Solutions to Chapter 1 Exercises

1.1 *Explain the change in the view of quality control in the United States between the decades of the 1950s, 60s, 70s, and today.*

Quality control before the 1980's was characterized by:
- the need to keep bad parts from reaching the customer, mostly through the use of mass inspection techniques.
- employing the QC department as a policing function trying to catch bad product before it goes out the door.
- constant "fire-fighting", frantically trying to solve each new problem as it would arise.
- the drive to meet the acceptable standard of productivity, often typified by the work standard, and the acceptable level of quality, often articulated in terms of an "acceptable quality level" (AQL).

From the 1980's to the present, quality control has:
- employed statistics to identify improvement opportunities in the process.
- emphasized the continual improvement in both quality and productivity.
- begun to work side-by-side with manufacturing to produce a better product and enhance the company's competitive position.
- begun to shift away from quality as primarily a manufacturing-based concept to quality as a design-based concept as well, i.e., pushing the quality efforts of the organization farther upstream into engineering design.

1.2 *What changes must take place for the United States to become competitive again in the world marketplace?*

To again become competitive in the world marketplace, the U.S. must:
- institute a process control philosophy which enables both quality and productivity to increase simultaneously.
- expand the quality concept to the design function where the practices of experimental design for product design and improvement and concurrent product/process design can develop.
- establish an over-arching quality philosophy which touches all aspects and systems within the company.

1.3 *What are the four major milestone events/circumstances in the history of quality control, each of which has led to a major step forward in the concepts, methods, and implementation of quality control?*

Four major events that led to the application of modern quality principles are:
- Shewhart's introduction of a statistical measure for quality improvement at the process in the form of the control chart.
- Deming's contributions to a new management philosophy for the institutionalization of quality improvement across the entire organization.
- Taguchi's introduction of quality engineering, and in particular, the parameter design/robust design concept.
- the emergence of a world marketplace forcing entire nations to re-think and re-design their approach to quality.

1.4 *What was the effect of division of labor on the standard of quality of goods manufactured in the United States? Why did this occur?*

The division of labor lowered quality standards in the U.S. by:
- emphasizing production over quality, i.e. emphasizing getting the numbers out.
- creating an acceptable quality level which inhibited improvement.
- taking away the worker's ownership in, and understanding and appreciation for the entire end product and its function in the customer's hands; taking away the worker's pride in the process.

1.5 *Are the use of work standards and/or wage incentives consistent with our view of quality today? Explain.*

Work standards are inconsistent with today's quality view since:
- they focus on production numbers with little regard for quality.
- they place a cap on productivity by making everyone think that if the standard is being met, then the process is operating in a satisfactory manner, that is, there is no need to look for further improvements.
- they inhibit efforts for improvement in both quality and productivity by removing incentives for making those efforts.

1.6 *What is the danger associated with the use of "acceptance sampling" for quality control? Why does the type of attitude it promotes hinder the enhancement of competitive position?*

Acceptance sampling:
- focuses on the product, instead of on improvements in the process.
- works toward containment of bad parts, rather than the prevention of the bad parts from arising in the first place.
- tends to promote the notion that there exists some "acceptable" level of defective material that we can live with, that, in fact, is economical to strive for in a total system cost sense.
- promotes an uneconomical approach to quality by not allowing quality and productivity to improve together.

1.7 *What are some possible effects realized by the general acceptance of the idea of AQL?*

Acceptance of the AQL concept:
- stifles creativity by removing incentives for improvement.
- allows scrap to be accepted as part of everyday business and planning.
- motivates the belief that there exists an economic tradeoff between improved quality by the continual reduction in defective material and the cost of doing so.

1.8 *What was Shewhart's basic approach to quality control?*

Shewhart emphasized:
- economic operation of the process; the need to maintain the routine operation of the process if it is to be economical.
- the importance of consistency of process operation; the presence of only "chance" variation sources to insure the economic/routine operation of the process.
- the use of statistics to recognize the presence of an inconsistent process, and the removal of the root causes(s) of variation sources to improve the economic operation of the process.

1.9 *How did Shewhart's approach to quality control differ from that of Dodge and Romig?*

Dodge and Romig concentrated on:
- using statistics/probability theory in a product control environment (Shewhart did so in a process control environment).
- rejecting parts based on some acceptable quality level (Shewhart continually sought to improve the process to improve the product).
- keeping defective product out of the customer's hands (Shewhart did so by reducing process variation to improve the quality of the process output).

1.10 *What is wrong with the phenomenon of "change of necessity"?*

Change out of necessity generally results in:
- lagging behind competitors, since real change cannot happen overnight.
- lost opportunity due to the gains that would have been realized had change begun earlier.

- a reactive rather than a proactive quality philosophy.

1.11 *Why has the United States over the last decade become concerned with improving quality? What forces may be at work now that did not exist 20, 30, 40 years ago - or did they?*

The U.S. has become more quality conscious in recent years because:

- a world marketplace emerged that threatened the economic success of nearly every industry.
- competitors abroad started "playing the game" under a new set of rules which included the pursuit of higher levels of quality through the more rigorous use of quality design and improvement methods. Many of the methods used have been available for many decades, but only recently has the global market forced companies into use.
- companies have begun to see the broad-based benefits of the process control methodology in terms of the enhancement of competitive position.

1.12 *Who has responsibility for initiating quality control? What things need to be done?*

Only management can effectively initiate and carry through on the institutionalization of a quality design and control program. Management must:

- put quality and the never-ending pursuit of improvement on an institutional basis.
- be prepared to provide the workers with the necessary tools for successful implementation.
- lead and actively participate in the development and ongoing operation of the program, not merely support it with words and/or budget.

1.13 *Explain why it is important to consider variation about the nominal as an a measure of product/process performance; that is, why is it not sufficient or advisable to consider only performance on average?*

Today, more emphasis is being given to articulating quality in terms of variation in performance in the field during use. Consistency of function is today recognized as an important customer-based attribute of a product. Products that perform with small variation are considered desirable over others that have the same level of average performance but more variability of performance about that average. Taguchi has recognized the fact that products that function in a robust fashion, that is, have low variation about the nominal in the presence of noise/variation inherent in the use environment, generally result in longer life and less trouble in the field during continued use.

1.14 *How/why do some of the newer concepts/ways of viewing quality encourage manufacturers to reduce the variability about the nominal in their products/processes; that is, what motivates the continual pursuit of variation reduction?*

Newer concepts of quality relate loss in quality (loss in customer utility and satisfaction) directly to the amount of functional variation in performance during field use. This loss can directly affect the company's competitive position from the standpoint of trouble in field use, e.g., early wearout and failure resulting in increased warranty costs, and in terms of customer dissatisfaction resulting from inconsistent, erratic performance during use. Also, reduction in variability is shown to directly increase the level of productivity, that is, eliminating waste and making the processes more efficient.

1.15 *A major automobile manufacturer advertises that it performs 100% inspection on all processes that produce parts for the brake systems in its cars. They claim that the consumer can feel good about being safe in their cars. What should the consumer feel bad about? Is there any situation in which measuring every part might be useful?*

The consumer should be wary because:

- the cost of 100% inspection is most likely reflected in the car's sticker price.

- 100% inspection is not always successful in containing defects, and, most likely, the company is putting less emphasis on attention to the processes that manufacture the brake system.
- the inspection/product control/defect containment approach to quality does not put emphasis on quality upstream, i. e., quality by improved product and process design.

In general, the measurement of every part is unnecessary and costly. Statistically-based sampling of the product can produce such information (if required) with a sufficient level of confidence.

1.16 *The percent defective from a process that makes injection-molded plastic keychains has gradually been rising to the point where it can no longer meet production demands in a single 8-hour shift per day. The shop floor manager sends you a memo recommending that a second shift be added on this machine in order to get the product out the door. As his or her boss, how would you respond to this memo?*

Adding a second shift is a poor solution because:

- it does not get at the root cause of the problem to eliminate it.
- waste and inefficiency in the process and the product are actually increased as we make "more of the same," i.e., poor quality product.
- it is improving the S/N ratio of the process by increasing the signal, not reducing the noise, eliminating the problem in the first place.
- it tends to promote the notion that it is the job of production to get out the numbers, and that quality is someone else's job.

1.17 *After experimenting with a certain product's performance in the field, it is found that better quality raw materials significantly improve the product's performance in all areas. Based on these results, would you recommend that the more expensive raw material be used for this process? Of what is this an example? How might we better deal with this issue?*

Rather than recommending the more expensive materials, future experimentation should be done to exploit any nonlinearities in the material quality - product performance relationship, that is, pursue the development of a more robustly performing product. This could improve output quality while using the same materials. Using a more expensive raw material is an example of developing a more robust product by "increasing the signal", not reducing the transmission of the environmental noise through design (Taguchi's parameter design concept).

1.18 *Provide an example in your personal or professional life in which you solved a problem by:*
(a) increasing the "signal,"
(b) decreasing the "noise"
in the signal-to-noise ratio you might use to characterize the performance of the process? Carefully explain your answer.

1.19 Your boss likes the color scheme you specified for the decoration on a new motorcycle helmet, and begins production immediately in order to have the first ones off the line in time for his son's birthday. Although you've had no chance to consider design changes that may prove necessary, he assures you that later modifications will cause minimal down-time on the line. Is your boss considering all the costs involved? How would you prove to him that his decision was a poor one?

The boss is not considering costs due to:

- the poorly designed helmets that are already produced.
- the bad reputation gained from the selling of such helmets.

Experimenting with the proposed design before production starts will considerably reduce the need to redesign the line and the harmful effects resulting from selling poorly designed helmets.

1.20 *Explain the difference between testing and experimentation. Which do you think is more useful in the engineering design process and why?*

Testing involves:
- using many products with the same design to perform life tests to see how the design performs on average over a span of time.

Experimentation is concerned with:
- comparing performance with regard to different levels of the parameters of a given design to seek the most attractive performance levels according to some pre-specified criteria. Experimentation is more useful in the design process because it yields more information on how the product's performance may change as the important design parameters are altered/adjusted.

1.21 *What is meant by the term "robust" in the context of product design?*

A robust design is one which enables a product to consistently perform at or near its intended nominal level of performance despite varying conditions in the use environment. That is, it minimizes the effect of noise in the environment on the variation in performance of the product.

1.22 *What criterion does Taguchi recommend using when selecting nominal values for the controllable variables in a product/process design?*

Taguchi advocates selecting nominal values of the important design parameters so as to minimize the amount of noise/variation in the functional environment that is transmitted to the product's performance as it functions in field use.

1.23 *Relate the differences between the U.S. and Japanese design life cycles (Fig. 1.5) to the differences between the two countries' quality efforts by activity (Fig. 1.1). Which approach would seem to be more costly? Why?*

The Japanese have been known to:
- concentrate their efforts more on product development and design.
- have few or no design changes once production has begun.

U.S. companies have tended to:
- spend their effort on problem-solving during production.
- have a large amount of design changes after production has begun.

Design changes during production cause down-time and re-design of production lines, as well as higher warranty/repair costs for products already produced.

1.24 *What do you think is Taguchi's most important contribution in terms of his approach to quality design and improvement relative to the more traditional, Western approach to quality control?*

Taguchi's most important contribution is his attention to quality as a design issue not just a manufacturing issue, and in particular, his concept of robust/parameter design. By varying parameters through design of experiments to obtain a more robust/consistently functioning product rather than by tightening tolerances or using more expensive materials, quality as measured by performance in the field can be improved.

1.25 *The purpose of the Baldridge Award program is to improve quality and productivity in companies and organizations to achieve efficiency, competitiveness, and profitability. Hundreds have won the award since its inception. Collect information on at least 10 of these companies to make an evaluation of their success, particularly in terms of quality and productivity, since receiving the award.*

The NIST website (http://www.quality.nist.gov/) provides a list of all the Baldrige winners from 1988-2005. It also provides contacts, company/organization profiles, and in some cases award application summaries. The instructor may wish to assign specific companies/organizations with a balance among manufacturing, service, small and large businesses, education, and healthcare as well as balancing the organizations across the time period of the award.

1.26 *Describe each of the structural steps of DMADV of a Six Sigma program for product and process design.*

The DMADV approach to design consists of five phases (www.motorola.com):

- Define Requirements
  - Develop team charter
  - Clarify mission/vision/scope
  - Identify customer needs
  - Identify measurable CTQs (Critical to Quality characteristics)
  - Establish business case and decision tollgate process
  - Set design goals
- Measure Performance
  - Qualify measurements systems
  - Define performance metrics
  - Identify data sources
  - Quantify allowable variability
- Analyze Relationships
  - Prioritization
  - Develop initial transfer function models
  - Quantify variability
  - Develop CTQ flow-down
  - Identify innovative design alternatives
- Design Solution
  - Validate/refine transfer function models
  - Select among design alternatives
  - Identify trade-offs
  - Predict impact
  - Assess reliability/manufacturability
- Verify Functionality
  - Validate predictions
  - Identify and remediate failure modes
  - Conduct pilot/prototype and verify functionality
  - Demonstrate attainment of design goals and CTQs
  - Deliver detailed design

1.27 *Many different Six Sigma structures have been employed for applications, each with a somewhat different focus on certain aspects of process improvement. Compare two of these structures, DMAIC vs. DMADV, for their specific foci.*

DMAIC (Design-Measure-Analyze-Improve-Control) methodology is used when a process is in existence at the company, but it fails to meet the consumer specification and is not performing at the expected level of efficiency. It deals with incremental improvement in process.

DMADV (Define-Measure-Analyze-Design-Verify) methodology is used when a process is in not in existence at the company and a new process needs to be developed. DMADV is also used when the process is performing at an optimal level and still does not meet the consumer specifications. It involves improvement in methodology adopted for process.

A nice comparison of DMAIC and DMADV is provided by T. Pyzdek at http://www.pyzdek.com/DMAICDMADV.htm.

1.28 *What are some advantages and disadvantages of a quality certification program in general and of IS09000 in particular?*

The benefits of a quality certification program (e.g., ISO 9000) include consistent delivery of a product or service to a defined standard and improved bottom line performance and market credibility. The ISO 9000 quality management system can enable a company to increase profitability and customer satisfaction through reduced waste and rework, shortened cycle times, improved problem identification and resolution and improved supplier relations. Some organizations require ISO certification to achieve status as a preferred supplier. Some disadvantages, perceived or real, might include costly implementation, time-consuming documentation and maintenance of the program, and the need for both management and employee buy-in at all levels of the organization.

1.29 *Do you think a quality certification program such as ISO9000 ensures continuous improvement? Why? or Why not?*

Achievement of quality certification, e.g., ISO 9000, only means that the organization has formally put in place a system that meets the guidelines of the program and has demonstrated its ability to carry out the procedures of the certification program to the point of satisfying initial certification. From this point, it is the responsibility of management to insure that the procedures and methods of the program are institutionalized within the organization. It is likely that many organizations achieve certification to make them eligible to do business with a certain company or set of companies and superficially do what is necessary to keep that company happy. To truly improve competitive position will require that the company achieving certification use this step in the evolution of the firm to adopt and practice continuous improvement.

1.30 *Briefly explain the interconnections among the seven steps in the Baldrige Award model presented in this chapter.*

There are many articles and testimonials that can be found on the web that can be useful in understanding the Baldrige Award model and its seven steps. Instructors should encourage students to search the web (e.g., via Google) to find and read a number of these.
