QUALITY MANAGEMENT SYSTEMS: ISO 9000, SUPPLIER CERTIFICATION REQUIREMENTS, THE MALCOLM BALDRIGE AWARD, AND SIX SIGMA

MAJOR TOPICS
- Quality Management Systems
- ISO 9000
- Supplier Certification Requirements
- ISO 14000: Environmental Management
- Malcolm Baldrige National Quality Award
- Six Sigma
- Summary
- Lessons Learned
- Chapter Problems
- Case Study 3.1 Malcolm Baldrige Award Criteria

Throughout this text, different concepts, tools, and techniques will be presented. Individually, each concept, tool, and technique has merit and together they make up the supporting pieces of a total quality management system. ISO 9000, supplier certification requirements, Six Sigma, and the Malcolm Baldrige National Quality Award provide guidelines for a unified approach to quality and organizational management, encouraging companies to create their own quality systems. Each offers a road map for companies to follow in their quest for quality.
QUALITY MANAGEMENT SYSTEMS

To best fulfill customer needs, requirements, and expectations, organizations create and utilize quality management systems. Within a quality management system, the necessary ingredients exist to enable the organization’s employees to identify, design, develop, produce, deliver, and support products or services that the customer wants. A quality management system is dynamic. It is able to adapt and change to meet the needs, requirements, and expectations of its customers. The principles supporting a quality management system include: creating and maintaining a customer focus, involved leadership, an engaged workforce, process management and improvement, and fact-based decision-making. Managers of a quality management system coordinate the efforts of those in the system to effectively provide products or services for their customers. Quality management systems enable organizations to enhance their efficiency and effectiveness. Certification and registration validates compliance to a nationally recognized standard.

Management begins to develop a system by creating a vision or mission that sets the direction for the company. The vision is supported by strategies, which are in turn supported by goals and objectives. Developing and shaping visions, missions, strategies, goals, and objectives is a complicated process. Standards such as ISO 9000, methodologies like Six Sigma, and awards like the Malcolm Baldrige National Quality Award provide guidance for establishing a quality management system’s structure, maintaining records, and integrating the use of quality techniques. Quality systems like ISO 9000 and TS 16949 are basically asking that organizations say what they are going to do and then do what they say. These quality systems do not mandate particular policies, procedures, and actions. However, they ask organizations to document the policies and procedures they have and the actions they take. Comprehensive methodologies like Six Sigma create a mindset and an approach to doing business that has quality as its core. Awards like the Malcolm Baldrige National Quality Award provide guidelines for excellence. All will use the concepts, tools, and techniques provided in this text.

ISO 9000

Continued growth in international trade revealed the need for a set of quality standards to facilitate the relationship between suppliers and purchasers. The creation of the ISO 9000 series of international standards began in 1979 with the formation of a technical committee with participants from 20 countries. Named the International Organization for Standardization, this Geneva-based association continues to revise and update the standards on a regular schedule. The name “ISO 9000” has its origin in the Greek word *isos*, meaning “equal.” The intent of the standards is to make comparisons between companies equal. Note that ISO 9000 refers to the entire standard; when speaking of specific certification requirements, ISO 9001 is used.

The purpose of the ISO standards is to facilitate the multinational exchange of products and services by providing a clear set of quality system requirements. Companies competing on a global basis find it necessary to adopt and adhere to these standards. The standards provide a baseline against which an organization’s quality system can be judged. This baseline has as its foundation the achievement of customer satisfaction through multidisciplinary participation in quality improvement efforts, documentation of systems and procedures, and the basic structural elements necessary to quality systems. The generic nature of the standards allows the interested company to determine the specifics of how the standards apply to its organization. Many companies use ISO 9000 as the foundation for their continuous improvement efforts. ISO 9000 encourages organizations to develop, install, and utilize a quality management system that supports continuous improvement through the prevention of defects, and the reduction of variation and waste.

Accepted around the world, ISO 9000 is applicable to nearly all organizations large and small, including manufacturers of pieces, parts, assemblies, and finished goods; developers of software; producers of processed materials, including liquids, gases, solids, or combinations; municipalities; logistics providers (e.g., UPS, FedEx, DHL); hospitals; and service providers. The ISO organization estimates that, worldwide, 8 out of 10 cars contain parts or components designed or manufactured under the ISO 9000:2015 certification system. Since its inception, ISO 9000 has become an internationally accepted standard for quality in business-to-business dealings. More than a million organizations worldwide have attained certification.

In 2015, the ISO 9000 standards were revised significantly so that their structure more closely resembles the way organizations manage processes. ISO 9001:2015 takes a process-oriented approach rather than a product focus. A process approach applies to how an organization does the work it does. A product approach focuses primarily on the product produced. The standard encourages organizations to understand and manage how each process’ performance affects other related processes when those processes intersect and interact. Utilizing a process approach enables an organization to consistently meet customer requirements. Process-focused organizations understand the importance of value-added activities and effective process management. Broadly written, the ISO 9000 requirements describe what a company must accomplish in order to meet customer expectations. However, how these things are accomplished is left up to the particular company.

Ten key clauses comprise the ISO 9000:2015 standards. These clauses are:

- Scope
- Normative references
- Terms and definitions
- Context of the organization
- Leadership
Planning
Support
Operation
Performance evaluation
Improvement

Context of the organization refers to the needs, requirements, and expectations of the people and companies the organization regularly interacts with. This section also sets the scope of the quality management system. The leadership clause holds management accountable for the effectiveness of the organization. Within it, management roles, responsibilities, and authority are reviewed. The planning clause addresses the need to identify risks and opportunities as they relate to quality objectives. Support refers to the infrastructure, process environment, monitoring and measuring devices, and knowledge needs of the organization. The operation clause emphasizes the functions and processes of outside suppliers, including conformity of goods and services to requirements. Performance evaluation refers to evaluating processes using appropriate monitoring, measuring, and analysis procedures. The improvement clause encourages organizations to continue to work to a higher level of performance by monitoring, measuring, analyzing, and preventing nonconformities (Figure 3.1 and 3.2).

Documentation and record keeping are important aspects of ISO 9000. ISO 9000 requires records of many plant activities, including employee training records; procedures, policies, and instructions; process control charts and capability records; purchasing records; test and reliability data; audit records; incoming and final inspection records; and equipment calibration records. Companies following the ISO 9000 system need to keep records of any information that is useful in the operation of the organization. Evidence that procedures, policies, and instructions are being followed must also accompany these records. Essentially the organization’s quality management system must: say what the organization does, do what the organization says it will do, record what it did, verify the results, and take action on the difference.

Documentation often takes the form of standard operating procedures (SOP). An SOP will generally provide information at three levels. The overview level covers the purpose and the scope of the SOP. It may discuss organizational expectations and responsibilities as they relate to the procedure. The mid-level details definitions, policies, and describes the process at a high level. At the third level, detailed information, including a step-by-step description of the specific tasks in the process, are provided. Well-written SOPs tell people why it must be done (top level), what must be done (mid-level), and how it is to be done (base level).

The advantages of a fully documented quality management system are many. Documentation describes how work must be accomplished. Structured correctly, documentation will apply to a variety of situations, not just specific products. Documents serve as guides and ensure that work is performed consistently. Sound documentation can be used to determine and correct the causes of poor quality. Documentation defines existing work methods and provides a foundation for improvement.

In ISO 9000 a great deal of emphasis is placed on the need for excellent record keeping. In most cases, since the product has left the manufacturing facility or the service has been performed, only clearly kept records can serve as evidence of product or service quality. Sloppy or poorly
CHAPTER THREE

maintained records give the impression of poor quality. High-quality records are easy to retrieve, legible, appropriate, accurate, and complete. Necessary records may originate internally or be produced externally. Customer or technical specifications and regulatory requirements are considered external records. Internally produced records include forms, reports, drawings, meeting minutes, problem-solving documentation, and process control charts. A high-quality documentation control system will contain records that are easily identified and used in the decision-making process.

Companies seeking registration must have their compliance with the ISO 9001 criteria judged by an independent ISO 9000 certified registrar. Figure 3.3 shows the flow of a typical registration process. Before the ISO 9000 governing body grants certification, a registrar conducts a thorough audit to verify that the company does indeed meet the requirements as set forth in ISO 9001. When the company desiring accreditation feels it is ready, it invites an auditor to observe the company’s operations and determine its level of compliance with the standards. Many firms find that conducting an internal audit before the actual registrar visit is more effective than a single audit. During this pre-audit, deficiencies in the company’s methods can be identified and corrected prior to the registrar’s official visit. Registrars seek to determine if the actions taken by an organization have been effective at meeting or exceeding the requirements established by the standard. They investigate whether the organization effectively operates and controls processes. Management systems are reviewed to determine their effectiveness. Once registration has been achieved, surveillance audits are conducted, often unannounced, approximately every six months. These audits are intended to ensure continued compliance. When preparing for a certification audit, a company must develop an implementation plan that identifies the people involved and defines their roles, responsibilities, deliverables, timelines, and budgets. Once created, the plan is managed through frequent review meetings to determine the progress. Once the system has been fully documented, the company will contact a registrar and plan his or her visit.

Companies wishing to implement ISO 9000 should determine management’s level of commitment. Management support can be gained by pointing out the benefits of compliance. Assess the company’s current situation. What are the present costs associated with poor quality as evidenced by scrap or rework or lost customers? What new markets could open up if certification were achieved? The answers to these questions will show how achieving ISO 9001 certification will benefit the bottom line.

Obtaining ISO 9001 certification provides many benefits. Companies that have achieved certification cite increased revenue as a major benefit. Since ISO 9000 is recognized globally, certification allows these companies to expand their geographic markets. They are also able to service new customers who require ISO 9000 compliance from their suppliers. Additionally, existing customers benefit from ISO 9001 certification. Companies complying with ISO 9001 requirements have been able to improve their product and service quality and pass the benefits on to their customers. Internally, companies benefit from compliance. Reduced costs are evidenced through decreased...
<table>
<thead>
<tr>
<th>Step</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Decide to implement ISO 9000</td>
</tr>
<tr>
<td>2.</td>
<td>Form management committee</td>
</tr>
<tr>
<td>3.</td>
<td>Develop strategic plan</td>
</tr>
<tr>
<td>4.</td>
<td>Begin ISO 9000 training</td>
</tr>
<tr>
<td>5.</td>
<td>Educate workforce</td>
</tr>
<tr>
<td>6.</td>
<td>Do cost assessment</td>
</tr>
<tr>
<td>7.</td>
<td>Do self-assessment</td>
</tr>
<tr>
<td>8.</td>
<td>Establish steering committee</td>
</tr>
<tr>
<td>9.</td>
<td>Communicate intentions to entire corporation</td>
</tr>
<tr>
<td>10.</td>
<td>Select and train audit teams</td>
</tr>
<tr>
<td>11.</td>
<td>Continue ISO 9000 training</td>
</tr>
<tr>
<td>12.</td>
<td>Continue education</td>
</tr>
<tr>
<td>13.</td>
<td>Begin implementing standards</td>
</tr>
<tr>
<td>14.</td>
<td>Conduct internal audits</td>
</tr>
<tr>
<td>15.</td>
<td>Organize quality system</td>
</tr>
<tr>
<td>16.</td>
<td>Select registrar</td>
</tr>
<tr>
<td>17.</td>
<td>Continue to train audit teams</td>
</tr>
<tr>
<td>18.</td>
<td>Continue ISO 9000 training</td>
</tr>
<tr>
<td>19.</td>
<td>Continue education</td>
</tr>
<tr>
<td>20.</td>
<td>Define areas for improvement</td>
</tr>
<tr>
<td>21.</td>
<td>Continue internal audits</td>
</tr>
<tr>
<td>22.</td>
<td>Begin documentation:</td>
</tr>
<tr>
<td>23.</td>
<td>Analyze processes</td>
</tr>
<tr>
<td>24.</td>
<td>Write procedures</td>
</tr>
<tr>
<td>25.</td>
<td>Continue to train audit teams</td>
</tr>
<tr>
<td>26.</td>
<td>Continue ISO 9000 training</td>
</tr>
<tr>
<td>27.</td>
<td>Continue education</td>
</tr>
<tr>
<td>28.</td>
<td>Create quality manual</td>
</tr>
<tr>
<td>29.</td>
<td>Implement New Procedures</td>
</tr>
<tr>
<td>30.</td>
<td>Conduct internal audits</td>
</tr>
<tr>
<td>31.</td>
<td>Conduct registration assessment</td>
</tr>
<tr>
<td>32.</td>
<td>Revise, improve, update, review, take corrective action based on initial visit</td>
</tr>
<tr>
<td>33.</td>
<td>Revise quality manual</td>
</tr>
<tr>
<td>34.</td>
<td>Conduct management review</td>
</tr>
<tr>
<td>35.</td>
<td>Begin pre-assessment procedures</td>
</tr>
<tr>
<td>36.</td>
<td>Correct deficiencies</td>
</tr>
<tr>
<td>37.</td>
<td>Document and implement practices</td>
</tr>
<tr>
<td>38.</td>
<td>Revise quality manual</td>
</tr>
<tr>
<td>39.</td>
<td>Conduct management review</td>
</tr>
<tr>
<td>40.</td>
<td>Complete registration</td>
</tr>
<tr>
<td>41.</td>
<td>Strive for continuous improvement</td>
</tr>
<tr>
<td>42.</td>
<td>Conduct surveillance audits</td>
</tr>
<tr>
<td>43.</td>
<td>Conduct management reviews</td>
</tr>
</tbody>
</table>

**FIGURE 3.3** ISO 9000 Registration Cycle
scrap and rework, fewer warranty claims, improved customer satisfaction, reduced customer support costs, and improved productivity.

Obtaining ISO 9001 certification is a time-consuming and costly process. Depending on the current state of an organization’s quality system, preparation for certification may take several thousand employee-hours and cost thousands of dollars. Costs depend on the company size, the strength of the organization’s existing quality system, and the number of plants within the company requesting certification.

As with any major process improvement, the opportunity to fail exists. Attempts to incorporate ISO 9001 into the way a company does business may be hindered by a variety of forces, including insufficient management involvement in the process, inadequate resources, lack of an implementation plan, or lack of understanding about ISO 9000 and its benefits. This last force, a lack of understanding about ISO 9000, is particularly crucial. ISO 9001 certification requires significant documentation. The additional burden of paperwork, without an understanding of how this newfound information can be used in decision-making, leads to problems. It is important to realize that standardized procedures and organized information go a long way toward preventing errors that lead to poor quality products and services. Individuals who are unaware of how to access the power that procedures and information provide may miss out on improvement opportunities. It is up to management to encourage the use of this information, thus gaining the maximum benefits from ISO 9000.

The high cost of certification is counterbalanced by the benefits of an organization will receive by using the requirements as a guide to improve their processes. Quality becomes more consistent, and the percentage of “done right the first time” jobs increases. Improved procedures and removal of redundant operations also dramatically improve a company’s effectiveness. ISO 9000 standards facilitate international trade and dramatically improve record-keeping. To learn more about ISO 9000, visit the ISO website at www.iso.org or at the American Society for Quality www.asq.org.

**SUPPLIER CERTIFICATION REQUIREMENTS**

Major corporations often purchase raw materials, parts, subassemblies, and assemblies from outside sources. To ensure quality products, the suppliers of these parts and materials are subjected to rigorous requirements. Purchasers establish these requirements and judge conformance to them by visiting the supplier’s plant site and reviewing the supplier’s quality systems. Quality management systems like ISO 9000, TL 9000, ISO/TS 16949, ISO/IEC 17025, and AS 9100 document organizational policies, procedures, work instructions, and forms.

Among motor vehicle manufacturers, though purchasers developed their own requirements, strong similarities existed in quality system and documentation requirements. Redundant requirements and multiple plant visits from purchasers placed a significant burden on suppliers. Conforming to several different, yet similar, sets of requirements meant unnecessarily expended time, effort, and money. Recognizing the overlap in requirements, the major automotive manufacturers—General Motors, Ford, and Chrysler—as well as truck manufacturers, created a task force in the early 1990s to develop a quality system that has as its foundation ISO 9000. Named “Quality System Requirements QS 9000,” this comprehensive requirement was intended to develop fundamental quality systems that provide for continuous improvement. QS 9000 eliminated redundant requirements while maintaining customer-specific, division-specific, and commodity-specific requirements. QS 9000 emphasized defect prevention as well as the reduction of variation and waste. Today, companies and their internal and external suppliers of production and service parts, subassemblies, materials, components, or other items to the major motor vehicle manufacturers choose to conform to ISO 9000 or TS 16949.

Though QS 9000 established customer requirements for several of the major automotive manufacturers, QS 9000 was not an international specification. To fill the need for a global automotive system, in 1999, ISO introduced ISO/TS 16949, Quality Management Systems: Automotive Suppliers—Particular Requirements for the Application of ISO 9001:2015 for Automotive Production and Relevant Service Part Organizations. Developed by the International Automotive Oversight Bureau and submitted to ISO for approval and publication, ISO/TS 16949 defines automotive industry standards worldwide. ISO/TS 16949 aligns existing automotive systems around the world, including AVSQ (Italian), EAQF (French), QS 9000 (U.S.), and VDA6.1 (German) systems. ISO/TS 16949 does not replace AVSQ, EAQF, QS 9000, or VDA6.1; it is a global set of standards presented as an option to these systems. Linked to ISO 9000:2015 and revised in 2016, the document allows automotive companies to retain individual control over more of the specific requirements. The document includes terms and definitions specific to the automotive industry; requirements related to engineering specifications and records retention; process efficiency expectations; product design skills and training related to human resources management; product realization, acceptance, and change control requirements; and customer-designated special characteristics. Specific clauses focus on leadership, planning, support, operations, performance evaluation, and improvement. For more information concerning ISO/TS 16949, contact the Automotive Industry Action Group at www.aiag.org.

While ISO 9001 is the best known of the quality systems certifications, other quality management systems certifications have been developed in a variety of industries. As the benefits of utilizing an organized quality management system become better known, an increasing number of business sectors will create appropriate standards.
ISO 9000 at JRPS

As a small job shop, JRPS had few formalized systems and processes. Under new leadership changes focus on standardizing the way they do business. Having become familiar with quality systems like ISO 9000 and ISO 16949 at their previous positions, JRPS leadership understood the challenge before them. To achieve ISO 9001 certification, an organization must set up standard procedures and document their processes and practices. They feel ISO 9001 certification will bring them several benefits. The standards will guide them as they establish the foundation of a good quality system. Maintaining certification involves reviewing and improving existing systems and processes. These activities will keep them in a proactive mode. The greatest benefit they see is that the highly recognized standard will provide them with access to a broader range of customers.

To begin their pursuit of ISO 9000 certification, leadership worked with an ISO 9000 consultant to lay out a three-year strategic plan. As a starting point, they identified their key processes as:
Benchmarking is a continuous process of measuring products, services, and practices against competitors or industry leaders. Benchmarking lets an organization know where they stand compared with others in their industry. Companies also use the award guidelines to determine a baseline. Baselining is measuring the current level of quality in an organization. Baselines are used to show where a company is, so that it knows where it should concentrate its improvement efforts.

The Malcolm Baldrige National Quality Award focuses on organizational results, customers and workforce, and on an organization’s strategy for the future. The award focuses on the following key areas: leadership, strategy, customers, workforce, operations, measurement, analysis, and knowledge management, and results (Figure 3.4).

The following descriptions are paraphrased from the Malcolm Baldrige National Quality Award criteria.

1.0 Leadership The criteria in Section 1.0 are used to examine senior-level management’s commitment to and involvement in process improvement. Company leaders are expected to develop and sustain a customer focus supported by visible actions and values on their part. This section also examines how the organization addresses its responsibilities to the public and exhibits good citizenship. This section also addresses the role of senior leadership and an organization’s governance and how it handles social responsibilities like conservation of natural resources, community support, and other public concerns.

2.0 Strategy To score well in this category, a company needs to have sound strategy development and strategy implementation process in place. Strategic thinking supports organizational excellence. Key aspects to this section include customer-focused excellence, operational performance improvement and innovation, and organizational learning and learning by workforce members. Leaders are...
expected to consider strategic opportunities, challenges, and risks while they optimize the use of resources including a skilled workforce.

**3.0 Customers** The third category of the Baldrige Award criteria deals with the company’s relationship with its customers. How well does the organization listen to the voice of the customer? This category focuses on a company’s knowledge of customer requirements, expectations, and preferences as well as marketplace competitiveness. In other words, does the organization capture actionable information from the customer? The criteria also seeks to determine if the company has put this knowledge to work in the improvement of their products, processes, systems, and services. Success in this category leads to improved customer engagement through customer acquisition, satisfaction, and retention. This category clarifies a company’s commitment to its customers.

**4.0 Measurement, Analysis, and Knowledge Management** The award recognizes that information is only useful when it is put to work to identify areas for improvement. This category investigates a company’s use of information and performance measurement systems to encourage excellence. Performance information must be used to improve operational competitiveness. Competitive comparisons and benchmarking are encouraged to review and analyze organizational performance. Areas of interest include measurement, analysis, and improvement of organizational performance, and knowledge management information, and information technology.

**5.0 Workforce** Reviewers for the Baldrige Award are interested in a company’s plans and actions that enable its workforce to perform to the fullest potential in alignment with the company’s overall strategic objectives. How does the workforce support and improve its workforce capability and capacity? Employee involvement, education, training, and recognition are considered in this category. A company’s work environment receives careful scrutiny in an effort to determine how the company has built and maintains a work environment conducive to performance excellence as well as personal and organizational growth. Subcategories include workforce engagement and workforce environment.

**6.0 Operations** Within this category, the company is judged on how it designs and manages the work performed, product design and delivery, innovation, and operational effectiveness. Companies must provide details on their key business processes as they relate to customers, products, and service delivery. Topics of interest include: work processes and operational effectiveness.

**7.0 Results** Ultimately, the purpose of being in business is to stay in business. This category examines a company’s performance and improvement in several key business areas including customer satisfaction, product and service performance, financial and marketplace performance, human resources, and operational performance. Benchmarking is encouraged to see how the company compares with its competitors. Areas of interest are product and process results, customer-focused results, financial and market results, workforce-focused results, and leadership and governance results.

The criteria for the Malcolm Baldrige Award are updated annually. Recipients of the award are from a variety of industries, including telecommunications, banking, automotive, hospitality industry, education, hospitals, building products, and manufacturing (Figure 3.5). For more information about the award criteria, contact the U.S. Commerce Department’s National Institute of Standards and Technology at www.nist.gov. For a complete list of Malcolm Baldrige National Quality Award recipients, including organization profiles and contact data, visit www.quality.nist.gov.

**SIX SIGMA**

In the 1990s, a concept entitled Six Sigma was conceived by Bill Smith, a reliability engineer for Motorola Corporation. His research led him to believe that the increasing complexity of systems and products used by consumers created higher-than-desired system failure rates. In “Reliability,” we learned that to increase system reliability and reduce failure rates, the components utilized in complex systems and products have to have individual failure rates approaching zero. With this in mind, Smith took a holistic view of reliability and quality and developed a strategy for improving both. Smith worked with others to develop...
Manufacturing
Motorola Commercial, Government & Industrial Solutions Sector
Clarke American Checks, Inc.
Dana Corporation–Spicer Driveshaft Division
ST Microelectronics, Inc. Region Americas
Boeing Airlift and Tanker Programs
Solar Turbines Incorporated
3M Dental Product Division
Soletron Corporation
ADAC Laboratories
Armstrong World Industries, Inc., Building Products Operations
AT&T Network Systems Group Transmission Systems Business Unit
Texas Instruments Incorporated Defense Systems & Electronics Group
Eastman Chemical Company
Cadillac Motor Car Company
Westinghouse Electric Corporation Commercial Nuclear Fuel Division
Xerox Corporation, Business Products Systems
IBM Rochester

Service
PricewaterhouseCoopers Public Sector Practice
Caterpillar Financial Services Corporation—United States.
Boeing Aerospace Support
Operations Management International, Inc.
Merrill Lynch Credit Corporation
Dana Commercial Credit Corporation
Verizon Information Services
AT&T Universal Card Services
The Ritz-Carlton Hotel Company
Federal Express Corporation

Small Business
Sunny Fresh Foods
Branch-Smith Printing Division
Pal’s Sudden Service
Wallace Co., Inc.
Globe Metallurgical, Inc.
Granite Rock Company
Ames Rubber Corporation
Texas Nameplate Company, Inc.
Los Alamos National Bank
Trident Precision Manufacturing, Inc.
Lockheed Martin Missiles and Fire Control

Healthcare
Hill Country Memorial
St. David’s HealthCare
Baptist Hospital, Inc.
St. Luke’s Hospital of Kansas City
SSM Health Care

Education
Community Consolidated School District 15
Pearl River School District
University of Wisconsin-Stout
Chugach School District
Pewaukee School District

Nonprofit
Elevations Credit Union
City of Irving, Texas
Concordia Publishing House

FIGURE 3.5  Partial List of Malcolm Baldrige National Quality Award Winners since 1988
Source: The National Institute of Standards and Technology, 1988

the Six Sigma Breakthrough Strategy, which is essentially a highly focused system of problem solving. Six Sigma’s goal is to reach 3.4 defects per million opportunities over the long term. Figure 3.6 shows the impact of achieving 6σ levels of process performance. Did you know that, according to data published by ASQ, correct prescription writing, correct restaurant bill calculation, and proper airline baggage handling takes place at the 4σ? Automotive expectation of quality exceed 5σ, as do safe aircraft carrier landings. Domestic airline fatality rates nearly reach 7σ.

Six Sigma is about results, enhancing profitability through improved quality and efficiency. At the strategic business level, upper management must decide to implement Six Sigma. They set strategic business goals and metrics. At the operational process level, middle managers translate strategic business goals into process goals and measures. They also identify process problems and projects. At the project level, employees obtain green and black belt certifications while working on improvement projects throughout the organization.

Six Sigma seeks to reduce the variability present in processes. Improvement projects are chosen based on their ability to contribute to the bottom line on a company’s income statement. Projects should be connected to the strategic objectives and goals of the corporation. Projects that do not directly tie to customer issues or financial results are often difficult to sell to management. Six Sigma projects are easy to identify. They seek out sources of waste such as overtime and warranty claims; investigate production backlogs or areas in need of more capacity; and focus on customer and environmental issues. With high-volume products even small improvements can produce a significant impact on the financial statement. When choosing a Six Sigma project or any improvement project, care should be taken to avoid poorly defined objectives or metrics. Key business metrics include revenue dollars, labor rates, fixed and variable unit costs, gross margin rates, operating margin rates, inventory costs, general and administrative expenses, cash flow, warranty costs, product liability costs, and cost avoidance. The following example provides information about how to choose a project.

Example 3.1  Justifying a Project
Queensville Manufacturing Corporation creates specialty packaging for automotive industry suppliers. The project team has been working to improve a particularly tough packaging problem involving transporting finished transmissions to the original equipment manufacturer (OEM). Company management has told the team that several key projects, including theirs, are competing for funding. To ensure acceptance of their project, the team wants to develop strong metrics to show how investment in their project will result in significant cost savings and improved customer satisfaction through increased quality. After brainstorming about their project, the team developed the following list of objectives and metrics for their project.
Six Sigma projects have eight essential phases: recognize, define, measure, analyze, improve, control, standardize, and integrate. This cycle is sometimes expressed as DMAIC (define, measure, analyze, improve, control). As Figure 3.7 shows, the generic steps for Six Sigma project implementation are similar to the problem-solving steps presented in this chapter. The tools utilized during a project include statistical process control techniques, customer input, failure modes and effects analysis, design of experiments, process mapping, cause-and-effect diagrams, multivariate analysis, pre-control, and design for manufacturability. Six Sigma also places a heavy reliance on graphical methods for analysis. The Six Sigma methodology is implemented in a variety of circumstances; some companies will change these steps to suit their needs. As with any strategy, a variety of acronyms exist (Figure 3.8).

Motorola Corporation utilizes terminology from Karate as a method to designate the experience and ability levels of Six Sigma project participants. Green Belts are individuals who have completed a designated number of hours of training in the Six Sigma methodology. To achieve Green Belt status, a participant must also complete a cost-savings project of a specified size, often $10,000, within a stipulated amount of time. Black Belts are individuals with extensive training in the Six Sigma methodology. Before becoming a Black Belt, an individual must have completed a specified number of successful projects under the guidance and direction of Master Black Belts. Often companies expect the improvement projects overseen by a Black Belt to result in savings of $100,000 or more. Master Black Belts are individuals with extensive training who have completed a large-scale improvement project, usually saving $1,000,000 or more for the company. Often before designating someone a Master Black Belt, a company will...
require a Master's Degree from an accredited university. Master Black Belts provide training and guide trainees during their projects. Figure 3.9 shows the responsibilities of project participants.

It is important to understand the origin of the term Six Sigma. Six Sigma is a methodology, $6\sigma$ is the value used to calculate process capability, $C_p$. The spread of a distribution of average process measurements can only be compared with the specifications set for the process using $C_p$, where

$$C_p = \frac{USL - LSL}{6\sigma}$$

When $6\sigma = USL - LSL$, process capability $C_p = 1$. When this happens, the process is considered to be operating at $3\sigma$. Three standard deviations added to the average value will equal the upper specification limit, and three standard deviations subtracted from the average value will equal the lower specification limit (Figure 3.10). When $C_p = 1$, the process is capable of producing products that conform to specifications provided that the variation present in the process does not increase and that the average value equals the target value. In other words, the average cannot shift. That is a lot to ask from a process, so those operating processes often reduce the amount of variation present in the process so that $6\sigma < USL - LSL$.

Some companies choose to add a design margin of 25 percent to allow for process shifts, requiring that the parts produced vary 25 percent less than the specifications allow. A 25 percent margin results in a $C_p = 1.33$. When $C_p = 1.33$, the process is considered to be operating at $4\sigma$. Four standard deviations added to the average value

<table>
<thead>
<tr>
<th>Responsibility</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>Recognize</td>
</tr>
<tr>
<td>Management/Master Black Belts</td>
<td>Define</td>
</tr>
<tr>
<td>Black Belts/Green Belts</td>
<td>Measure</td>
</tr>
<tr>
<td>Black Belts/Green Belts</td>
<td>Analyze</td>
</tr>
<tr>
<td>Black Belts/Green Belts</td>
<td>Improve</td>
</tr>
<tr>
<td>Black Belts/Green Belts</td>
<td>Control</td>
</tr>
<tr>
<td>Management</td>
<td>Standardize</td>
</tr>
<tr>
<td>Management</td>
<td>Integrate</td>
</tr>
</tbody>
</table>

FIGURE 3.9 Six Sigma Responsibility Matrix
Quality Management Systems 57

will equal the upper specification limit, and four standard deviations subtracted from the average value will equal the lower specification limit. This concept can be repeated for $5\sigma$ and $C_p = 1.66$.

When $C_p = 2.00$, $6\sigma$ has been achieved. Six standard deviations added to the average value will equal the upper specification limit, and six standard deviations subtracted from the average value will equal the lower specification limit (Figure 3.11). Those who developed the Six Sigma methodology felt that a value of $C_p = 2.00$ provides adequate protection against the possibilities of a process mean shift or an increase in variation. Operating at a $6\sigma$ level also enables a company’s production to have virtually zero defects. The long-term expectation for the number of defects per million opportunities is 3.4. Compare this to a process that is operating at $3\sigma$ and centered. Such a process will have a number of defectives per million opportunities of 1,350 out of each side of the specification limits for a total of 2,700. If the process center were to shift 1.5$\sigma$, the total number of defectives per million opportunities at the $3\sigma$ level would be 66,807. A process operating at $4\sigma$ will have 6,210 defects per million opportunities over the long term, whereas a process operating at the $5\sigma$ level will have 233 defects per million opportunities long term. The formula for long-term $\sigma$ is

$$\sigma = \text{Normsinv}(1 - [\text{DPMO}/1,000,000]) + 1.5$$

Even if the cost to correct the defect is only $100, operating at the $3\sigma$ level while experiencing a process shift will cost a company $6,680,700 per million parts. Improving performance to $4\sigma$ reduces that amount to $621,000 per million parts produced. Six $\sigma$ performance costs just $340 per million parts.

Selecting the right metrics, the right thing to measure, is critical when working to improve process performance. Measures or metrics enable users to quantify the amount of improvement taking place. It is important that metrics be critical to quality. In other words, they need to be linked to bottom-line results. Six Sigma practitioners use many different quality metrics in decision-making. These include:

- $C_{pk}$ (the distance from the process average to the nearest specification limit divided by $3\sigma$)
- Cost of poor quality (the costs associated with failure)
- Sigma level (the number of standard deviations to the nearest specification limit)

Defects per million opportunities

As with any process improvement methodology, there are issues that need to be examined carefully. One criticism is that Six Sigma methodology does not offer anything new. Comparisons have been made between ISO 9000 and Six Sigma, continuous improvement strategies and Six Sigma strategies, and significant similarities exist (Table 3.1). Comparisons have also been made between Master Black Belt qualifications and the qualifications for a certified quality engineer (CQE). Once again, the similarities are striking (Table 3.2). Other certifications available through ASQ (www.asq.org) include certified quality technician, certified quality engineer, and certified quality manager.

Another criticism is the focus on defectives per million. Can we really call them defectives? The term itself brings to mind product liability issues. How does a customer view a company that is focused on counting defectives? Should defect counts be seen as the focus or are companies really trying to focus on process improvement?

The Six Sigma methodology encourages companies to take a customer focus and improve their business processes. Using DMAIC as a guideline, companies seek opportunities to enhance their ability to do business. Process improvement of any kind leads to benefits for the company from the reduction of waste, costs, and lost opportunities. Ultimately, it is the customer who enjoys enhanced quality and reduced costs.

![Figure 3.11](https://example.com/figure3_11.png) The Value of $6\sigma$ Occurs When $6\sigma < \text{USL} - \text{LSL}$, Process Capability, $C_p = 2$
### TABLE 3.1 Comparison of ISO 9000, the Malcolm Baldrige Award Criteria, and Continuous Improvement/Quality Management

<table>
<thead>
<tr>
<th>ISO 9000</th>
<th>Baldrige Award</th>
<th>CI/QM</th>
<th>Six Sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope</td>
<td>Quality management system Continuous improvement</td>
<td>Quality of management</td>
<td>Quality management and corporate citizenship Continuous improvement</td>
</tr>
<tr>
<td>Basis for defining quality</td>
<td>Features and characteristics of product or service</td>
<td>Customer-driven</td>
<td>Customer-driven</td>
</tr>
<tr>
<td>Purpose</td>
<td>Clear quality management system requirements for international cooperation</td>
<td>Results-driven competitiveness through total quality management</td>
<td>Continuous improvement of customer service</td>
</tr>
<tr>
<td>Assessment</td>
<td>Requirements based</td>
<td>Performance based</td>
<td>Based on total organizational commitment to quality</td>
</tr>
<tr>
<td>Focus</td>
<td>International trade Quality links between suppliers and purchasers Record keeping</td>
<td>Customer satisfaction Competitive comparisons</td>
<td>Processes needed to satisfy internal and external customers</td>
</tr>
</tbody>
</table>

### TABLE 3.2 Body of Knowledge Comparison of CQE and Black Belt Certification

<table>
<thead>
<tr>
<th>Category</th>
<th>ASQ Certified Quality Engineer (CQE) Certification Requirements</th>
<th>Black Belt Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>Management and Leadership in Quality Engineering</td>
<td>Enterprise-Wide Deployment</td>
</tr>
<tr>
<td>Product Design</td>
<td>Product and Process Design</td>
<td>Design for Six Sigma</td>
</tr>
<tr>
<td>Quality Management Systems</td>
<td>Quality Systems Development, Implementation, and Verification</td>
<td>Not covered</td>
</tr>
<tr>
<td>Quality Assurance</td>
<td>Planning, Controlling, and Assuring Product and Process Quality, Costs of Quality and Quality Audits</td>
<td>Not covered</td>
</tr>
<tr>
<td>Reliability</td>
<td>Reliability, Risk Management and Maintainability</td>
<td>Reliability</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Problem Solving and Quality Improvement</td>
<td>Define-Measure-Analyze-Improve-Control</td>
</tr>
<tr>
<td>Quality Tools</td>
<td>Problem Solving and Quality Improvement</td>
<td>DMAIC</td>
</tr>
<tr>
<td>Project Management</td>
<td>Not covered</td>
<td>Project Management</td>
</tr>
<tr>
<td>Team Concepts</td>
<td>Not covered</td>
<td>Team Leadership</td>
</tr>
<tr>
<td>Statistical Methods</td>
<td>Probability and Statistics Collecting, Summarizing, and Decision-making</td>
<td>Probability and Statistics Collecting, Summarizing, and Decision-making</td>
</tr>
<tr>
<td>Design of Experiments</td>
<td>Design of Experiments</td>
<td>Design of Experiments</td>
</tr>
<tr>
<td>Statistical Process Control</td>
<td>Statistical Process Control</td>
<td>Statistical Process Control</td>
</tr>
<tr>
<td>Lean Manufacturing</td>
<td>Not covered</td>
<td>Lean Enterprise</td>
</tr>
<tr>
<td>Other Techniques</td>
<td>FMEA, FMECA, FTA</td>
<td>FMEA, QFD Multivariate Studies</td>
</tr>
</tbody>
</table>

### Becoming a Black Belt

Following graduation, Chris joined a multinational logistics organization. Early on, his manager encouraged him to further his education by becoming a Six Sigma Green Belt. Since his college program of study had included a four-course series in quality assurance, Chris felt confident that he was well prepared for this adventure. When he began his Green Belt certification process in the fall, his classes included exposure to the quality tools listed in Figure 3.12. Since his training was really a review of his college
Six Sigma Principles
Lean Concepts and Principles
Quality Philosophies
Performance Measures/Metrics
Value-stream Process Mapping
Problem-solving and Problem-solving tools
  Check Sheets
  Pareto Chart
  Cause-and-Effect Diagram Analysis
  Scatter Diagrams
Statistical Process Control
  Frequency Diagrams
  Histograms
  Statistics
  Data Collection
  Data types and sampling techniques
  X and R charts
  Process Capability Analysis
  P, u, c charts
  Root Cause Analysis
  Variation Reduction
  Multi-vari studies
  Hypothesis testing
Design of Experiments Basics
Design for Six Sigma (DFSS)
Failure Modes and Effects Analysis
Project Management
Voice of the Customer
Benchmarking
Teams
Lean Tools
Green Belt Project

FIGURE 3.12 Training Typically Required for Green Belt Certification
Source: Donna C. Summers, Quality, 6e, © 2018, Pearson Education, Inc., New York, NY

Malcolm Baldrige Award is an integrated approach that uses results-based performance assessments to improve competitiveness, whereas the ISO 9000 standards focus on functional requirements and record keeping to support international cooperation. Six Sigma drives improvement focused on the bottom line. None of these has the clear continuous improvement mandate that characterizes a total quality system. The Baldrige Award criteria, which set standards for leadership and customer-driven quality, most closely reflect the total quality concept.

Organizational leadership must understand that quality improvement initiatives are about achieving long-term, sustained changes. These efforts take time and are not
short-term fixes. Continuous improvement efforts, Six Sigma, and ISO 9000 are based on quality improvement principles that complement each other. Regardless of which approach an organization takes, all quality management systems stress eight key principles:

- **Customer focus:** identifying customer expectations
- **Process improvement based on customer expectations**
- **Fact-based decision-making:** measures critical to customer expectations
- **Systems approach to management:** tracking measures
- **Leadership:** commitment to excellence
- **Involvement of people**
- **Continuous improvement**
- **Mutually beneficial supplier relationships**

**LESSONS LEARNED**

1. ISO 9000 is a requirements-based assessment that supports the development of a quality management system.
2. ISO 9000 standards focus on functional requirements and record keeping to support international cooperation in business-to-business dealings.
3. Quality systems like TS 16949 combine requirements from ISO 9000 with sector- and customer-specific requirements.
4. Many quality systems require that suppliers create, document, and implement a quality management system.
5. ISO 14000 is primarily focused on the efforts made by an organization to minimize any harmful impact on the environment that its business activities may cause.
6. Six Sigma is a methodology that seeks to improve profits through improved quality and efficiency.
7. Companies competing for the Malcolm Baldrige National Quality Award must perform well in the following categories: leadership; strategy; customers; measurement, analysis, and knowledge management; workforce; operations; results.
8. The Malcolm Baldrige Award uses results-based performance assessments to improve competitiveness.
9. The Baldrige Award criteria, with their standards for leadership and customer-driven quality, most closely reflect the total quality system.

**CHAPTER PROBLEMS**

**QUALITY SYSTEMS**

1. What is meant by the term quality system?
2. Why would a quality system be critical to providing a quality product or service?
3. What attributes would you expect to be present in a company that has a sound quality system?
4. Describe the quality system that existed at your most recent place of employment. How would you rate its effectiveness? Support your rating with examples.

ISO 9000/ISO 14000

5. Describe which types of companies would use ISO 9001.
6. Find an article about a company that is in the process of achieving or has achieved ISO 9000 or ISO 14000 certification. What were the steps that they had to take? What difficulties did they encounter?
7. Contact a local company that is in the process of achieving or has achieved ISO 9000 or ISO 14000 certification. What were the steps that they had to take? What difficulties did they encounter?
8. Describe the differences between the ISO 9000 series of requirements and the requirements for TS 16949.
9. Consider your current place of employment or where you were employed in the past. How would implementing ISO 9000 improve the way your organization does business?
10. Describe ISO 14000 to someone who has not heard of it.
11. What are the benefits of certification?
12. Describe the registration process.
13. Why is record keeping important? What types of records do certified organizations keep?

MALCOLM BALDRIGE

14. Describe the main premise of each of the criteria for the Malcolm Baldrige Award.
15. Research a Malcolm Baldrige Award winner. What did they have to change about their quality system in order to become a winner? What did they consider the most important criterion? Why? How did they go about achieving that criterion?
16. Discuss the differences among ISO 9000, the Baldrige Award, and Six Sigma.
17. Why is the Malcolm Baldrige National Quality Award the most comprehensive guide to organization-wide improvement? What does it have that ISO 9000 and Six Sigma lack?

SIX SIGMA

18. Describe the Six Sigma concept.
19. How does Six Sigma bring about a reduction of defects?
20. What tools does Six Sigma use?
21. How are Six Sigma projects selected?
22. Describe the differences among Green Belts, Black Belts, and Master Black Belts.
Malcolm Baldrige Award Criteria

Many firms have implemented comprehensive quality improvement programs. Recent articles in trade publications as well as nationally known magazines such as Forbes, BusinessWeek, and Newsweek have reported on what these companies have been doing in the area of quality.

Assignment

Read one or more comprehensive articles from a current business or news magazine and on the basis of your reading assess the quality improvement activities of one company. Choose one of the seven areas found in the Malcolm Baldrige Award criteria and make your assessment along the same guidelines. You may wish to strengthen your assessment by contacting the company itself. Use the following questions to aid you in investigating the firm.

1. Leadership
   a. What is the attitude and involvement of top management? How is this visible? Check top management’s understanding of quality, their investment of time and money in quality issues, their willingness to seek help on quality management, their support of each other and subordinates, the level of importance they place on quality, and their participation in quality process.
   b. What importance does the company management place on developing a quality culture? How is this visible? Check their understanding of quality, their investment of time and money in quality issues, their willingness to seek help on quality management, their support of each other and subordinates, the level of importance they place on quality, and their training of employees.
   c. What is your perception of importance of quality to this company? How is this visible? Is the company’s position based on eliminating defects by inspection? judging cost of quality by scrap and rework? or preventing defects through design of process and product?
   d. Does the organization address the need for a responsible, informed, transparent, and accountable governing body that protects the interests of key stakeholders?
   e. Is the organization societally responsible? How does the organization address legal compliance, ethics, risks, public concerns, conservation of natural resources, and other societal concerns?

2. Strategy
   a. What importance does the company place on quality in its strategic planning? How is this visible? Check management’s understanding of customer-focused excellence, operational performance improvement and innovation, organizational learning, quality, their investment of time and money in quality issues, how their interest is reflected in the strategic plan, the level of importance they assign the strategic plan, and whether quality control is evident throughout the plan or in just one section.
   b. How does the company develop and implement their plans and strategies for the short term? for the long term?
   c. Which benchmarks does the company use to measure quality? Are the benchmarks relative to the market leader or to competitors in general? What are management’s projections about the market?
   d. How does the company rank the following:
      ▪ Cost of manufacturing and product provision
      ▪ Volume of output
      ▪ Meeting schedules
      ▪ Quality
   e. Does the company management feel that a certain level of defects is acceptable as a cost of doing business and a way of company life?
   f. Is quality first incorporated into the process at the concept development/preliminary research level? the product development level? the production/operations level? at final inspection?
   h. Are the following measures used to evaluate overall quality?
      ▪ Zero defects
      ▪ Parts per million
      ▪ Reject or rework rate
      ▪ Cost of quality
   i. The company’s quality improvement program is best described as:
      ▪ There is no formal program.
      ▪ The program emphasizes short-range solutions.
      ▪ The program emphasizes motivational projects and slogans.
      ▪ A formal improvement program creates widespread awareness and involvement.
      ▪ The quality process is an integral part of ongoing company operations and strategy.
   j. Perceived barriers to a better company are
      ▪ Top-management inattention
Perception of program costs
Inadequate organization of quality effort
Inadequate training
Costs of quality not computed
Low awareness of need for quality emphasis
Crisis management a way of life (leaves no time)
No formal program/process for improvement
The management system
The workers

k. The following steps in a quality improvement plan have (have not) been taken:
- Obtained top-management commitment to establish a formal policy on quality
- Begun implementation of a formal companywide policy on quality
- Organized cross-functional improvement teams
- Established measures of quality (departmentally and in employee evaluation system)
- Established the cost of quality
- Established and implemented a companywide training program
- Begun identifying and correcting quality problems
- Set and begun to move toward quality goals

l. What objectives has the company set?
- Less rework
- Less scrap
- Fewer defects
- Plant utilization
- Improved yield
- Design improvements
- Fewer engineering changes (material, labor, process changes)
- Workforce training
- Improved testing
- Lower energy use
- Better material usage
- Lower labor hours per unit

3. Customers

a. How does the company capture the voice of the customer? How does the organization listen to the customer and obtain actionable information?
b. How does the organization achieve customer engagement?
c. How are customer concerns handled? What is the follow-up process?
d. Which statement(s) describe company efforts to provide the best customer service:
   - The process has unequivocal support of top management.

Middle management is able to make significant changes.
Employees assume the major responsibility for ensuring customer satisfaction.
Formal training in customer satisfaction is provided to all employees.

e. How does the company gather quality feedback from their customers?
- Through customer surveys
- Through a telephone hotline
- Through customer focus groups
- Through sales force or service representative reports
- Through social media

f. Customer complaints are received by
- The CEO or his/her office
- The marketing or sales department
- The quality assurance staff
- Service support departments
- Customer complaint bureaus

4. Measurement, Analysis, and Knowledge Management

a. What types of data and information does the company collect? Are these records on customer-related issues? on internal operations? on company performance? on cost and financial matters?
b. How does the company ensure the reliability of the data throughout their company? Are their records consistent? standardized? timely? updated? Is there rapid access to data? What is the scope of the data?
c. How are their information and control systems used? Do they have key methods of data collection and analysis? systematic collection on paper? systematic collection with computers? How do they use the information collected to solve problems? Can problems be traced to their source?
d. Is the organization’s performance management system aligned and integrated in order to yield data and information? How is this comparative data used to support business analysis and decision-making?

5. Workforce

a. Is performance excellence incorporated into the human resources system through
   - Job descriptions of the president, vice president, managers, etc.
   - Performance appraisals
   - Individual rewards for performance improvement efforts
   - Hiring practices
   - Education and training programs
b. How does the company encourage employees to buy in to creating and maintaining performance excellence?
   - Through incentives
   - Through stressing value to customers
   - Through surveys or other forms of customer feedback
   - Through the example of management

c. Has the performance excellence message been distributed throughout the organization so that employees can use it in their day-to-day job activities? How has it been distributed?

d. If the importance of performance excellence has been communicated throughout the corporation, how is that emphasis made visible?
   - Are all employees aware of the importance of performance excellence? How is this visible?
   - Are all employees aware of how performance excellence is measured? How is this visible?
   - Are all employees aware of the role of performance excellence in their job? How is this visible?
   - Are all employees aware of how to achieve performance excellence in their job? How is this visible?

e. Have teams been established to encourage cross-functional performance excellence efforts?
   - If yes, do multifunctional teams seek continuous improvement?
   - If yes, do teams have been formed in nonmanufacturing and staff departments to encourage performance excellence companywide?

f. Which of the following topics are stressed in employee participation groups? Is this stress reflected in the minutes, in attitudes, in solutions to problems?
   - Product quality
   - Service quality
   - Quality of work life
   - Productivity
   - Cost
   - Safety
   - Energy
   - Schedules
   - Specifications
   - Long-term versus quick-fix solutions

6. Operations

a. How are designs of products, services, and processes developed so that customer requirements are translated into design and quality requirements?

b. How do people handle problem solving and decision-making? How is this visible?
   - Crisis management prevails. Quality problems arise and are fought on an ad hoc basis.
   - Individuals or teams are set up to investigate major problems.
   - Problem solving is institutionalized and operationalized between departments. Attempts are frequently made to blame others.
   - Problems and potential problems are identified early in development. Data and history are used for problem prevention.

c. The following quality-related costs are compiled and analyzed on a regular basis:
   - Scrap
   - Product liability
   - Product redesign
   - Repair
   - Warranty claims
   - Consumer contacts/concerns
   - Inspection
   - Specification/documentation review
   - Design review
   - Engineering change orders
   - Service after service
   - Rework
   - Quality audits
   - Test and acceptance
   - Supplier evaluation and surveillance

d. How are costs of quality (or non-quality) calculated?
   - Costs are not computed; there is little or no awareness of total costs.
   - Direct costs are computed for rework, scrap, and returns, but the total cost of non-quality is not.
   - Total costs are computed and are related to percentage of sales or operations.
   - The costs of quality (prevention, appraisal, failure) are computed and reduced to 2 to 3 percent of actual sales.
e. Are periodic audits conducted to determine if the system is meeting the goals?

f. How are supplier relationships studied?
   - Suppliers are certified by requiring evidence of statistical process control (SPC).
   - Defects in shipments are identified and suppliers have to pay for them.
   - A close working relationship has been established, allowing the suppliers to participate in the design/ manufacture of the products.
   - A just-in-time system has been established.
   - Suppliers are rated with a formal system based on quality levels, capacity, production facilities, and delivery on schedule.

7. Results
   a. How does the company track the key measures of product, service, and process quality?
   b. How does the company benchmark itself against other companies?
   c. How does the company justify expenditures on quality improvements?
      - By traditional accounting procedures (expenditures justified only if lower than cost of product failure)
      - By normal capital budgeting procedures that incorporate risk-adjusted net present value and discounted costs of capital

   - By cash flow increase
   - By the bottom line: return on investment, net profit percent, etc.

d. Does the finance and accounting system play the following roles in the quality management system?
   - Does it calculate and track cost of quality?
   - Does it measure and report performance trends?
   - Does it distribute performance data to appropriate persons?
   - Does it design, track, and utilize performance measures?
   - Does it compare performance to competition?
   - Does it encourage innovation and new ways to encourage performance excellence?

e. What tangible benefits has this company seen related to their performance excellence program? How are the benefits visible? How are they measured?
   - Increased sales
   - Increased return on investment
   - Customer satisfaction
   - Lower cost
   - Higher selling price
   - More repeat business
   - Higher market share
   - Improved cash flow

f. How are supplier relationships studied?
   - Suppliers are certified by requiring evidence of statistical process control (SPC).
   - Defects in shipments are identified and suppliers have to pay for them.
   - A close working relationship has been established, allowing the suppliers to participate in the design manufacture of the products.
   - A just-in-time system has been established.
   - Suppliers are rated with a formal system based on quality levels, capacity, production facilities, and delivery on schedule.