. Only answers in parts "a" and "c" are correct.

17. Create a blueprint of an object you design including two quality characteristics and associated specification limits.

18. Propose an additional quality characteristic for the screw design in Figure 2.3 and give associated specification limits.

19. Which of the following is true about manufacturing SOPs?
    a. They take the same format for all organizations and all applications.
    b. They can be evaluated using SPC charting in some cases.
    c. They are always written using dimensionless units.
    d. Answers in parts "a" and "b" are both correct.
    e. Answers in parts "a" and "c" are both correct.

20. Which of the following is true about manufacturing SOPs?
    a. They are sometimes made up by engineers who do not know the implications.
    b. According to the text, the most important criterion for SOPs is conciseness.
    c. They cannot contain quality characteristics and specification limits.
    d. Answers in parts "a" and "b" are both correct.
    e. Answers in parts "a" and "c" are both correct.

21. Which of the following is true about measurement SOPs?
    a. They are sometimes made up by engineers who do not know the implications.
    b. They describe how to make products that conform to specifications.
    c. They can be evaluated using gauge R&R.

d. Answers in parts “a” and “b” are both correct.
e. Answers in parts “a” and “c” are both correct.

22. Which of the following is true about measurement SOPs?
    a. They take the same format at all organizations for all applications.
    b. They are always written using dimensionless units.
    c. The same procedure can be documented in different ways.
    d. Answers in parts “a” and “b” are both correct.
    e. Answers in parts “a” and “c” are both correct.

23. Write an example of a manufacturing SOP for a problem in your life.

24. Write an example of a measurement SOP for a problem in your life.

25. In two sentences, critique the SOP in Table 2.3. What might be unclear to an operator trying to follow it?

26. In two sentences, critique the SOP in Table 2.5. What might be unclear to an operator trying to follow it?

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