TRAINING PROGRAM

PROJECT QUALITY MANAGEMENT

PRESENTED BY:
KARIM EL-DASH; PHD; PMP; CCE; AVS

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Table of Contents

The Development of Quality Management

The scientific revolution (roughly 1600 to 1687), which changed our perception of the universe, was followed by the industrial revolution (roughly 1760 to 1830, and beyond), which changed the way we live our lives. The relationship between science and industry—particularly the relationship between the scientific method and business management—gave rise to quality management. Quality management evolved as engineers, managers, executives, and government officials responded to the problems of their day. It was an evolution, not a planned series of developments. It is fair to say that, as we look back in history, some people and events seem more important to us now than they were thought to be at the time, and others seem less important now than they seemed then. I would argue that this understanding of quality management is still evolving and incomplete.

EMPIRICISM, MATHEMATICS, AND THE SCIENTIFIC METHOD

One of the key defining elements of science is empiricism—that is, the idea that observable facts and experience are the basis, or the most important basis, of knowledge. This distinguishes science from some religions and philosophies that grant authority for truth to a divine source or to a book from a divine source. Science looks at what is, and business needs to know what works. A small logical step from empiricism leads to a practical aspect of engineering and business: Doing what works and not doing what doesn't work is good for business.

Also, science frequently uses mathematics in many different ways. As we shall see, quality management has picked up the use of mathematics—especially statistics—from science.

A third key aspect of science is the scientific method, which is the process that scientists use to make and test theories. Here are the steps of the scientific method.

1. *Observe* something in nature or reality.

2. *Create a hypothesis,* a statement of a possible reason why the observed event happens.

3. *Design a test,* which will give observable results that can be interpreted to evaluate the hypothesis. For example, a test might show, "If X happens, the hypothesis seems to be true, but if Y happens, the hypothesis cannot be true." A test might also be designed to show which of two hypotheses is true.

4. *Perform the test and record the results.*

5. *Evaluate the results of the test.* If a test confirms a hypothesis, then it moves towards being a theory, which is simply an accepted hypothesis.

Smeaton and Scientific Engineering

John Smeaton, an English physicist inspired by Newton, was the first person to bring the scientific method to the world of engineering. In 1755, he took on the job of building the third Eddystone lighthouse on the coast of England. The first two lighthouses had been destroyed, and Smeaton took on the task of building a lighthouse that would last. His key tool was the idea of experimentation. He succeeded.

In fact, Smeaton succeeded so well at building things that he became known as the father of civil engineering. And behind every one of his successes and every one of his innovations was one method: the application of the scientific method to engineering problems. That is, Smeaton followed the steps of observation, hypothesis, and testing, not to produce theories about how the world works, but to produce practical methods that make things that work.

His remarkable accomplishments include:

- A recipe for concrete called hydraulic lime, the strongest to date, and the strongest for over another 100 years.
- Dovetail fitting of granite blocks, which he showed gave maximum strength in construction.
- Specialized cranes used for construction projects.

Smeaton's Lighthouse

Industrial Standardization in the 1800s

The next major step in the development of quality management had to do not with science, but with standardization. As early as the 1700s, mass production began through early versions of the assembly line, where each worker would make one part of an item, and then the item would be assembled and finished.

The earliest items made this way were probably guns. Certainly, the history of guns, munitions, and war materiel was crucial to the development of quality management. There is a very simple, practical reason for this. In wartime, large quantities of equipment need to be delivered on time, and every single one needs to work. In peacetime, delays are costly; in wartime they are deadly. In peacetime, delivering bad quality means losing a customer; in wartime, delivering bad quality means the customer may lose his life.

INDUSTRY STANDARDS

In the early to middle 1800s, in time for the Civil War, a new type of standard arose: the industrial standard. This standard was the solution to a problem faced by the U.S. military.

Guns are built of multiple parts that must be fitted very closely together so that there is no leakage of pressure or burning material when the gunpowder explodes. There can also be no blockage of the bullet's path down the barrel and out of the front of the gun. Early assembly lines were already being used, but, prior to the Civil War, each gun was assembled by hand, with parts filed down to a smooth fit if necessary. As a result, each gun worked, but it was unique.

Only a gunsmith with the proper training and skill could assemble a gun, and it could only be done at the factory. But guns break and are damaged in the field of battle. The army wanted guns with replaceable parts. That way, if the barrel of one gun was damaged, and the cylinder of another was damaged, the working parts of two guns could be reassembled to make one working gun. Or spare parts could be brought to the battlefield, so that guns could be fixed. In addition to replaceable parts, the army also wanted two suppliers of each type of gun. That way, if one supplier was cut off by the enemy—either by destruction of the factory, by cutting of supply lines, or by defection—the army could get the guns it needed from somewhere else.

For the army to get what it wanted, two different companies would have to produce parts of guns so similar that they could be mixed at the field of battle and assembled to make a working weapon. That required the customer—the army—to define a specification for its rifles and pistols. It also required every manufacturer in the industry to meet that specification for each part that it delivered.

Since the entire industry—gun manufacturing—had to meet one specification, it was called an industry specification. Meeting the army's needs required one new idea that is crucial to quality management: the notion of tolerances. It was no longer good enough to say, "the cylinder of the gun must be exactly 1.5 inches long." What does "exactly" mean? Can we be off by a tenth of an inch? A hundredth? A thousandth? A *tolerance* defines that exactly. For example, we might say, "The cylinder of the gun must be 1.5 inches long, plus or minus 0.05 inches." Or we might have a closer tolerance, "The cylinder of the gun must be 1.5 inches long, plus or minus 0.01 inches."

THE SECOND INDUSTRIAL REVOLUTION

The second industrial revolution is generally dated from 1871–1914. It is marked by the development of modern printing and electronic communications and the creation of smaller, more powerful engines that transformed transportation, particularly with cars and airplanes beginning to replace steam locomotives and steamships. What is not generally realized is how key elements of what would later be quality management were essential to the second industrial revolution.

While Smeaton was introducing feedback into the human process of design, automated feedback for automated machinery was developed because it was essential to the safe and reliable machine operations. In 1788, James Watt introduced the centrifugal governor—a device that regulates the power of an engine—to the steam engine. A governor keeps an engine running steadily even under varying loads. A modern example of a governor is a car with cruise control, which will maintain the same speed even if the car starts to go uphill, because more gas is sent to the engine to maintain the same speed. If the car starts to go downhill, then it speeds up due to gravity, and the cruise control detects that and sends less gas to the engine, keeping the car at a steady speed.

The notions of governance, regulation, control, and feedback are all essential to quality management in development of business, communications, and technical processes, and in the automated control of equipment and production. These ideas were essential to the second industrial revolution and in wide use, but no one had yet realized that they were all related ideas, or that they applied to business processes, to human resource processes, and to engineering.

INSPECTION

By the late 1800s, many things were being made in factories, using powerful furnaces and engines, powered tools, assembly lines, and inspection. At the end of each assembly line, every single component or product was inspected to make sure that it either met specifications or that it worked. Items that didn't work were either discarded or reworked. A discarded item might be thrown away, or it might be broken down or melted down into components that could be reused. The choice of discarding or reworking items depended on cost—whichever was less expensive was done.

Taylor Introduces Scientific Management

The biggest change for the worker from the pre-industrial period of craft guilds to the industrial revolution was the breaking up of work into tasks that were then ordered into an assembly line. The division of tasks was thought out, sometimes carefully. However, the method of doing the tasks was not. This was discovered by Frederick Winslow Taylor, who spent a lifetime developing and applying the principles of *scientific management,* and published his results in the treatise "The Principles of Scientific Management" in 1911. Scientific management is the direct predecessor of all of quality management. Indeed, a close look at Taylor's treatise shows that we have not yet consistently implemented all of his ideas, and that most failures in quality management over the past 100 years can be traced to errors in the application of management methods—errors that he warned against.

Taylor's key ideas can be summarized in two points:

- The scientific method can be used to define, and then to continuously improve, the best tools and methods for doing any job.
- Changing an organization's way of working requires principled management that makes the situation better for both management and workers. A slow, careful method must be followed so that management and workers work together towards common goals, and conflict is eliminated, rather than triggered, by the change in work process.

Taylor's innovations can be summarized in three key points:

- Use observation, measurement, and experiments to improve work processes as well as engineering practices. That is, we experiment to change the way we work, not just to define the technology and tools, then incidentally change the way we work.
- Set standards from experiments, then manage the work to bring everyone to the level of the standard. More experiments, including tests of suggestions from workers, can be used to improve the standards.
- Management has a key responsibility to work with the workers, guiding with the knowledge provided by science, but doing it is a way that engenders cooperation. In contrast, attempting to force improved methods on workers is a business disaster.

A new field of endeavor, *human resources,* arose in the 1930s to deal with the mass strikes that occurred when Taylor's ideas were misapplied. At first, the field of human resources was generally highly critical of Taylor and scientific management. More recently, the field has been trying to apply our scientific understanding of people—the field of psychology—to identify what workers are best for what jobs, and how improvements can be made. This follows Taylor's recommendation that we focus on "the accurate study of the motives which influence men."

Human resources has also proposed a model of the attitudes towards workers that goes a long way towards explaining the success or failure of the cooperative improvement of work processes that is essential to quality management. In 1960, Douglas MacGregor suggests that managers, whether we realize it or not, have one of two attitudes about workers, which he calls Theory X and Theory Y.

Theory X holds that people do not like to work, that they have to be made to work, and that they need supervision to make sure that they work. If managers hold this view, it usually leads to conflict when management wants to make changes to work processes. Theory Y holds that people like to work and want to do good work. Management succeeds by removing barriers to good work, eliminating hassle, and rewarding good work and improvements. When managers at a company believe Theory Y, quality management initiatives and continuous improvement can succeed.

Shewhart's Scientific Management

Walter Shewhart (1891-1967) was the next great figure in the history of quality management; professor of physics. The central focus of his work was *statistical quality control*— called at the time *statistical process control.* Now, it is generally referred to as *Quality Control,* though it is important to remember that quality control is simply inspection plus statistics. Shewhart also developed an approach called *Plan, Do, Check, Act (PDCA)* which is essential to quality management, both in statistical quality control and also more generally in continuous improvement. A third concept, the distinction between noise and data in a signal, was relevant to statistical quality control and also essential to the development of communications science.

PLAN, DO, CHECK, ACT (PDCA)

Shewhart created PDCA, a simple application of the scientific method that anyone can apply. In general, we can plan work that solves a problem, do that work, check to see if we got the results we wanted, and then take action to make use of what we learned. This can apply to trying to meet customer specifications and also to solving any other type of quality, effectiveness, or efficiency problem. Because PDCA is so simple, it can be used by any engineer, and even by many mechanics and office workers. PDCA was promoted by W. Edwards Deming, and therefore is part of Total Quality Management and continuous improvement and its descendants, including Six Sigma and ISO 9000.

Many definitions and explanations of PDCA are available. Here is a very clear one, focused on the primary goal of quality management—delivery to customer specifications—from the Note in Clause 0.2 of ISO 9001:2000 explaining that the PDCA cycle applies to processes:

- **Plan**. Establish the objectives and processes necessary to deliver results in accordance with customer requirements and the organization's policies.
- **Do**. Implement the processes.
- **Check.** Monitor and measure processes and product against policies, objectives, and requirements for the product and report the results.
- **Act**. Take actions to continually improve process performance.

The beauty of PDCA is that we can apply it over and over again to the same subject, correcting our course to achieve better and better results. This type of repetition of a process is called *iteration.* We can apply PDA to change results— improving quality—and also to changing any type of process. Process improvement can do many things: increase quality, increase effectiveness, increase efficiency, and more. Because PDCA has been promoted so widely, it has many names including the Shewhart cycle, the Deming cycle, and the continuous improvement cycle.

Deming

W. Edwards Deming, a colleague and protégé of Shewhart, deserves a chapter of his own. He popularized and advanced Shewhart's work, and added significantly to it. In cooperation with Japanese scientists, engineers, and industrial leaders, he pioneered the development of Total Quality Management (TQM). TQM was the first total solution to the quality problem that actually worked on a large scale. It includes PDCA, QC, and other quality methods which, used together, allow companies to sustain continuous improvement.

The R&D Function

The notion of research and development as a way to generate new business began with Thomas Alva Edison. In 1876, he founded the Menlo Park research lab, an inventor's laboratory that focused on creating new products for sale and improving products for commercial production. Edison is most famous for the electric light and the phonograph. Most inventors create one or a few patentable ideas: Edison was able to create hundreds.

Operations Research

One other field is the result of the application of scientific principles to business management, the field of Operations Research (OR). OR began in World War II when mathematical models were used to solve operational and logistical problems. OR includes a wide variety of business models and mathematical theories that can be applied to solve different problems. The common threads are usually systems models, advanced mathematics, the use of computers, and solutions that require both mathematical prediction and also intelligent human application and interpretation of the results of computer analysis. In this, OR parallels quality management. In both fields, the combination of human innovation and intelligence along with engineering or mathematical skill is essential.

Quiz:

Link the appropriate years, persons, and ideas.

	Year	Person, Organization, or Method	Idea
1	1755	Assembly lines	Applied the scientific method to engineering problems
2	1788	Frederick Winslow Taylor	Defined the first industry standard
3	Around 1850	James Watt	Inspection, followed by rework or discard
4	1876	John Smeaton	Plan, Do, Check, Act
5	Around 1900	Operations Research	Scientific Management
6	1911	The U.S. military	Statistical Quality Control
7	1920s–1950s	Thomas Alva Edison	The centrifugal governor
8	1920s–1980s	W. Edwards Deming	The first feedback device
9	1940s–1980s	Walter Shewhart	The R&D laboratory for maintenance of innovative leadership
10	1947–present	Walter Shewhart and W. Edwards Deming	The R&D laboratory for new inventions and viable commercial versions of products
11	1970	Xerox Palo Alto Research Center (PARC)	Total Quality Management

	Year	Person, Organization, or Method	Idea
1	1755		
2	1788		
3	Around 1850		
4	1876		
5	Around 1900		
6	1911		
7	1920s–1950s		
8	1920s–1980s		
9	1940s–1980s		
10	1947–present		
11	1970		

QUALITY MOVEMENT

Deming philosophy synopsis

The philosophy of W. Edwards Deming has been summarized as follows:

> "Dr. W. Edwards Deming taught that by adopting appropriate principles of management, organizations can increase quality and simultaneously reduce costs (by reducing waste, rework, staff attrition and litigation while increasing customer loyalty). The key is to practice continual improvement and think of manufacturing as a system, not as bits and pieces."

In the 1970s, Dr. Deming's philosophy was summarized by some of his Japanese proponents with the following 'a'-versus-'b' comparison:

(a) When people and organizations focus primarily on quality, defined by the following ratio,

$$Quality = \frac{Results\ of\ work\ efforts}{Total\ costs}$$

quality tends to increase and costs fall over time.

(b) However, when people and organizations focus primarily on *costs*, costs tend to rise and quality declines over time.

The Deming System of Profound Knowledge

"The prevailing style of management must undergo transformation. A system cannot understand itself. The transformation requires a view from outside. The aim of this chapter is to provide an outside view—a lens—that I call a system of profound knowledge. It provides a map of theory by which to understand the organizations that we work in.

"The first step is transformation of the individual. This transformation is discontinuous. It comes from understanding of the system of profound knowledge. The individual, transformed, will perceive new meaning to his life, to events, to numbers, to interactions between people.

"Once the individual understands the system of profound knowledge, he will apply its principles in every kind of relationship with other people. He will have a basis for judgment of his own decisions and for transformation of the organizations that he belongs to. The individual, once transformed, will:

- Set an example;
- Be a good listener, but will not compromise;
- Continually teach other people; and
- Help people to pull away from their current practices and beliefs and move into the new philosophy without a feeling of guilt about the past."

Deming advocated that all managers need to have what he called a System of Profound Knowledge, consisting of four parts:

1. ***Appreciation of a system***: understanding the overall processes involving suppliers, producers, and customers (or recipients) of goods and services (*explained below*);
2. ***Knowledge of variation***: the range and causes of variation in quality, and use of statistical sampling in measurements;
3. ***Theory of knowledge***: the concepts explaining knowledge and the limits of what can be known;
4. ***Knowledge of psychology***: concepts of human nature.

Deming explained, "One need not be eminent in any part nor in all four parts in order to understand it and to apply it. The 14 points for management in industry, education, and government follow naturally as application of this outside knowledge, for transformation from the present style of Western management to one of optimization."

"The various segments of the system of profound knowledge proposed here cannot be separated. They interact with each other. Thus, knowledge of psychology is incomplete without knowledge of variation.

"A manager of people needs to understand that all people are different. This is not ranking people. He needs to understand that the performance of anyone is governed largely by the system that he works in, the responsibility of management. A psychologist that possesses even a crude understanding of variation as will be learned in the experiment with the Red Beads could no longer participate in refinement of a plan for ranking people."

The *Appreciation of a system* involves understanding how interactions (i.e. feedback) between the elements of a system can result in internal restrictions that force the system to behave as a single organism that automatically seeks a steady state. It is this steady state that determines the output of the system rather than the individual elements. Thus it is the structure of the organization rather than the employees, alone, which holds the key to improving the quality of output.

The *Knowledge of variation* involves understanding that everything measured consists of both "normal" variation due to the flexibility of the system and of "special causes" that create defects. Quality involves recognizing the difference in order to eliminate "special causes" while controlling normal variation. Deming taught that making changes in response to "normal" variation would only make the system perform worse. Understanding variation includes the mathematical certainty that variation will normally occur within six standard deviations of the mean.

The System of Profound Knowledge is the basis for application of Deming's famous 14 Points for Management, described below.

Dr. W. Edward Deming's 14 points

Deming offered fourteen key principles for management for transforming business effectiveness. The points were first presented in his book *Out of the Crisis.*

1. Create constancy of purpose toward improvement of product and service, with the aim to become competitive and stay in business, and to provide jobs.
2. Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.
3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.
4. End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move towards a single supplier for any one item, on a long-term relationship of loyalty and trust.
5. Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.
6. Institute training on the job.
7. Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.
8. Drive out fear, so that everyone may work effectively for the company.
9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.
10. Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.
11. a. Eliminate work standards (quotas) on the factory floor. Substitute leadership.

    b. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute leadership.
12. a. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.

    b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, *inter alia," abolishment of the annual or merit rating and of management by objective.*
13. Institute a vigorous program of education and self-improvement.
14. Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job.

"Massive training is required to instill the courage to break with tradition. Every activity and every job is a part of the process."

Seven Deadly Diseases

The "Seven Deadly Diseases" include

1. Lack of constancy of purpose
2. Emphasis on short-term profits
3. Evaluation by performance, merit rating, or annual review of performance
4. Mobility of management
5. Running a company on visible figures alone
6. Excessive medical costs
7. Excessive costs of warranty, fueled by lawyers who work for contingency fees

"A Lesser Category of Obstacles" includes

1. Neglecting long-range planning
2. Relying on technology to solve problems
3. Seeking examples to follow rather than developing solutions
4. Excuses, such as "Our problems are different"

Deming's advocacy of the Plan-Do-Check-Act cycle, his 14 Points, and Seven Deadly Diseases have had tremendous influence outside of manufacturing and have been applied in other arenas, such as in the relatively new field of sales process engineering.

Dr. Juran Quality Program

Dr. Joseph M. Juran was born in December 24th of 1904 at Braila, Rumania, he graduated as an Electric Engineer bachelor in science in 1924 and now a day he is considered the leader of the quality management of the last 70 years. The influence of the scripts he has written is considered the core of quality management, i.e. Juran's Quality Handbook 5th edition.

The relevant things that Dr. Juran did was conceptualized the Pareto Principal to apply it in quality management. He also spent some years with the reengineering concepts. During this time he observed that an organization could work better if they standardized the process and give more importance to the quality.

After the Second World War, he started to get rename in Japan. Japanese executives were preoccupied for giving to their companies an aggregated value and maintain them between the best companies worldwide. Dr. Juran had a set of principals and methodologies that helped to the companies stay over their competitors and implement them in Japan with great success. Dr. Juran got recognized in countries like Japan and USA because the executives got excellent results with his programs.

Dr. Juran worked together with tools like Pareto Principle and Total Quality Management and others that are part of the program that Dr. Juran used to increase the culture of quality in companies.

Key distinctive attributes of program

Juran Trilogy

Dr. Juran's trilogy defined the three management processes required by every organization to improve: Quality control, quality improvement and quality planning.

This Trilogy shows how an organization can improve every aspect by better understanding of the relationship between processes that plan, control and improve quality as well as business results. It was created in the 1950's and defines managing for quality as three basic quality-oriented, interrelated processes:

Quality Planning --- To determine customer needs and develop processes and products required to meet and exceed those of the customer needs. The processes are called Design for Six Sigma or Concurrent Engineering. This can be particularly challenging for a planning team, because customers are not always consistent with what they say they want. The challenge for quality planning is to identify the most important needs from all the needs expressed by the customer.

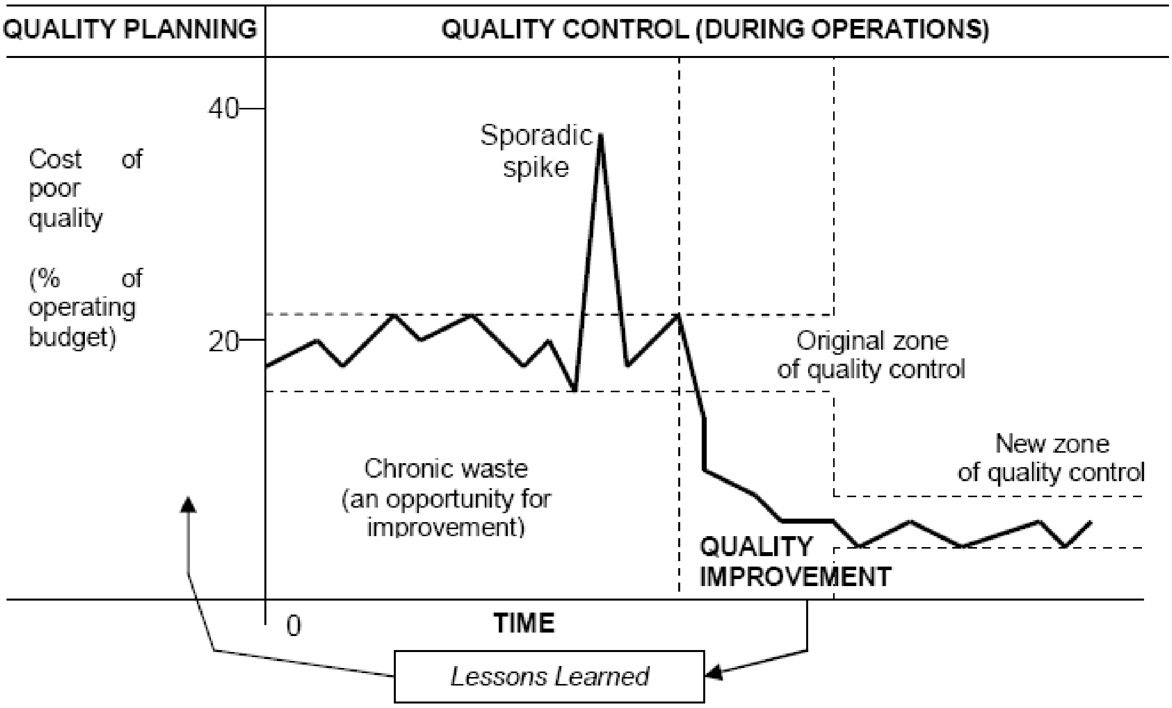
- Identify who are the customers.
- Determine the needs of those customers.
- Translate those needs into our language.
- Develop a product that can respond to those needs.
- Optimize the product features so as to meet our needs and customer needs.

Quality Control --- The purposes of quality control is to ensure the process is running in optimal effectiveness, or to ensure that any level of chronic waste inherent in the process does not get worst. Chronic waste, which is a cost of poor quality that can exist in any process, may exist due to various factors including deficiencies in the original planning. It could cost a lot of money to the company, from rework time to scrap product to overdue receivables. If the waste does get worst (sporadic spike), a corrective action team is brought in to determine the cause or causes of this abnormal variation. Once the cause or causes had been determined and corrected, the process again falls into the zone defined by the "quality control" limits.

- Prove that the process can produce the product under operating conditions with minimal inspection.
- Transfer the process to Operations.

<u>*Quality Improvement*</u> --- Eliminate waste, defects and rework that improves processes and reduces the cost of poor quality. The processes have to be constantly challenged and continuously improved. Such an improvement does not happen of its own accord. It results from purposeful Quality Improvement or "Breakthrough."

- Develop a process which is able to produce the product.
- Optimize the process.



Juran's Trilogy

<u>Juran's ten steps to Quality improvement</u>

1. Build awareness of the need and opportunity for improvement
2. Set goals for improvement
3. Organize to reach the goals
4. Provide training
5. Carry out projects to solve problems
6. Report progress
7. Give recognition

8. Communicate results
9. Keep score
10. Maintain momentum by making annual improvement part of the regular systems and processes of the company

Juran's Zero Defects

Get it right first time

How much do quality failures cost your company?

Quality defects have significant costs associated with them - some of the most obvious being money, time, resources, and lost reputation. And programs to eliminate quality defects can be expensive and time consuming. Do you insist on eliminating defects entirely no matter the cost? Or, do you accept that a certain, albeit very small, percentage of defects is acceptable, and just accept the costs and learn to live with them?

One of the most influential ideas about this was the notion of "zero defects." This phrase was coined by Philip Crosby in his 1979 book titled, "Quality is Free."

His position was that where there are zero defects, there are no costs associated with issues of poor quality; and hence, quality becomes free.

Explaining the Idea

Zero defects is a way of thinking and doing that reinforces the notion that defects are not acceptable, and that everyone should "do things right the first time". The idea here is that with a philosophy of zero defects, you can increase profits both by eliminating the cost of failure and increasing revenues through increased customer satisfaction.

Tip:

While this will probably be true, it may not be true in every case!

"Zero defects" is referred to as a philosophy, a mentality or a movement. It's not a program, nor does it have distinct steps to follow or rules to abide by. This is perhaps why zero defects can be so effective, because it means it's adaptable to any situation, business, profession or industry.

The question that often comes up when zero defects is discussed, is whether or not zero defects is ever attainable. Essentially, does adopting a zero defect environment only set users up for failure?

Zero defects is NOT about being perfect. Zero defects is about changing your perspective. It does this by demanding that you:

- Recognize the high cost of quality issues;
- Continuously think of the places where flaws may be introduced; and
- Work proactively to address the flaws in your systems and processes, which allow defects to occur.

Zero defects is a standard. It is a measure against which any system; process, action, or outcome can be analyzed. When zero defects is the goal, every aspect of the business is subject to scrutiny in terms of whether it measures up.

Tip:

"*The quality manager must be clear, right from the start, that zero defects is not a motivation program. Its purpose is to communicate to all employees the literal meaning of the words 'zero defects' and the thought that everyone should do things right the first time.*"
Quality Is Free by Philip B. Crosby (McGraw-Hill Books, 1979)

When you think about it, we expect zero defects when we are talking about items or services that we use. If you buy a fancy new plasma TV and your pixels start burning by the thousands, you demand satisfaction. When you take the car in for brake service, you expect that the mechanic will install the parts exactly as the manufacturer prescribes. No defect is an acceptable defect when it affects you personally.

So why then, is it so easy to accept that "defects happen" when you are the one producing the product or providing the service? This is the interesting dichotomy that presents itself. Zero defects is one of the best ways to resolve the discord between what we expect for ourselves and what we can accept for others.

Tip:

Be very careful about where you apply zero defects. If what you're doing contributes towards a mission critical or complex goal, you'd better adopt a zero defects approach, or things could quickly unravel.

However, if you fanatically follow a zero defects approach in areas which don't need it, you'll most likely be wasting resources. One of the most important of these resources is time, and this is where people are accused of time-destroying "perfectionism."

Adopting Zero Defects

There are no step-by-step instructions for achieving zero defects, and there is no magic combination of elements that will result in them. There are, however, some guidelines and techniques to use when you decide you are ready to embrace the zero defects concept.

Management must commit to zero defects. Zero defects requires a top down approach: The best-intentioned employees cannot provide zero defects if they are not given the tools to do so.

- When you decide that zero defects is the approach you want to take, recognize that it likely represents a significant change to the way people do things. Manage the introduction using the principles of change management.
- Understand what your customers expect in terms of quality. Design systems that support zero defects where it matters, but don't over-design if the end-user just doesn't care.
- Zero defects requires a proactive approach. If you wait for flaws to emerge you are too late.
- Create quality improvement teams. Zero defects must be integrated with the corporate culture. Zero defects needs to be accepted as "the ways things are done around here".

- Learn poka - yoke (POH-kay YOH-kay.) Invented in the 1960s by Shigeo Shingo of Japan, it translates to "prevent inadvertent mistakes". It's an approach that emphasizes designing systems that make defects almost impossible or, if they can't be avoided, easy to detect and address. To implement zero defects, you have to have strong systems in place.
- Monitor your progress. Build mechanisms into your systems and methods of operating that provide continuous feedback. This allows you act quickly when flaws do occur.
- Measure your quality efforts. It is important to express your progress in terms of the bottom line. Take baseline measurements so you understand the cost of defects in your organization, and can measure the benefits your achieving in eliminating them.
- Build quality into your performance expectations. Encourage members of your team to think about how they can achieve zero defects, and reward them when they're successful.
- Recognize that although zero defects is a destination, circumstances keep changing. Monitor, evaluate, and adapt in a continuous, never-ending cycle.

Quality circles

In the 1960s Juran said: "*The quality-circle movement is a tremendous one which no other country seems to be able to imitate. Through the development of this movement, Japan will be swept to world leadership in quality.*"

Certainly Japan did make a rapid advance in quality standards from the 1960s onwards, and quality circles were part of this advance. However, quality circles were only one part of the Japanese quality revolution.

Quality circles will work if the following rules are applied:

1. The circle should consist only of volunteers.
2. The members of the circle should all be from different functional areas.
3. The problem to be studied should be chosen by the team, and not imposed by management. Problems looked at by the circle may not always be directly related to quality or, initially, be seen as important by management.
4. Management must wholeheartedly support the circle, even where initially decisions and recommendations made by the circle are of an apparently trivial nature or could cost the company money (such as a recommendation for monogrammed overalls).
5. The members of the circle will need to be trained in working as a team (group dynamics), problem-solving techniques, and in how to present reports. The basic method study approach of asking why (what, where, when, who, and how) is a standard quality circle approach to problem solving, and members need to be taught how to apply this structured approach to solving problems.
6. The leader of the circle and the internal management of the circle should be decided by the members.
7. Management should provide a middle manager as mentor to the circle. The mentor's role is to assist when requested and generally to provide support. The mentor does not manage the circle.

The overall tenor of these rules is trust and empowerment. Management of the organization has to be seen to be willing to trust the members of the circle to act responsibly, and must then be active in supporting the circle. Although initially the circle may not appear to be addressing hard quality issues, very real benefits can be expected as the confidence of the members increases.

Side benefits of quality circles, which are nonetheless important, are the fostering of a supportive environment that encourages workers to become involved in increasing quality and productivity, and the development of the problem-solving and reporting skills of lower-level staff.

In Japan, the quality circle traditionally meets in its own time rather than during normal working hours. Not only do circles concern themselves with quality improvement; they also become a social group engaged in sporting and social activities. It is not expected in a European country that a quality circle would meet in the members' own time; few workers are that committed to an organization. However, there is no reason why, once the quality circle is up and running, management could not support and encourage social events for a circle, perhaps in recognition of an achievement.

Malcolm Baldrige National Quality Award

The Malcolm Baldrige National Quality Award is given by the United States National Institute of Standards and Technology. Through the actions of the National Productivity Advisory Committee chaired by Jack Grayson, it was established by the Malcolm Baldrige National Quality Improvement Act of 1987 - and named for Malcolm Baldrige, who served as United States Secretary of Commerce during the Reagan administration from 1981 until his 1987 death in a rodeo accident. APQC, organized the first White House Conference on Productivity, spearheading the creation and design of the Malcolm Baldrige National Quality Award in 1987, and jointly administering the award for its first three years. The program recognizes quality service in the business, health care, education, and nonprofit sectors and was inspired by the ideas of Total Quality Management or TQM. This is the only quality award that is actually awarded by the President of the United States. This award and the Ron Brown Award are the two U.S. presidential awards given to corporations.

The original stated purposes of the award were to:

- promote quality awareness
- recognize quality achievements of the US companies
- publicize successful quality strategies

The current award criteria are stated to have three important roles in strengthening US competitiveness:

- To help improve organizational performance practices, capabilities and results
- To facilitate communication and sharing of the best practice information among US organizations of all types
- To serve as a working tool for understanding and managing performance and for guiding planning and opportunities for learning

The criteria are designed to help organizations use an aligned approach to organizational performance management that results in:

- Delivery of ever-improving value to customers, contributing to market success
- Improvement in overall organizational effectiveness and capabilities
- Organizational and personal learning

The seven categories of the criteria are:

1. Leadership
2. Strategic Planning
3. Customer & Market Focus
4. Measurement, Analysis and Knowledge Management
5. Workforce Focus
6. Process Management
7. Results

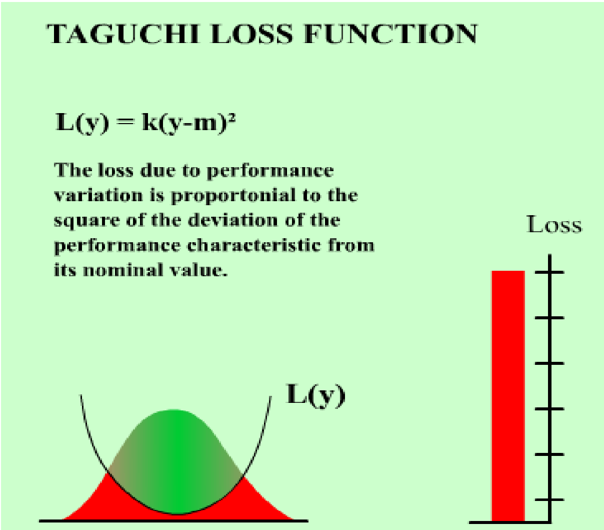
Taguchi Loss Function

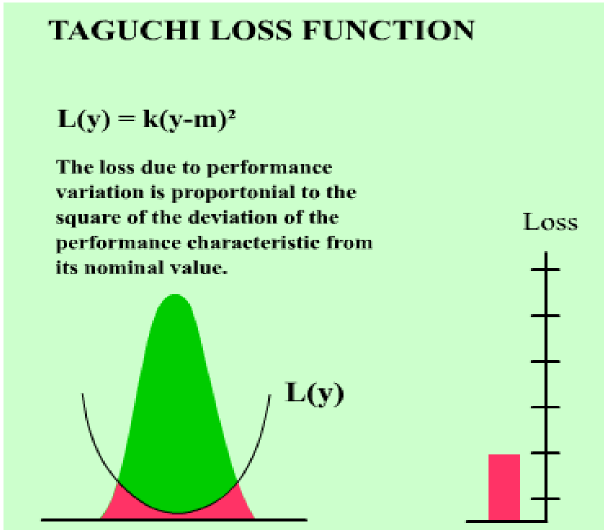
Definition

The Taguchi loss function is a way to show how each non-perfect part produced, results in a loss for the company. Deming states that it shows: "a minimal loss at the nominal value, and an ever-increasing loss with departure either way from the nominal value."

A technical definition is:

"A parabolic representation that estimates the quality loss, expressed monetarily, that results when quality characteristics deviate from the target values. The cost of this deviation increases quadratically as the characteristic moves farther from the target value."





Graphically, the loss function is represented as shown above.

Interpreting the chart:

This standard representation of the loss function demonstrates a few of the key attributes of loss. For example, the target value and the bottom of the parabolic function intersect, implying that as parts are produced at the nominal value, little or no loss occurs. Also, the curve flattens as it approaches and departs from the target value. (This shows that as products approach the nominal value, the loss incurred is less than when it departs from the target.) Any departure from the nominal value results in a loss!

Loss can be measured per part. Measuring loss encourages a focus on achieving less variation. As we understand how even a little variation from the nominal results in a loss, the tendency would be to try and keep product and process as close to the nominal value as possible. This is what is so beneficial about the Taguchi loss. It always keeps our focus on the need to continually improve.

Application

A company that manufactures parts that require a large amount of machining grew tired of the high costs of tooling. To avoid premature replacement of these expensive tools, the manager suggested that operators set the machine to run at the high-end of the specification limits. As the tool would wear down, the products would end up measuring on the low-end of the specification limits. So, the machine would start by producing parts on the high-end and after a period of time, the machine would produce parts that fell just inside of the specs.

The variation of parts produced on this machine was much greater than it should be, since the strategy was to use the entire spec width allowed rather than produce the highest quality part possible. Products may fall within spec, but will not produce close to the nominal. Several of these "good parts" may not assemble well, may require recall, or may come back under warranty. The Taguchi loss would be very high.

We should consider these vital questions:

* Is the savings of tool life worth the cost of poor products?

* Would it be better to replace the tool twice as often, reduce variation, or look at incoming part quality?

Calculations

Formulas:

Loss at a point:

$$\mathbf{L(x) = k*(x-t)^2}$$

where,
k = loss coefficient

x = measured value

t = target value

Average Loss of a sample set:

$$\mathbf{L = k*(s^2 + (pm - t)^2)}$$

where,
s = standard deviation of sample

pm = process mean

Total Loss = Avg. Loss * number of samples

For example: A medical company produces a part that has a hole measuring 0.5" + 0.050". The tooling used to make the hole is worn and needs replacing, but management doesn't feel it necessary since it still makes "good parts". All parts pass QC, but several parts have been rejected by assembly. Failure cost per part is $0.45. Using the loss function, explain why it may be to the benefit of the company and customer to replace or sharpen the tool more frequently. Use the data below:

Measured Value

0.459	0.478	0.495	0.501	0.511	0.527
0.462	0.483	0.495	0.501	0.516	0.532
0.467	0.489	0.495	0.502	0.521	0.532
0.474	0.491	0.498	0.505	0.524	0.533
0.476	0.492	0.500	0.509	0.527	0.536

Solution:

The average of the points is 0.501 and the standard deviation is about 0.022.

Find k,

using $L(x) = k * (x-t)^2$

$\$0.45 = k * (0.550 - 0.500)^2$

$k = 18000$

Next, using the Average loss equation:

$L = k * (s^2 + (pm - t)^2)$

$L = 18000 * (.022^2 + (.501 - .500)^2) = 8.73$

So the average loss per part in this set is $8.73.

For the loss of the total 30 parts produced:

= L * number of samples

= $8.73 * 30

= $261.90

From the calculations above, one can determine that at 0.500", no loss is experienced. At a measured value of 0.501", the loss is $0.018, and with a value of 0.536", the loss would be as much as $23.00.

Even though all measurements were within specification limits and the average hole size was 0.501", the Taguchi loss shows that the company lost about $261.90 per 30 parts being made. If the batch size was increased to 1000 parts, then the loss would be $8730 per batch. Due to variation being caused by the old tooling, the department is losing a significant amount of money.

From the chart, we can see that deviation from the nominal, could cost as much as $0.30 per part. In addition we would want to investigate whether this kind of deviation would compromise the integrity of the final product after assembly to the point of product failure.

Taguchi Design of Experiment

Design of Experiments (DOE) is a powerful statistical technique introduced by R. A. Fisher in England in the 1920's to study the effect of multiple variables simultaneously. In his early applications, Fisher wanted to find out how much rain, water, fertilizer, sunshine, etc. are needed to produce the best crop.

Since that time, much development of the technique has taken place in the academic environment, but did help generate many applications in the production floor.

As a researcher in Electronic Control Laboratory in Japan, Dr. Genechi Taguchi carried out significant research with DOE techniques in the late 1940's. He spent considerable effort to make this experimental technique more user-friendly (easy to apply) and applied it to improve the quality of manufactured products. Dr. Taguchi's standardized version of DOE, popularly known as the Taguchi method or Taguchi approach, was introduced in the USA in the early 1980's. Today it is one of the most effective quality building tools used by engineers in all types of manufacturing activities.

The DOE using Taguchi approach can economically satisfy the needs of problem solving and product/process design optimization projects. By learning and applying this technique, engineers, scientists, and researchers can significantly reduce the time required for experimental investigations.

DOE can be highly effective when yow wish to:

- Optimize product and process designs, study the effects of multiple factors (i.e.- variables, parameters, ingredients, etc.) on the performance, and solve production problems by objectively laying out the investigative experiments.
- Study Influence of individual factors on the performance and determine which factor has more influence, which ones have less. You can also find out which factor should have tighter tolerance and which tolerance should be relaxed. The information from the experiment will tell you how to allocate quality assurance resources based on the objective data. It will indicate whether a supplier's part causes problems or not (ANOVA data), and how to combine different factors in their proper settings to get the best results.

Further, the experimental data will allow you determine:

- How to substitute a less expensive part to get the same performance improvement you propose
- How much money you can save the design
- How you can determine which factor is causing most variations in the result
- How you can set up your process such that it is insensitive to the uncontrollable factors
- Which factors have more influence on the mean performance
- What you need to do to reduce performance variation around the target
- How your response varies proportional to signal factor (Dynamic response)
- How to combine multiple criteria of evaluation into a single index
- How you can adjust factor for overall satisfaction of criteria an adjust factors for a system whose of evaluations
- How the uncontrollable factors affect the performance etc.,

Advantage of DOE Using Taguchi Approach

The application of DOE requires careful planning, prudent layout of the experiment, and expert analysis of results. Based on years of research and applications Dr. Genechi Taguchi has standardized the methods for each of these DOE application steps described below. Thus, DOE using the Taguchi approach has become a much more attractive tool to practicing engineers and scientists.

Experiment planning and problem formulation -

Experiment planning guidelines are consistent with modern work disciplines of working as teams. Consensus decisions about experimental objectives and factors make the projects more successful.

Experiment layout -High emphasis is put on cost and size of experiments... Size of the experiment for a given number of factors and levels is standardized...

Approach and priority for column assignments are established... Clear guidelines are available to deal with factors and interactions (interaction tables)...

Uncontrollable factors are formally treated to reduce variation... Discrete prescriptions for setting up test conditions under uncontrollable factors are described... Guidelines for carrying out the experiments and number of samples to be tested are defined

Data analysis -Steps for analysis are standardized (main effect, NOVA and Optimum)... Standard practice for determination of the optimum is recommended... Guidelines for test of significance and pooling are defined.

Interpretation of results - Clear guidelines about meaning of error term. Discrete indicator about confirmation of results (Confidence interval). Ability to quantify improvements in terms of dollars (Loss function)

Overall advantage - DOE using Taguchi approach attempts to improve quality which is defined as the consistency of performance. Consistency is achieved when variation is reduced. This can be done by moving the mean performance to the target as well as by reducing variations around the target. The prime motivation behind the Taguchi experiment design technique is to achieve reduced variation (also known as ROBUST DESIGN). This technique, therefore, is focused to attain the desired quality objectives in all steps. The classical DOE does not specifically address quality.

Kaizen

The Japanese have a word for “continuous improvement”: kaizen. The word is derived from a philosophy of gradual day-by-day betterment of life and spiritual enlightenment. Kaizen has been adopted by Japanese business to denote gradual unending improvement for the organization. The philosophy is the doing of little things better to achieve a long-term objective.

Kaizen moves the organization’s focus away from the bottom line, and the fitful starts and stops that come from major changes, towards continuous improvement of service. Japanese firms have for many years taken quality for granted. Kaizen is now so deeply ingrained that people do not even realize that they are thinking it. The philosophy is that not one day should go by without some kind of improvement being made somewhere in the company.

The far-reaching nature of kaizen can now be seen in Japanese government and social programs. All this means trust. The managers have to stop being bosses and trust the staff; the staff must believe in the managers. This may require a major paradigm change for some people. The end goal is to gain a competitive edge by reducing costs and improving the quality of the service. In order to determine the level of quality to aim for, it is first necessary to find out what the customer wants and to be very mindful of what the competition is doing. The daily aim should be accepted as being kaizen – that is, some improvement somewhere in the business.

JIT (Just-in-Time)

`Just-in-time' is a management philosophy and not a technique.

It originally referred to the production of goods to meet customer demand exactly, in time, quality and quantity, whether the `customer' is the final purchaser of the product or another process further along the production line.

It has now come to mean producing with minimum waste. "Waste" is taken in its most general sense and includes time and resources as well as materials. Elements of JIT include:

- Continuous improvement.
    - Attacking fundamental problems - anything that does not add value to the product.
    - Devising systems to identify problems.
    - Striving for simplicity - simpler systems may be easier to understand, easier to manage and less likely to go wrong.
    - A product oriented layout - produces less time spent moving of materials and parts.
    - Quality control at source - each worker is responsible for the quality of their own output.
    - Poka-yoke - `foolproof' tools, methods, jigs etc. prevent mistakes
    - Preventative maintenance, Total productive maintenance - ensuring machinery and equipment functions perfectly when it is required, and continually improving it.
- Eliminating waste. There are seven types of waste:
    - waste from overproduction.
    - waste of waiting time.
    - transportation waste.
    - processing waste.
    - inventory waste.
    - waste of motion.
    - waste from product defects.
- Good housekeeping - workplace cleanliness and organization.
- Set-up time reduction - increases flexibility and allows smaller batches. Ideal batch size is 1item. Multi-process handling - a multi-skilled workforce has greater productivity, flexibility and job satisfaction.
- Leveled / mixed production - to smooth the flow of products through the factory.
- Kanbans - simple tools to `pull' products and components through the process.
- Jidoka (Autonomation) - providing machines with the autonomous capability to use judgment, so workers can do more useful things than standing watching them work.
- Andon (trouble lights) - to signal problems to initiate corrective action.

JIT - Background and History

JIT is a Japanese management philosophy which has been applied in practice since the early 1970s in many Japanese manufacturing organizations. It was first developed and perfected within the Toyota manufacturing plants by Taiichi Ohno as a means of meeting consumer demands with minimum delays. Taiichi Ohno is frequently referred to as the father of JIT.

Toyota was able to meet the increasing challenges for survival through an approach that focused on people, plants and systems. Toyota realized that JIT would only be successful if every individual within the organization was involved and committed to it, if the plant and processes were arranged for maximum output and efficiency, and if quality and production programs were scheduled to meet demands exactly.

JIT manufacturing has the capacity, when properly adapted to the organization, to strengthen the organization's competitiveness in the marketplace substantially by reducing wastes and improving product quality and efficiency of production.

There are strong cultural aspects associated with the emergence of JIT in Japan. The Japanese work ethic involves the following concepts.

- Workers are highly motivated to seek constant improvement upon that which already exists. Although high standards are currently being met, there exist even higher standards to achieve.
- Companies focus on group effort which involves the combining of talents and sharing knowledge, problem-solving skills, ideas and the achievement of a common goal.
- Work itself takes precedence over leisure. It is not unusual for a Japanese employee to work 14-hour days.
- Employees tend to remain with one company throughout the course of their career span. This allows the opportunity for them to hone their skills and abilities at a constant rate while offering numerous benefits to the company.

These benefits manifest themselves in employee loyalty, low turnover costs and fulfillment of company goals.

Total Quality Management

TQM is a management philosophy, a paradigm, a continuous improvement approach to doing business through a new management model. The TQM philosophy evolved from the continuous improvement philosophy with a focus on *quality* as the main dimension of business. Under TQM, emphasizing the quality of the product or service predominates. TQM expands beyond statistical process control to embrace a wider scope of management activities of how we manage people and organizations by focusing on the entire process, not just simple measurements.

TQM is a comprehensive management system which:

- Focuses on meeting owners'/customers' needs by providing quality services at a cost that provides value to the owners/customers
- Is driven by the quest for continuous improvement in all operations
- Recognizes that everyone in the organization has owners/customers who are either internal or external
- Views an organization as an internal system with a common aim rather than as individual departments acting to maximize their own performances
- Focuses on the *way* tasks are accomplished rather than simply *what* tasks are accomplished
- Emphasizes teamwork and a high level of participation by all employees

TQM beliefs

Presented here are universal total quality management beliefs.

- Owner/customer satisfaction is the measure of quality
- Everyone has owners/customers; everyone is an owner/customer
- Quality improvement must be continuous
- Analyzing the processes used to create products and services is key to quality improvement
- Measurement, a skilled use of analytical tools, and employee involvement are critical sources of quality improvement ideas and innovations
- Sustained total quality management is not possible without active, visible, consistent, and enabling leadership by managers at all levels
- If we do not continuously improve the quality of products and services that we provide our owners/customers, someone else will

Characteristics of Successful TQM Companies

The characteristics that are common to companies that successfully implement TQM in their daily operations are listed here.

- Strive for owner/customer satisfaction and employee satisfaction
- Strive for accident-free jobsites

- Recognize that the owner/customer provides the revenue while the employees are responsible for the profit
- Recognize the need for measurement and fact-based decision making
- Arrange for employees to become involved in helping the company improve
- Train extensively
- Work hard at improving communication inside and outside the company
- Use teams of employees to improve processes
- Place a strong emphasis on the right kind of leadership, and provide supervisors with a significant amount of leadership training
- Involve subcontractors and suppliers, requiring them to adopt TQM
- Strive for **continuous** improvement

Quality principles that successful TQM companies recognize The quality principles that successful TQM companies recognize and attempt to continually incorporate into their actions are the following:

- People will produce quality goods and services when the meaning of quality is expressed daily in their relations with their work, colleagues, and organization.
- Inspection of the *process* is as important as inspection of the *product*. Quality improvement can be achieved *by the workers closest to the process.*
- Each system with a certain degree of complexity has a *probability of variation*, which can be understood by scientific methods.
- Workers work *in* the system to improve the system; *managers work on the system to improve the system.*
- Total quality management is a strategic choice made by top management, and must be *consistently translated* into guidelines provided to the whole organization.
- Envision what you desire to be as an organization, but *start working from where you actually are.*
- Studies have indicated that people like working on a quality-managed jobsite especially due to the cleaner site and safer place to work.
- Accept the responsibility for quality. Establish datums for measurement.
- Use the principle of *get it right, the first time, every time*.
- Understand that quality is a journey, not a destination. It consists of steps that form a process that is continuous.

Quality for the Customer

What do we mean by quality for the customer? We need to answer this question from three perspectives:

- *The customer perspective*. Quality for the customer means that, in selecting and buying the product or service, the customer has a hassle-free experience, and in using the product or service it meets or exceeds expectations for as long as they want it to. If we are providing quality for customers, then, at any moment during or after the process, they would buy more from us or recommend us to others.
- *Customer quality from the business perspective*. Key issues include: Identifying the target market and the needs of that market, establishing effective communication with customers or customer representatives to develop a good requirements specification, providing high-quality sales and customer service so that the customer likes the company and the interaction, as well as the product or service, and doing all of this affordably.
- *Customer quality from the technical perspective*. Technical groups can only deliver quality to the customer if the requirements specification is a true, complete, clear representation of the wants, needs, and expectations of the requirements of all targeted customers and all stakeholders.

Consumers

In defining quality for consumers, we need to address these issues:

- *Identifying customer groups*. We identify our market by segmenting it into customer groups. Usually, we define them by age, gender, and where they live. But we can use other key factors as needed.
- *Describing each customer group*. We describe each customer group by identifying: the purchaser, who decides to buy and pays for the item; the user, who actually uses it; and any other stakeholders who may be involved in the purchase decision or who need to be satisfied with the product or service. We then identify the customer's key need or problem to be solved and other elements of their interest in the product or service.
- *Defining the customer requirements specification*. At this point, we are ready to work out the details of what the customer really wants, and to describe it in such a way that our technical team can create the product or service and our marketing group can figure out how to promote and advertise it. We do this by working with representative customers or sometimes, by working with customer representatives. For example, a savvy marketing department might be able to define a product modification or an initial prototype of a new product, so that we save money by not working directly with the customer. The risk of using customer representatives is that, if they are wrong, we make a product that we think the customer wants, but which is not really valuable to the customer.

BUSINESS CUSTOMERS

Defining the needs of business customers and selling to them is a bit more straightforward than it is when we sell to consumers. Value to a business is that which improves the bottom line. Our first goal is to answer these questions:

- How does our product or service improve the customer's bottom line?

- What roles or job titles define the decision makers in the selection of this product or service?
- What are the key factors in the decision? If there is direct competition, what would make us better? If there is not, how can we demonstrate to our customers the value of what we do?

The Voice of the Customer

The voice of the customer is an approach that developed in the early 1990s in North America among both the promoters and critics of Total Quality Management. It has since been adopted by the more recent Six Sigma quality movement. "The voice of the customer" is a simple catch-phrase to remind us that we need to be certain we are addressing customer requirements—not purely internal requirements—or our idea of what the customer wants. This issue can be raised in product design, and also in troubleshooting quality problems. It allows us to ask:

- Do we really know what the customer wants? Or do we need to find a way to gather or check customer requirements?
- Do we know if this issue really matters to the customer? Let's make sure before we fix what isn't broken.
- Do we really know the customer's view and issues on the problem we're working on? Or, are we doing the customers' thinking for them, instead of listening to them?

Key Quality Concepts

Define requirements

Requirements definition is the process of taking all of the requirements from different sources and combining them into a *requirements specification*—a single set of documents that gives everyone what they need to know about requirements in a format that they can read and understand. There will be an executive summary— a page or two in business language. The customers will get a summary and also a detailed, clear write-up of everything they asked for. But the bulk of the requirements specification will be a technical document for the team developing the product. It will have two components: a technical requirements specification, which can run to several hundred pages for something as simple as an automobile engine; and a *requirements tracing matrix* that links each requirement to its source (customer, stakeholder, or standard), and to the features of each component required to achieve the customer requirement. As we develop the product, the requirements tracing matrix is expanded to include our quality control plan, showing how each requirement is associated with various checks and tests.

Types of Requirements

- *An input requirement* applies when we check an input, such as a raw material or a subcomponent, provided by a vendor, before using it in our own process.
- *A process requirement* is a measure of a process as it is happening, not the measure of an element of a product. For example, if a method requires that an enamel finish be fired for 30 minutes at a temperature of 2500 degrees Fahrenheit, we will need a way to test if that was done. Or if a building code requires that wiring was done by a certified electrician, we will need to be able to prove we used a certified electrician.
- *An output requirement* is what we usually think of as a definable, measurable feature of the output (product or component).

There are several important things to note about these three types of requirements:

- *Each type applies to components as well as to the whole product*. Using ham-and-cheese example, an input requirement would be the use of a particular brand and grade of ham. A process requirement for each component might be that the ham is grilled, the bread be toasted, and the cheese be melted. An output requirement for a component would be that there be a certain total weight and thinness of slice of the ham.
- *Some component tests can only be tested before assembly*. It would be difficult to certify the total weight of cheese in the sandwich after the sandwich was made, but easy before the cheese was put into the sandwich.
- *Sometimes, requirements are interchangeable*. For example, we might be able to satisfy an output requirement—tastes spicy—by testing an input requirement—such as "used 1 1⁄2 teaspoons of spicy mustard."
- *Process requirements generally require measurement or validation during the process and cannot be reliably obtained later*. For example, we can only know that our chef was wearing a hat and gloves—a health requirement— if we observe or confirm this while the sandwich is being made. It is possible to determine what happened in a process after the fact through investigation.

- *Some requirements can only be measured by a destruct test*. The only way to know if a ham-and-cheese sandwich is really good is to take a few bites—so we'd better make some extras for testing!

REQUIREMENTS, MEASUREMENT, TOLERANCES, AND ERROR

To do quality management, we have to fully define each requirement. What does a fully defined requirement look like?

- *A unique attribute* is defined or measured. For example, we might look at the type of bread, whether the bread is toasted, and the thickness of the slice. Each of these is a separate attribute, and we handle it separately.
- *Each attribute needs to be defined in a way that can be determined or measured*. For example, type of bread is defined (white, wheat, rye), but is not measured. Toasted could be either yes/no, or we could do a process measurement (length of time and toaster temperature), or a feature measurement (shade of color of the bread is within a defined range of medium to dark brown, neither too light, nor containing black.) The thickness of a slice would be measured.
- *Tolerances must be defined*. If a bread slice should be 1⁄2 inch thick, what is the allowable variation? Is anything between 0.4 inches and 0.6 inches acceptable? Or, we could have a range that doesn't have 0.5 in the middle, such as 0.40 inches to 0.65 inches. And how closely will we measure—in tenths of inches, or twentieths, or hundredths? If we don't assume that the slices are even, we would have to define multiple attributes, such as thickness of the thickest and thinnest locations on the slice.

PLANNING FOR INDEPENDENT, COST-EFFECTIVE CHECKING

- *Independent design*. All checks and tests should be designed independently of product development. If possible, the checks and tests should be defined by a separate person. If that is not feasible, the checks and tests should be defined first, before the product is designed.
- *Independent checking and testing*. As much as feasible, checking and testing should be carried out by people and equipment different from the people doing the work. People should definitely check their own work. That is valuable, but it is not enough. After a person thinks the job is done right, it should be checked independently to make sure it meets the specification, not his or her interpretation of the specification.

We control cost by choosing:

- *What to check and what to test.* Generally, checking is less expensive than testing, though with automation and computers, that is not always true. Also, checking and testing usually catch different types of errors.
- *When to check or test.* Usually, the earlier the better.
- *How to check or test*. Different methods have different cost per item. For example, I know a company that is developing the first nondestructive test for certain types of stress in metal. The innovation will radically reduce testing time and cost in certain applications.

Benchmarking

A *benchmark* is a defined measure of productivity in comparison to something else. We can benchmark internally, seeking to maintain or improve performance, or we can try to find industry benchmarks, and compare ourselves to our competitors.

Sometimes, industry associations can provide information in support of benchmarks that we should achieve. We should always evaluate them closely to be sure that the benchmark is appropriate and realistic in our work environment. For example, if we are using older equipment, we might not be able to achieve an industry average rate of production. Also, we should make sure that achieving that benchmark increases or at least maintains customer quality while lowering cost. There is no point achieving a benchmark if it means losing customers or losing dollars.

Best Practices

Information about solid, measurable benchmarks is hard to obtain and harder to fit into unique situation. Developing and using *best practices* is a powerful improvement method. A best practice is simply the best way to do a repeating process at your organization. Best practices:

- Must be defined, written down, and repeatable.
- Must meet or exceed applicable standards and regulations.
- May be derived from general standards, industry standards, industry best practices, research into activities of other companies or industries, consultant expertise, or internal research.
- Must be adapted and optimized for your organization.
- Are found, implemented, and improved over time.
- May be very technical and specific, or be broad and adaptable. If they are broad and adaptable, there should be guidelines for effective adaptation included in the practice.
- Must be more effective than any other available method, so that they are truly best.

Checking

Before we look at each type of checking, we should grasp one essential principle of quality management. The sooner—the earlier in the process—we eliminate error, the better.

The best choice is that, with good requirements specification and design, we prevent the error altogether. So error prevention is the least expensive option. In order of time and cost, here are six ways to deal with error:

1. *Do it right the first time*. Put top-notch effort into quality definition, planning, and design, so that the product or service is as free of error as possible from the beginning.
2. *Catch the errors in early reviews of the plans*. We should invest a lot of our quality management effort in review—ideally, close, structured review— of plans and design documents.
3. *Doing good production work*. If we work as a team to make sure that inputs from vendors are checked, equipment is working well, and people are following procedures, we minimize error and waste in production.

4. *Checking production work*. This would include all forms of inspection and testing, with correction of the defect or scrapping of the component to prevent the defect from reaching the customer.
5. *Letting the customer receive the error, and then doing a good job of fixing it.* Here, the customer has to deal with the frustration of the error, but we do a good job of helping with the cost through warranties, service plans, and affordable, high-quality customer service.
6. *Letting the customer receive the error, and then not providing good customer support*. In this case, the customer pays the price, and we almost certainly lose the customer. We also risk loss of reputation and legal action against us.

One way to fully appreciate the above list is to realize that, for every error, one of these six things will happen. Another way is to realize that these six errors fall into three sequential stages— planning, development of the product or service, and delivery to the customer.

Many studies across all industries have demonstrated that there is a cost and time ratio for planning: development: delivery of 1:10:100. This is called the 1:10:100 rule, and it states that each error will cost ten times more to fix in development than it would to fix in planning, and 100 times more if the error actually reaches the customer. Some experts, most notably Dr. Harold Kerzner, have discovered much higher ratios. Dr. Kerzner cites a client who found that, in a five stage project life cycle, the ratio was 1:5:25:100:1000.

There are three basic methods of checking:

1. *Review* is the process of comparing a document, such as a requirements specification or a design plan to standards or requirements that govern the process or results required of that document. Reviews can be highly formal and strict, or they can be loose and informal.
2. *Inspection* is the act of examining an attribute of a product, service, or component and comparing it to its specification. Some comparisons are discrete, such as "Did a red, blue, or black t-shirt go into the box for the customer?" while others involve measurement. Where measurement is involved, we determine if the attribute is within specified tolerances.

   Statistical quality control is a special case of inspection where we test only a sample of the product and extrapolate to statements about the entire batch of the product using statistical methods.
3. *Testing* is the process of actually doing something with a product, service, or component and seeing what happens. Key issues in testing include the design of experiments, the cost of testing, and the type of test. Tests should be designed to check the maximum number of features at the lowest costs.

   Destruct tests are tests that check a feature, but destroy the product in doing so. Clearly, destruct tests can only be used on prototypes or samples of our final product, not on every item we were going to sell!

Quiz

1. Which of these is the most effective way to use requirements?

(a) Separate standards from customer, technical, and stakeholder requirements, and deal with each one independently.

(b) In business, allow the customer to define the standards you must meet.

(c) Define a set of requirements that includes customer requirements, stakeholder requirements, technical requirements, and applicable standards and regulations, then strive to meet it.

(d) Constantly seek to improve and change requirements throughout product development.

2. Which of these is *not* one of the three types of requirements?

(a) an output requirement

(b) a statistical requirement

(c) an process requirement

(d) an input requirement

3. Which of these is *not* true of the 1:10:100 rule?

(a) It describes the ratio time and cost for error elimination across planning: development: delivery.

(b) It has been found to apply in many industries and situations.

(c) Lower ratios have been found in certain cases.

(d) Higher ratios have been found in certain cases.

4. Which of the following is *not* a legitimate option when a single defect is found in inspection or testing of a single instance of product?

(a) Allowing the product to go to the customer with the defect.

(b) Reworking the product to eliminate the defect, then making sure that the product is error free before delivery.

(c) Selling the product for a different use with less demanding requirements.

(d) Scrapping the product.

(e) All of these are legitimate options

5. All of the following methods have been used by businesses to deal with known errors in products. Which one is *least effective* for the business in the long run?

(a) When an error is found, fix it or scrap the product with the error.

(b) When an error is found, trace the effects forward and evaluate the consequences.

(c) When an error is found, trace the causes backwards to determine causes and root causes.

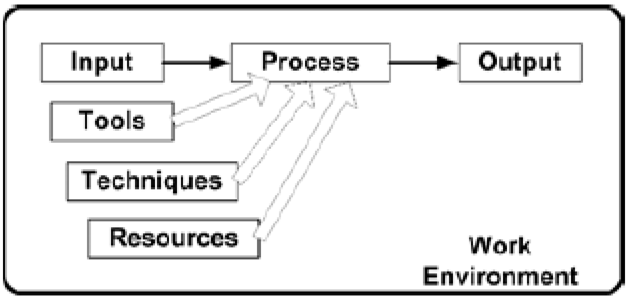
(d) Define a solution to the error, and inform customer service representatives, so that the company can make money from repair bills and service contracts.

Quality: A Process Flow Perspective

The idea of seeing a business as a bunch of flows through pipes is not a new one. Chemical engineering developed a method called *flow diagramming* for chemical plants, and that led to *data flow diagramming* for business by the 1950s. We also talk about work flow, information flow, and cash flow. When things are flowing, it's good for business.

We can think of each task as having three core elements, and four ancillary elements. The major elements are:

- *Inputs*, which are the ingredients, raw materials, or components that go into a process and become part of the output.
- *Process*, the activity of transforming inputs to make outputs—the work.
- *Outputs*, the end results of a task, such as a component or a finished product.



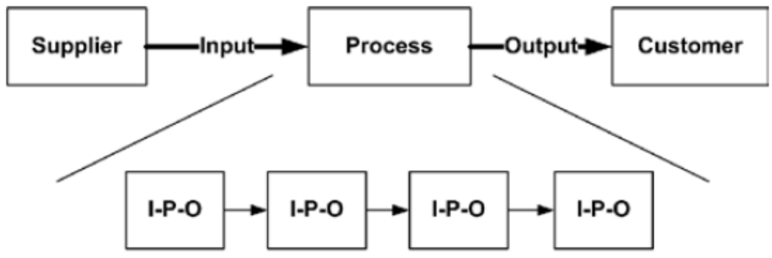
The input-process-output model

The additional, minor elements are:

- *Tools or equipment*, which are used for the task, but not used up.
- *Resources*, including disposable items (such as cleaning supplies), and our effort, which are used up in the process but do not get included in the product.
- *Techniques*, the instructions for the work process.
- *The work environment*, the space and conditions within which the work is being done.

Of course, each product may be built using many tasks—perhaps thousands or even millions. Tasks are linked because the output of one task is the input of another, until we can link the suppliers through all the tasks to the customer. This is called the Supplier-Input-Process-Output-Customer model, SIPOC.

Of course, a single product or company has many such chains that link all suppliers through many processes to all customers.



Supplier-Input-Process-Output-Customer
(SIPOC)

We can map the five stages of our quality management framework to the SIPOC model as follows:

- *Quality definition* comes before the definition of processes.
- *Quality planning* includes defining what processes are required to deliver the product to meet or exceed specifications, putting them in order by linking outputs of one process to inputs of the next, and then defining all seven aspects of each process with requirements and tolerances on all key variables, so that we can consistently produce all outputs of all processes to specification.
- *Quality control* in the broad sense including all forms of checking ensures that outputs and processes meet requirements, that defective output is reworked or scrapped, and that all seven aspects of processes are adjusted and restored to work within tolerances.
- *Quality assurance* includes activities to evaluate and improve processes, re-engineer work to eliminate unnecessary processes or steps, ensure effective communication and mutual understanding throughout the SIPOC chain, and auditing and review to ensure all processes are maintained to standard and improved.
- *Delivering quality* means carrying the SIPOC chain all the way through to the customer's receipt of the product or service, to the customer's perception that he or she has indeed received value and quality in the product, service, and contact with the company.

Defining Quality

Here are some excellent practices for obtaining good requirements:

- *Define your goal clearly at the start.* Are you seeking to define a new product? Are you seeking to learn about what your customers do and don't like about your current product? Are you seeking to compare customer opinions of your product or service and your competitors'? Are you seeking to determine what specific changes to your product or service the customers most want?
- *Make it interactive.* We learn more by letting customers try out or taste or play with a sample or prototype than we do by asking questions. We want the customers focused on the product, not on us. If a prototype or sample isn't possible, then we should use pictures, charts, and diagrams.
- *Record everything*. If possible, videotape or audiotape the sessions. If not, have two note takers so you lose as little as possible.
- *Use industry best practices*, such as focus groups and structure requirements elicitation methods.

- *Learn and use good survey design.* Good surveys are harder to make than you would think.
- *Study your results*. Don't just gather a lot of data and ignore it. Put it all together and learn what you need to know.
- *Check and test your results*. If you have a limited set of customers, or customer representatives, have them check and improve what you come up with from the sessions before it goes final. Otherwise, use multiple methods, such as a survey, a focus group, and a limited pilot product launch before you go into full production.

Some Characteristics of a Good Requirements Specification Adapted from IEEE standard 830-1993 and *Creating a Software Engineering Culture* by Karl E. Wiegers

Characteristic	**Description**
Complete	Nothing is missing, all attributes relevant to customer satisfaction are included, defined, and given tolerances.
Consistent	The specification contains no internal contradictions.
Correct	The specification accurately reflects customers' and stakeholders' wants and needs.
Feasible	Delivering to the specification is possible with technology that is available, can be obtained, or can be developed. Delivering to the specification is possible within time, cost, and other constraints.
Modifiable	The specification is designed so that future changes can be made in a defined, practical, traceable way.
Necessary	Each requirement adds value for the customer.
Prioritized	Requirements are ranked as to how essential it is to include each in the book. A group at the top may be listed as required, and then optional ones listed below that, in priority order.
Testable	Each requirement must be defined in a way that will allow for one or more tests of either process or product that will ensure conformance and detect error.
Traceable	Each element is uniquely identified so that its origin and purpose can be traced to ensure that it is necessary, appropriate, and accurate. This usually means assigning a number or code to each requirement that doesn't change, and then adding codes to indicate changes to a requirement and giving each new requirement its own code or number.
Unambiguous	Each requirement has only one possible interpretation.

Planning for Quality

Quality planning includes all of the work we do to organize and layout a plan for all stages of our quality work. Some of it begins even before we define product quality through requirements elicitation. After we have the requirements specification, we do a lot more quality planning. We define all of the reviews, inspections, and tests. We define our approach to QA, QC, rework and scrapping, process improvement, and delivering customer delight.

STATISTICAL QUALITY CONTROL

The only difference between statistical quality control and inspection is that, in inspection, we examine every single product. When we have thousands or millions of products made to the same specification, we can save time and money by applying Shewhart's statistical techniques and doing statistical quality control. If we can show that a sample of the product falls within a narrower tolerance, called the control limits, and certain other requirements are also met, then we can be confident that the whole batch fits within the customer's wider tolerance, called the specification limits.

Quality Assurance

Quality assurance (QA) developed in North America while TQM was developing in Japan. QA focused on solving quality problems, rather than living with rework and scrapping. The major difference between QA and TQM is that QA was usually performed at an engineering or management level with little executive support. Also, QA tended to gather information by auditing after the fact, which meant that it didn't bring in rapid benefits the way that methods that focus on the earliest parts of the process can. QA focused on production—the ratio of 10 in the 1:10:100 rules—more than on planning and requirements definition, where there is more to be gained.

Delivering Quality: Customer Delight

Key areas of improvement in customer delight include:

- *Training of salespeople, customer service representatives, and repair service people in customer service,* including listening skills, empathy, and follow through.
- *Empowerment of customer service representatives* within the company so that they can do what is needed to delight the customer.
- *Training in PDCA* so that customer service personnel can develop procedures and improve continuously.
- *Team customer service* to increase effectiveness and efficiency while reducing errors.
- *Automated information systems* for customer service, such as customer relations management (CRM) software systems.
- *Automated customer service* that embodies the highest quality customer service into artificial intelligence such as web interfaces and call management systems
- *Intelligent communications and training systems* that provide customer service representatives with the latest solutions and create cost-effective methods for communication with customers, such as support via Internet chat dialog.

Quiz

1. Which of these is *not* a reason that companies should maintain quality management initiatives?
- (a) When we don't spiral up towards more quality, we quickly spiral down towards less.
- (b) If our competitors keep the focus on quality and we don't, we will quickly fall behind and lose market share.
- (c) Quality management initiatives always show rapid results.
- (d) A steady commitment to quality solves other problems.

2. When describing flows in business, which one of these is *not* usually described as flowing? (This is a tricky one. If you get stuck, see the hint after the quiz.)
- (a) quality
- (b) cash
- (c) work
- (d) information

3. SIPOC stands for
- (a) Standard Industry Procedures Optimize Consumption.
- (b) Savvy Individuals Please Opinionated Customers.
- (c) Slick Industry Powerhouses Outwit Consumers.
- (d) Slipshod Irritating Products Outrage Customers.
- (e) Supplier, Input, Process, Output, Customer.

4. Which of these is *not* one of the qualities of a good requirements specification according to IEEE standard 830-1993?
- (a) consistent
- (b) integrated
- (c) feasible
- (d) unambiguous

5. Which of the following statements best describes the relationship between inspection and quality control?
- (a) QC replaced inspection.
- (b) QC provides information for process improvement, where inspection only supports the removal or repair of defects.
- (c) Inspection and quality control are very similar, but QC uses statistical sampling.
- (d) QC replaced inspection because you can't achieve quality by inspecting for defects, you have to control processes to prevent defects.

QUALITY FUNCTION DEPLOYMENT

Introduction

Dr. Mizuno, professor emeritus of the Tokyo Institute of Technology, is credited with initiating the quality function deployment (QFD) system. The first application of QFD was at Mitsubishi, Heavy Industries, Ltd., in the Kobe Shipyard, Japan, in 1972. After four years of case study development, refinement, and training, QFD was successfully implemented in the production of mini-vans by Toyota. Using 1977 as a base, a 20% reduction in startup costs was reported in the launch of the new van in October 1979, a 38% reduction by November 1982, and a cumulative 61% reduction by April 1984. Quality function deployment was first introduced in the United States in 1984 by Dr. Clausing of Xerox. QFD can be applied to practically any manufacturing or service industry. It has become a standard practice by most leading organizations, who also require it of their suppliers.

Quality function deployment enables the design phase to concentrate on the customer requirements, thereby spending less time on redesign and modifications. The saved time has been estimated at one-third to one-half of the time taken for redesign and modification using traditional means. This saving means reduced development cost and also additional income because the product enters the market sooner.

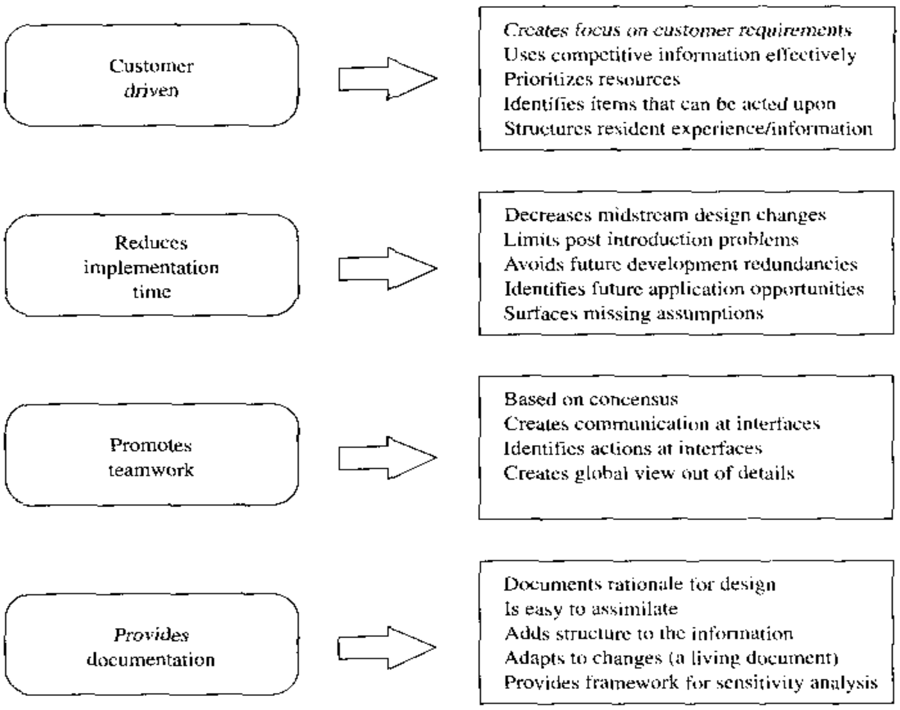


Figure 1- Benefits of QFD

Benefits of QFD

Quality function deployment was originally implemented to reduce start-up costs. Organizations using QFD have reported a reduced product development time. For example, U.S. car manufacturers of the late 1980s and early 1990s needed an average of five years to put a product on the market, from drawing board to showroom, whereas Honda put a new product on the market in two and a half years and Toyota did it in three years. Both organizations credit this reduced time to the use of QFD. Product quality and, consequently, customer satisfaction improve with QFD due to numerous factors depicted in Figure 1.

Customer Driven

Quality function deployment looks past the usual customer response and attempts to define the requirements in a set of basic needs, which are compared to all competitive information. All competitors are evaluated equally from customer and technical perspectives. This information can then be prioritized using a Pareto diagram. Management can then place resources where they will be the most beneficial in improving quality. Also, QFD takes the experience and information that are available within an organization and puts them together as a structured format that is easy to assimilate.

Reduces Implementation Time

Fewer engineering changes are needed when using QFD, and, when used properly, all conflicting design requirements can be identified and addressed prior to production.

This results in a reduction in retooling, operator training, and changes in traditional quality control measures. By using QFD, critical items are identified and can be monitored from product inception to production.

Promotes Teamwork

Quality function deployment forces a horizontal deployment of communication channels. Inputs are required from all facets of an organization, from marketing to production to sales, thus ensuring that the voice of the customer is being heard and that each department knows what the other is doing. This activity avoids misinterpretation, opinions, and miscues.

Provides Documentation

A database for future design or process improvements is created. Data that are historically scattered within operations, frequently lost and often referenced out of context, are now saved in an orderly manner to serve future needs. This database also serves as a training tool for new engineers.

House of Quality

The primary planning tool used in QFD is the house of quality. The house of quality translates the voice of the customer into design requirements that meet specific target values and matches those against how an organization will meet those requirements. Many managers and engineers consider the house of quality to be the primary chart in quality planning.

The structure of QFD can be thought of as a framework of a house, as shown in Figure 2.

The parts of the house of quality are described as follows:

The exterior walls of the house are the customer requirements. On the left side is a listing of the voice of the customer, or what the customer expects in the product. On the right side are the prioritized customer requirements, or planning matrix.

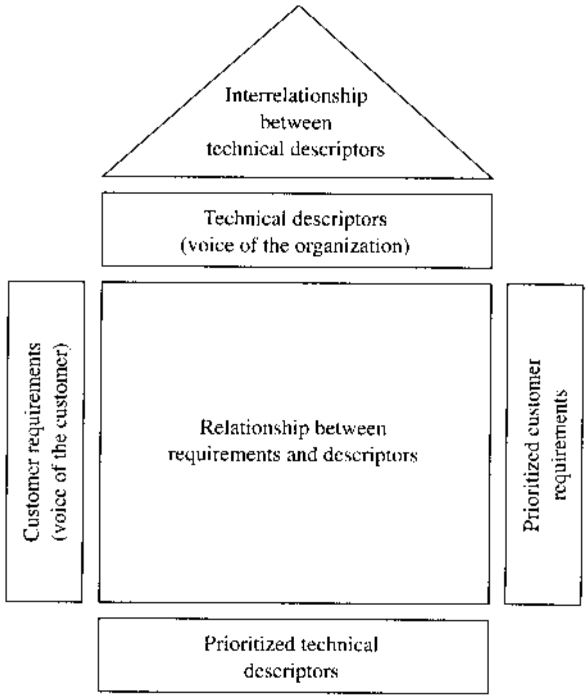


Figure 2 – House of Quality

Listed are items such as customer benchmarking, customer importance rating, target value, scale-up factor, and sales point.

The ceiling, or second floor, of the house contains the technical descriptors. Consistency of the product is provided through engineering characteristics, design constraints, and parameters.

The interior walls of the house are the relationships between customer requirements and technical descriptors. Customer expectations (customer requirements) are translated into engineering characteristics (technical descriptors).

The roof of the house is the interrelationship between technical descriptors. Tradeoffs between similar and/or conflicting technical descriptors are identified.

The foundation of the house is the prioritized technical descriptors. Items such as the technical benchmarking, degree of technical difficulty, and target value are listed.

This is the basic structure for the house of quality; once this format is understood, any other QFD matrices are fairly straightforward.

Building a House of Quality

The matrix that has been mentioned may appear to be confusing at first, but when it is looked at by parts, the matrix is significantly simplified. A basic house of quality matrix is shown in Figure 3. There is a considerable amount of information contained within this matrix. It is easier to comprehend once each part is discussed in detail.

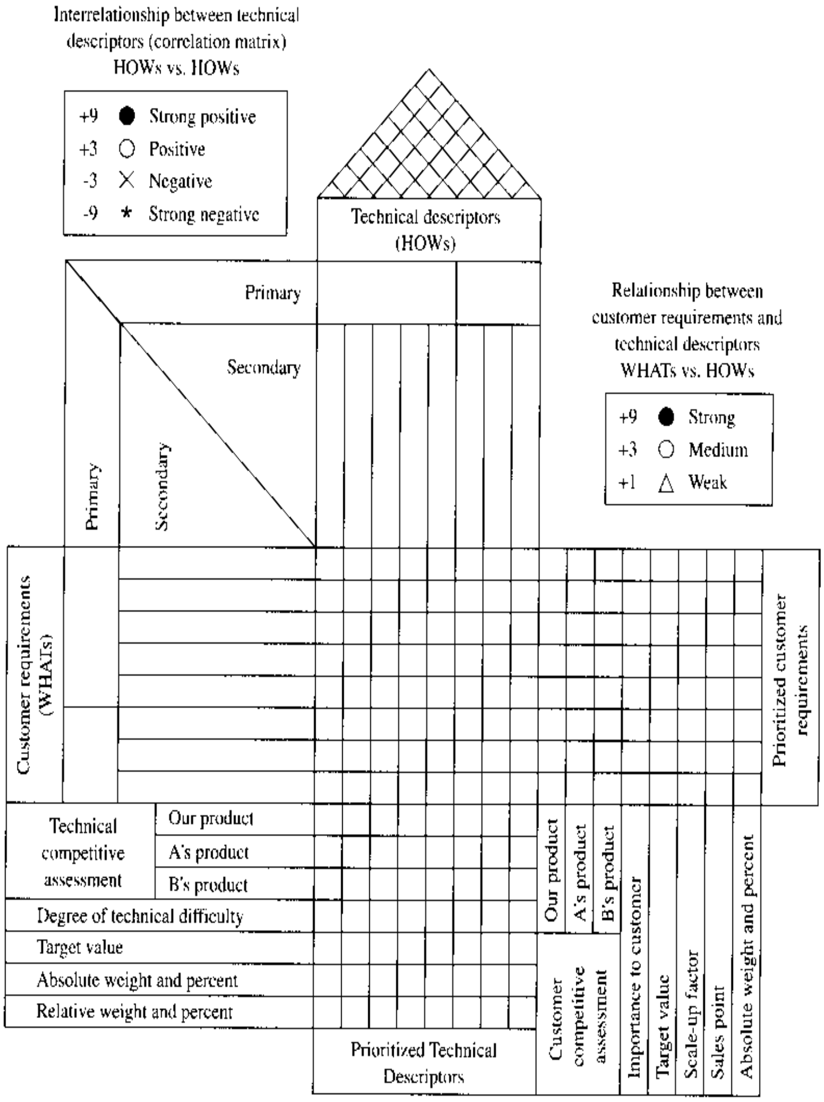


Figure 3 – Basic House of Quality Matrix

Step 1-List Customer Requirements (WHATs)

Quality function deployment starts with a list of goals/objectives. This list is often referred as the WHATs that a customer needs or expects in a particular product. This list of primary customer requirements is usually vague and very general in nature. Further definition is accomplished by defining a new, more detailed list of secondary customer requirements needed to support the primary customer requirements. In other words, a primary customer requirement may encompass numerous secondary customer requirements. Although the items on the list of secondary customer requirements represent greater detail than those on the list of primary customer requirements, they are often not directly actionable by the engineering staff and require yet further definition. Finally, the list of customer requirements is divided into a hierarchy of primary, secondary, and tertiary customer requirements, as shown in Figure 4. For example, a primary customer requirement might be dependability and the corresponding secondary customer requirements could include reliability, longevity, and maintainability.

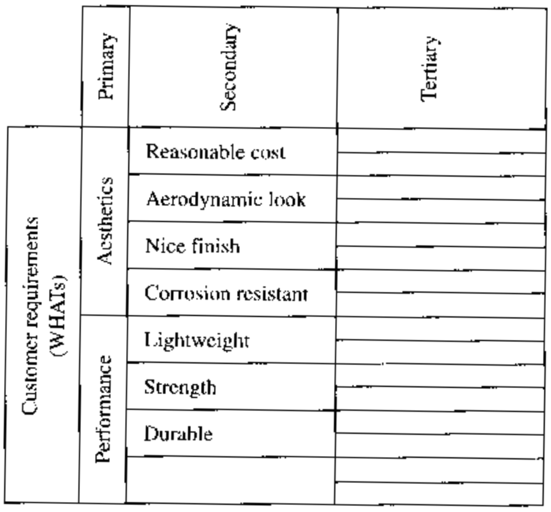


Figure 4 – Refinement of Customer Requirements

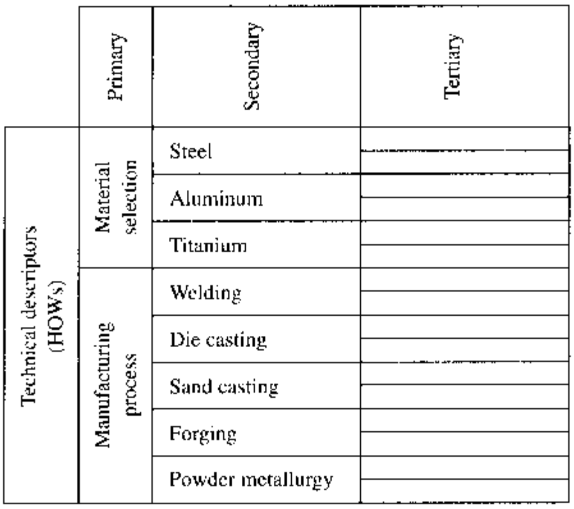


Figure 5 – Refinement of Technical Descriptors

Step 2-List Technical Descriptors (HOWs)

The goal of the house of quality is to design or change the design of a product in a way that meets or exceeds the customer expectations. Now that the customer needs and expectations have been expressed in terms of customer requirements, the QFD team must come up with engineering characteristics or technical descriptors (HOWs) that will affect one or more of the customer requirements. These technical descriptors make up the ceiling, or second floor, of the house of quality. Each engineering characteristic must directly affect a customer perception and be expressed in measurable terms.

Further definition of the primary technical descriptors is accomplished by defining a list of secondary technical descriptors that represent greater detail than those on the list of primary technical descriptors. This is similar to the process of translating system-level engineering specifications into part-level specifications. These secondary technical descriptors can include part specifications and manufacturing parameters that an engineer can act upon. Often the secondary technical descriptors are still not directly actionable, requiring yet further definition. This process of refinement is continued until every item on the list is actionable. Finally, the list of technical descriptors is divided into a hierarchy of primary, secondary, and tertiary technical descriptors, as shown in Figure 5.

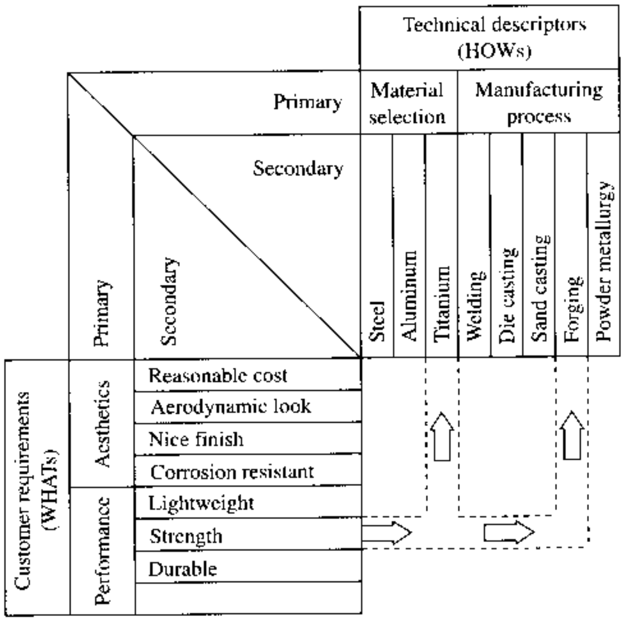


Figure 6 – Structuring an L-shaped diagram

Step 3-Develop a Relationship Matrix Between WHATs and HOWs

The next step in building a house of quality is to compare the customer requirements and technical descriptors and determine their respective relationships. Tracing the relationships between the customer requirements and the technical descriptors can become very confusing, because each customer requirement may affect more than one technical descriptor, and vice versa.

Structuring an l-shaped diagram

One way to reduce the confusion associated with determining the relationships between customer requirements and technical descriptors is to use an L-shaped matrix, as shown in Figure 6. The L shape, which is a two-dimensional relationship that shows the intersection of related pairs of items, is constructed by turning the list of technical descriptors perpendicular to the list of customer requirements. The L-shaped matrix makes interpreting the complex relations very easy and does not require a significant amount of experience.

Relationship matrix

The inside of the house of quality, called the relationship matrix, is now filled in by the QFD team. The relationship matrix is used to represent graphically the degree of influence between each technical descriptor and each customer requirement. This step may take a long time, because the number of evaluations is the product of the number of customer requirements and the number of technical descriptors. Doing this early in the development process will shorten the development cycle and lessen the need for future changes.

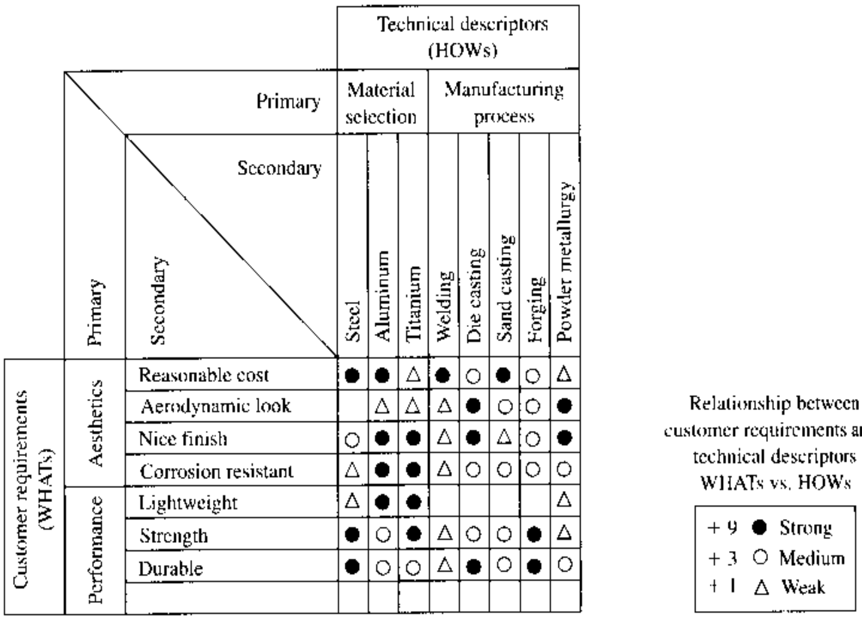


Figure 7 – Adding Relationship Matrix to the House of Quality

It is common to use symbols to represent the degree of relationship between the customer requirements and technical descriptors. For example,

- A solid circle represents a strong relationship.
- A single circle represents a medium relationship.
- A triangle represents a weak relationship.
- The box is left blank if no relationship exists.

It can become difficult to comprehend and interpret the matrix if too many symbols are used. Each degree of relationship between a customer requirement and a technical descriptor is defined by placing the respective symbol at the intersection of the customer requirement and technical descriptor, as shown in Figure 7. This method allows very complex relationships to be depicted and interpreted with very little experience.

The symbols that are used to define the relationships are now replaced with numbers; for example,

● =9

o =3

Δ =1

These weights will be used later in determining trade-off situations for conflicting characteristics and determining an absolute weight at the bottom of the matrix.

After the relationship matrix has been completed, it is evaluated for empty rows or columns. An empty row indicates that a customer requirement is not being addressed by any of the technical descriptors. Thus, the customer expectation is not being met. Additional technical descriptors must be considered in order to satisfy that particular customer requirement. An empty column indicates that a particular technical descriptor does not affect any of the customer requirements and, after careful scrutiny, may be removed from the house of quality.

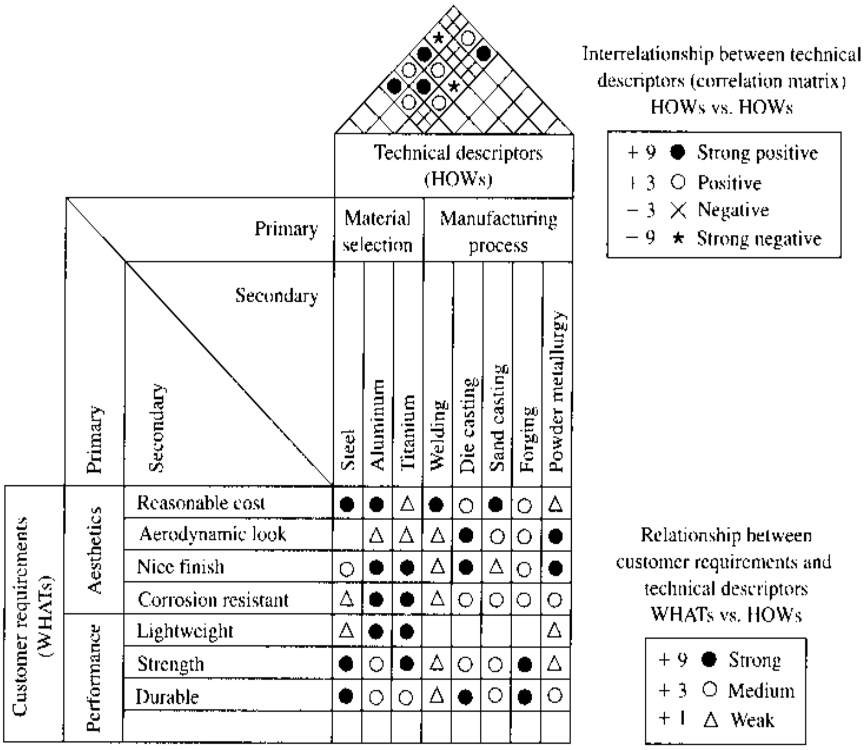


Figure 8 – Adding Interrelationship Matrix to the House of Quality

Step 4-Develop an Interrelationship Matrix Between HOWs

The roof of the house of quality, called the correlation matrix, is used to identify any interrelationships between each of the technical descriptors. The correlation matrix is a triangular table attached to the technical descriptors, as shown in Figure 8. Symbols are used to describe the strength of the interrelationships; for example,

- A solid circle represents a strong positive relationship.
- A circle represents a positive relationship.
- An X represents a negative relationship.
- An asterisk represents a strong negative relationship.

Step 5-Competitive Assessments

The competitive assessments are a pair of weighted tables (or graphs) that depict item for item how competitive products compare with current organization products. The competitive assessment tables are separated into two categories, customer assessment and technical assessment, as shown in Figures 9 and 10, respectively.

CUSTOMER COMPETITIVE ASSESSMENT

The customer competitive assessment makes up a block of columns corresponding to each customer requirement in the house of quality on the right side of the relationship matrix, as shown in Figure 9. The numbers 1 through 5 are listed in the competitive evaluation column to indicate a rating of 1 for worst and 5 for best. These rankings can also be plotted across from each customer requirement, using different symbols for each product.

The customer competitive assessment is a good way to determine if the customer requirements have been met and identify areas to concentrate on in the next design. The customer competitive assessment also contains an appraisal of where an organization stands relative to its major competitors in terms of each customer requirement. Both assessments are very important, because they give the organization an understanding on where its product stands in relationship to the market.

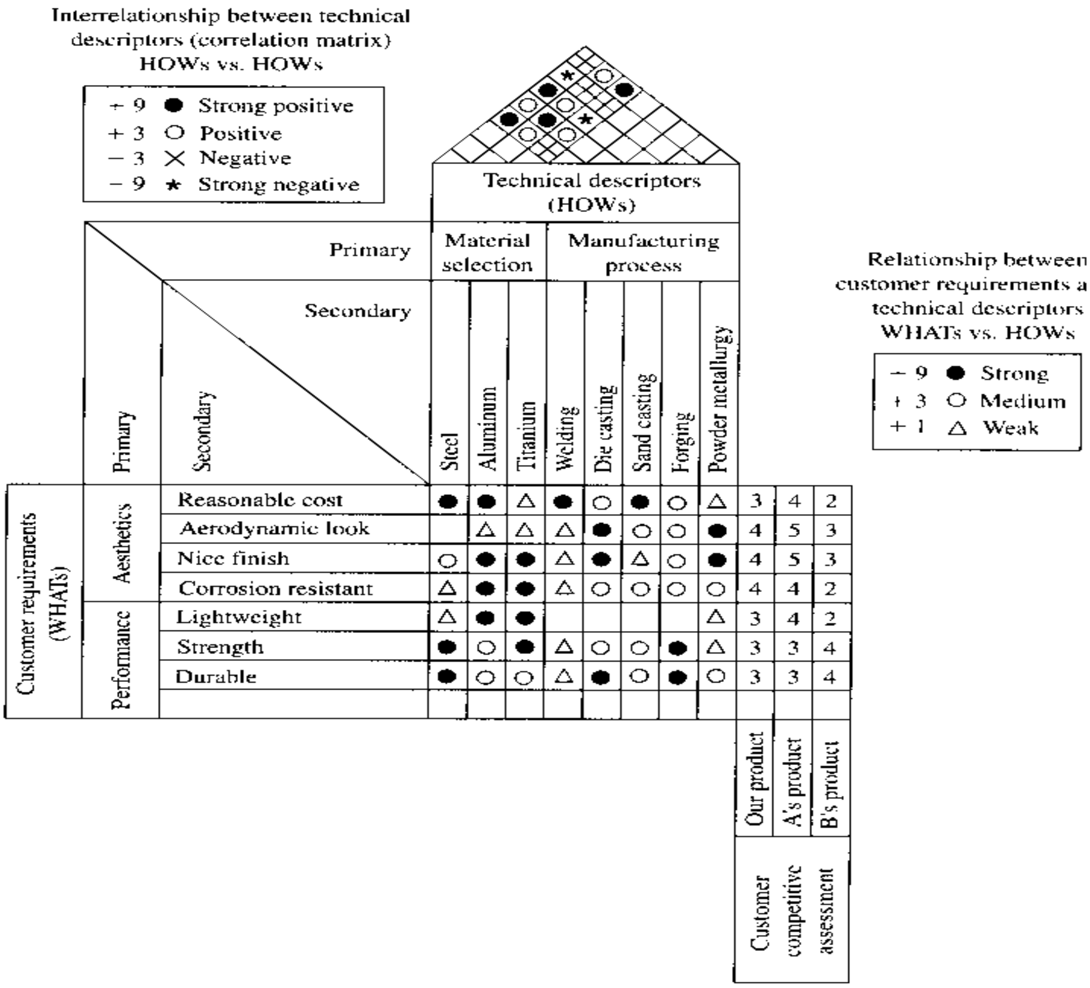


Figure 9 – Adding Customer Competitive Assessment to the House of Quality

Technical competitive assessment

The technical competitive assessment makes up a block of rows corresponding to each technical descriptor in the house of quality beneath the relationship matrix, as shown in Figure 10. After respective units have been established, the products are evaluated for each technical descriptor.

Similar to the customer competitive assessment, the test data are converted to the numbers 1 through 5, which are listed in the competitive evaluation row to indicate a rating, 1 for worst and 5 for best. These rankings can then be entered below each technical descriptor using the same numbers as used in the customer competitive assessment.

The technical competitive assessment is often useful in uncovering gaps in engineering judgment. When a technical descriptor directly relates to a customer requirement, a comparison is made between the customer's competitive evaluation and the objective measure ranking.

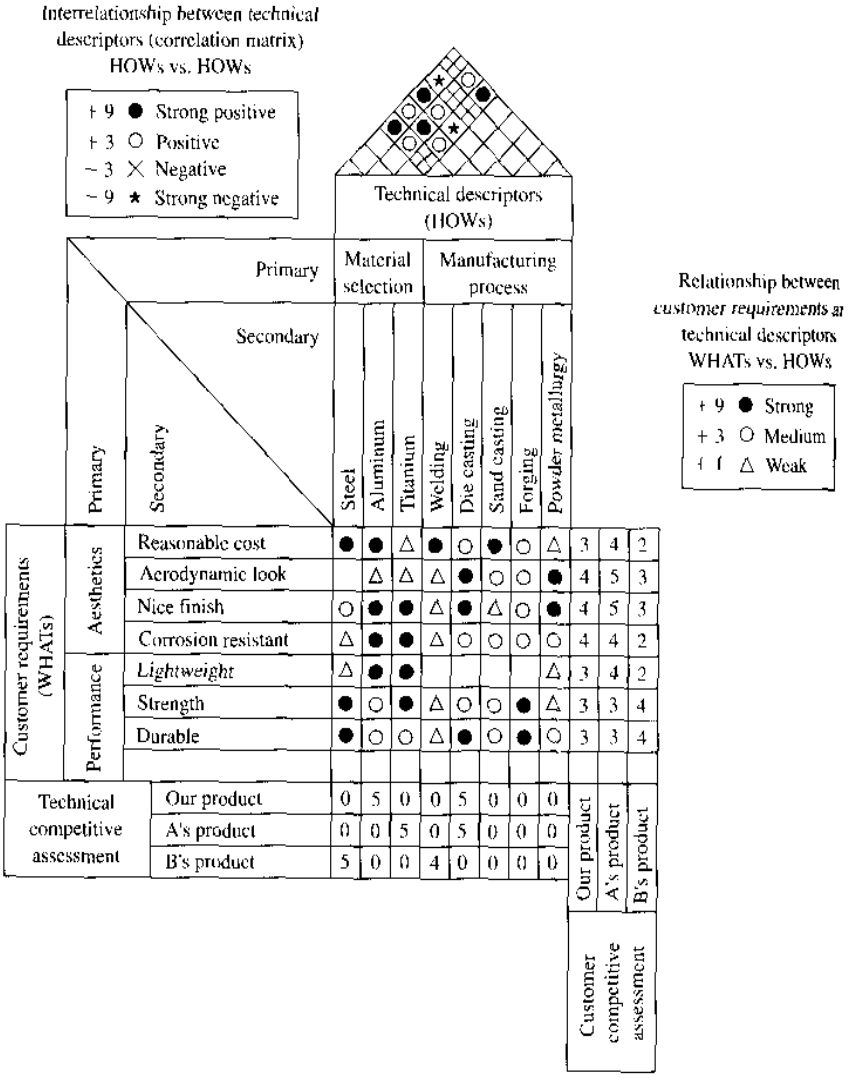


Figure 10 – Adding Technical Competitive Assessment to the House of Quality

Customer requirements and technical descriptors that are strongly related should also exhibit a strong relationship in their competitive assessments. If an organization's technical assessment shows its product to be superior to the competition, then the customer assessment should show a superior assessment. If the customer disagrees, then a mistake in engineering judgment has occurred and should be corrected.

Step 6-Develop Prioritized Customer Requirements

The prioritized customer requirements make up a block of columns corresponding to each customer requirement in the house of quality on the right side of the customer competitive assessment as shown in Figure 11. These prioritized customer requirements contain columns for importance to customer, target value, scale-up factor, sales point, and an absolute weight.

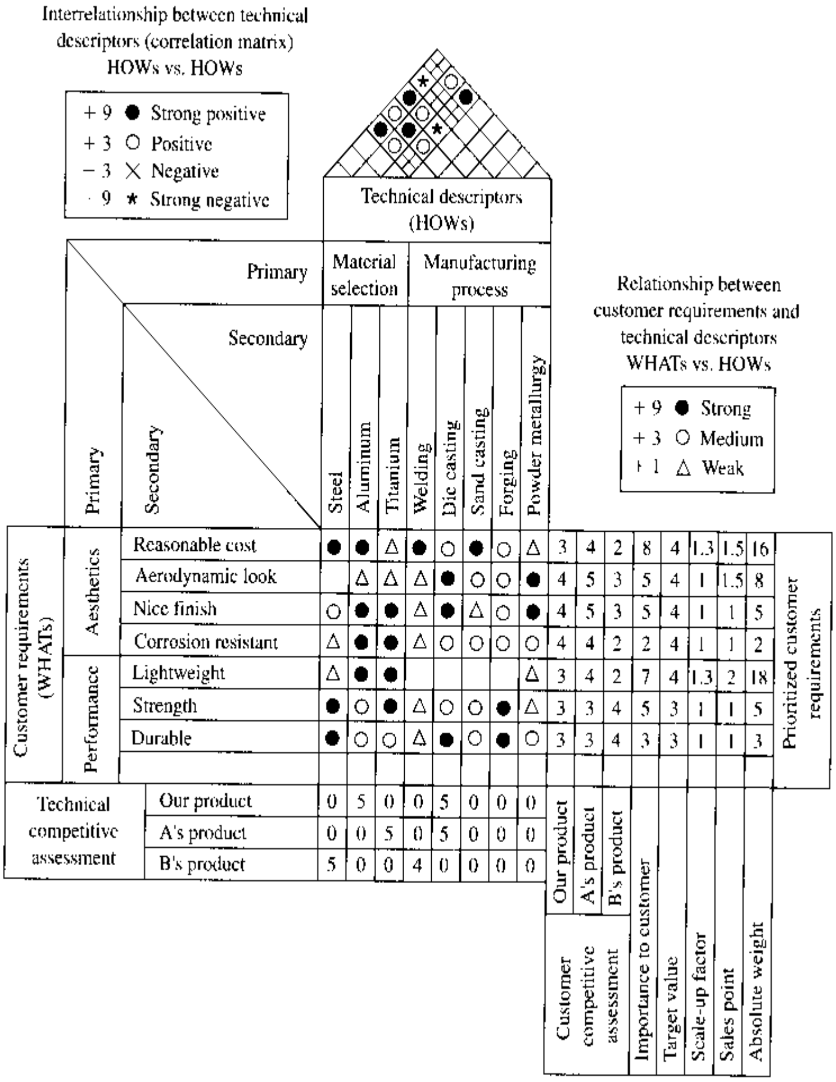


Figure 11 – Adding Prioritized Customer Requirements to the House of Quality

Importance to customer

The QFD team-or, preferably, the focus group-ranks each customer requirement by assigning it a rating. Numbers 1 through 10 are listed in the importance to customer column to indicate a rating of 1 for least important and 10 for very important. In other words, the more important the customer requirement, the higher the rating.

Importance ratings represent the relative importance of each customer requirement in terms of each other. Assigning ratings to customer requirements is sometimes difficult, because each member of the QFD team might believe different requirements should be ranked higher. The importance rating is useful for prioritizing efforts and making trade-off decisions.

TARGET VALUE

The target-value column is on the same scale as the customer competitive assessment (1 for worst, 5 for best can be used). This column is where the QFD team decides whether they want to keep their product unchanged, improve the product, or make the product better than the competition.

SCALE-UP FACTOR

The scale-up factor is the ratio of the target value to the product rating given in the customer competitive assessment. The higher the number, the more effort is needed. Here, the important consideration is the level where the product is now and what the target rating is and deciding whether the difference is within reason. Sometimes there is not a choice because of difficulties in accomplishing the target. Consequently, the target ratings often need to be reduced to more realistic values.

SALES POINT

The sales point tells the QFD team how well a customer requirement will sell. The objective here is to promote the best customer requirement and any remaining customer requirements that will help in the sale of the product. For example, the sales point is a value between 1.0 and 2.0, with 2.0 being the highest.

ABSOLUTE WEIGHT

Finally, the absolute weight is calculated by multiplying the importance to customer, scale-up factor, and sales point:

Absolute Weight = (Importance to Customer)(Scale-up Factor)(Sales Point)

A sample calculation is included in Figure 11. After summing all the absolute weights, a percent and rank for each customer requirement can be determined. The weight can then be used as a guide for the planning phase of the product development.

Step 7-Develop Prioritized Technical Descriptors

The prioritized technical descriptors make up a block of rows corresponding to each technical descriptor in the house of quality below the technical competitive assessment, as shown in Figure 12. These prioritized technical descriptors contain degree of technical difficulty, target value, and absolute and relative weights. The QFD team identifies technical descriptors that are most needed to fulfill customer requirements and need improvement. These measures provide specific objectives that guide the subsequent design and provide a means of objectively assessing progress and minimizing subjective opinions.

DEGREE OF DIFFICULTY

Many users of the house of quality add the degree of technical difficulty for implementing each technical descriptor, which is expressed in the first row of the prioritized technical descriptors. The degree of technical difficulty, when used, helps to evaluate the ability to implement certain quality improvements.

TARGET VALUE

A target value for each technical descriptor is also included below the degree of technical difficulty. This is an objective measure that defines values that must be obtained to achieve the technical descriptor. How much it takes to meet or exceed the customer's expectations is answered by evaluating all the information entered into the house of quality and selecting target values.

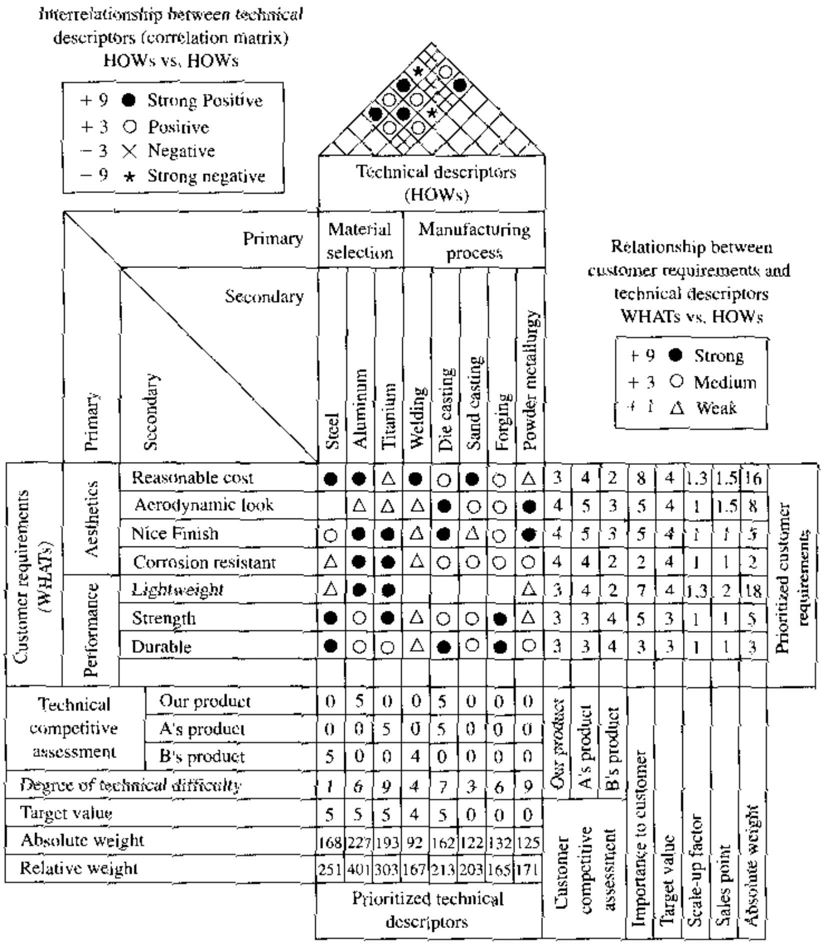


Figure 12 – Adding Prioritized Technical Descriptors to the House of Quality

ABSOLUTE WEIGHT

The last two rows of the prioritized technical descriptors are the absolute weight and relative weight. A popular and easy method for determining the weights is to assign numerical values to symbols in the relationship matrix symbols, as shown previously in Figure 8. The absolute weight for the j^{th} technical descriptor is then given by

$$a_j = \sum_{i=1}^{n} R_{ij} c_i$$

where

a_j = row vector of absolute weights for the technical descriptors (i = 1,…….,m)
R_{ij} = weights assigned to the relationship matrix (i = 1,….., n, j = 1,….., m)
c_i = column vector of importance to customer for the customer requirements (i=1, …., n)
m = number of technical descriptors
n = number of customer requirements

RELATIVE WEIGHT

In a similar manner, the relative weight for the j^{th} technical descriptor is then given by replacing the degree of importance for the customer requirements with the absolute weight for customer requirements. It is;

$$b_j = \sum_{i=1}^{n} R_{ij} d_i$$

where;

b_j = row vector of relative weights for the technical descriptors (1 = 1, ….., *m)*

d_i = column vector of absolute weights for the customer requirements (i=1, …….., *n)*

Higher absolute and relative ratings identify areas where engineering efforts need to be concentrated. The primary difference between these weights is that the relative weight also includes information on customer scale-up factor and sales point.

These weights show the impact of the technical characteristics on the customer requirements. They can be organized into a Pareto diagram to show which technical characteristics are important in meeting customer requirements. Along with the degree of technical difficulty, decisions can be made concerning where to allocate resources for quality improvement.

Each QFD team can customize the house of quality to suit their particular needs. For example, columns for the number of service complaints may be added.

QFD Process

The QFD matrix (house of quality) is the basis for all future matrices needed for the QFD method. Although each house of quality chart now contains a large amount of information, it is still necessary to refine the technical descriptors further until an actionable level of detail is achieved. Often, more than one matrix will be needed, depending on the complexity of the project. The process is accomplished by creating a new chart in which the HOWs (technical descriptors) of the previous chart become the WHATs (customer requirements) of the new chart. This process continues until each objective is refined to an actionable level. The HOW MUCH (prioritized technical descriptors) values are usually carried along to the next chart to facilitate communication. This action ensures that the target values are not lost during the QFD process. If the target values are changed, then the product is not meeting the customer requirements and not listening to the voice of the customer, which defeats the purpose of QFD.

QUALITY SYSTEMS

Introduction

The International Organization for standardization (ISO) ISO is composed of more than 90 member countries.

- The ISO Technical Committee (TC) developed A series of Five International standards for quality.

(**ISO 9000, 9001, 9002, 9003, 9004**) were intended to be advisory and were developed for use in two party contractual situation and internal auditing.

- Most organization have found that the system has led to:

- Fewer on site audit by customers.
- Increased market share.
- Improved quality, both internally and externally.
- Improved product and service quality levels from suppliers.
- Greater awareness of quality by employees.
- A documented formal system.
- Reduced operating cost.

ISO 9000 SERIES OF STANDARDS

The ISO 9000 series of standards is generic in scope. By design the series can be lored to fit any organization's needs.

It can be applied to construction, engineering, etc.

Its purpose is to unify quality terms and definitions and use those terms to demonstrate a supplier's capability

The five standards of the series:

1- **ISO 9000** "Quality Management and Quality Assurance Standards Guidelines for selection and use"

Explains fundamental quality concepts, defines key terms, and provide guideline for selecting.

2- **ISO 9001**, "quality systems- model for quality Assurance in design, development,

Production, installation, and servicing," is most comprehensive in the series.

3- **ISO 9002**," quality systems- model for quality Assurance in production, installation, and servicing," addresses the prevention, detection, and correction of problems during production and installation.

4- **ISO 9003**," quality systems- model for quality Assurance in final inspection and test" is the least comprehensive of the standards.

5- **ISO 9004**," quality management and quality system elements guideline" provides guidance for supplier.

Other Quality Systems

There are currently three other systems (QS-9000, TE-9000 and AS9000).

QS-9000

Uses the ISO 9001 as its foundation, but its requirements are much broader.

There are three sections in this standard.

I- common requirements, which include the exact text of ISO 9001.

II- Additional requirements covering production part approval process.

III- Customer specific requirements.

TE-9000

The tooling and equipment supplement (TE-9000).

Provide an interpretation of QS-9000 requirements as they apply to tooling and equipment.

Communizes quality system requirements.

Promote the effective use of reliability and maintainability.

AS-9000

The document is identical to ISO-9000 in most aspect, there are no industry specific element such as those occur in QS-9000.

AS-9000 builds on the simplicity of ISO-9000, adding insight and addressing the distinctive needs of the aerospace industry.

IMPLEMENTATION

There are number of steps that are necessary to implement quality management system.

1- Senior Management Commitment

The most important step that will meet or exceed an ISO-9000 standard is to acquire the full support of upper management. The chief executive officer (CEO) must be willing to commit the resource necessary to achieve certification. This is the critical to the success of the project. Without CEO's support, the process may continuously run into unnecessary road backs or even be doomed to failure.

2- Appoint the Management Representative

The step is the appointment of a management representative. The person is responsible for all parties involved in the process, both internal and external .It is important to note that the quality manager does not have to be the representative. The implementation of the quality system should involve everyone in the organization .The standard requires the management representative be a person who is able to ensure that the quality system is effectively implemented and maintained irrespective *of other responsibilities.*

3-Awareness

This step requires an awareness program. Because the process is going to affect members of the organization as well as require their input, it stands to reason that everyone should understand the quality system. They should know how it would affect day-today operations and the potential benefits. This information can be relayed through short, one-hour awareness training sessions.

4-Appoint An Implementation Team

An implementation team should be assembled. This team should be draw from the all levels and areas of the organization.

5-Training

The implementation team, supervisors, and internal audit team should be trained. The activity can be accomplished by sending team leaders for training and having them training, the other team members or by bringing the training in-house for all team members through a one-or two-day seminar.

6-Time Schedule

This activity develops a time schedule for the implementation and registration of the system. This time frame will vary, depending on the size and the type of organization and the extent of the existing quality system. Most organizations can complete the entire process in less than 1.5 years.

7-Select Element Owners

The implementation team selects owners for each of the system elements. Many of the owners will be members of the implementation team. Owners may be assigned more than one element. Each owner has the option of selecting a team to assist in the process.

8-Review The Present System

Perform a review of present quality system. Copies of all the quality manuals, procedures, work instructions, and forms presently in use are obtained. These documents are sorted into the system elements to determine what is available and what is needed to complete the system. This activity is a gab analysis and can be performed by the element owners and their teams or by an external consultant.

9-Write The Documents

Prepare written quality policy and procedure manuals –they can be combined into document. Write appropriate work instructions to maintain the quality of the specific function.

10-Install the New System

Integrate the policies, procedures, and work instructions into day –to day workings of the organization and documents what is being done .It is not necessary for all elements to be implemented at the same time.

11-Internal Audit

Conduct an internal audit of the quality system. This step is necessary to ensure that the system is working effectively and to provide management with information for the comprehensive management review.

12-Management Review

Conduct a management review .The management review is used to determine the effectiveness of the system in achieving the stated quality goals.

13-Preassessment

This step is optional .If a good job has been done on the previous step, Preassessment is not necessary.

14-Registration

This step requires three parts: choosing a registrar, submitting an application, and conducting the registrar's system audit. Considerations in choosing a registrar include cost, and lead-time. The application for registration should also include supplying the registrar with the policy and procedure manuals for their review.

DOCUMENTATION

A quality system is a method used to ensure that the quality level of a product of service is maintained. The system documentation can be viewed as a hierarchy containing four tiers as shown in Figure. All documentation moves from one level to the other in a descending order .If the system is properly structured, changes at one level will dom affect the levels above it but may affect those below.

1-Policy

This is the document that define what will be done and why. A quality policy manual should be written so it is clear, precise, practical, and easy to under strand. The why can be stated juste once as a quality policy statement. Each element of the standard is addressed individual and usually requires one page or less.

2-Procedure

These procedures describe the methods that will be used to implement and perform the stated policies. The procedures define who should perform specific tasks. They dictate the strategies that will be used to the quality of the system. Procedures are more detailed than the policies; however, they too should be written in a manner that will allow for easy understanding. Many organizations combine the policy and procedures into one document.

3-Work Instructions

Work instructions are usually department, machine, task, or products oriented and spell out how a job will be done. These instructions are the most detailed of the documentation hierarchy. A work instruction may be in the form of detailed drawing, recipe, routing sheet, or specific job function.

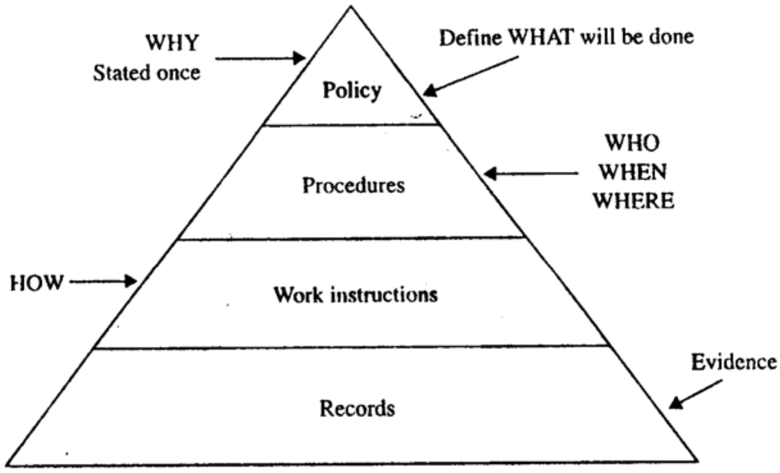


Figure **The Documentation Pyramid**

4-Records

The previous procedures may be forms that are filled out, a stamp of approval on a product, or a signature and date of some type of document. They provide data for corrective action and a way of recalling products, if necessary.

DOCUMENT DEVELOPMENT

To begin creating the documentation system, the implementation team should gather all the existing policies, procedures, work instructions, and forms that are presently in use. Each document should be reviewed and an attempt should be made to fit into of the elements. If a document does not appear to pertain to any element, it show set aside. Where it belongs may become evident at a later time. In addition they should decide if the document is currently accurate and up to date .If it is not, is so be updated or discarded.

As the documents are produced, the implementation team becomes the review committee .If changes appear necessary, suggestions are made and reviewed. The initiating team then either clarifies what they have written or revises the documents as required. When the documents have been completed, they should formatted in a manner that will allow for simple and effective document control.

ISO/ QS 9000 ELEMENTS

We will refer to the numbering system used in the **ISO 9001** standard. Additional information prescribed by QS-**9000**.

1-Management Responsibility

Three major topics are addressed here –the quality policy, responsibility and authority and management review. The quality policy statement should be a short statement that defines the organization objectives for, and commitment to, quality.

Responsibility and authority must be defined for all personnel affecting quality. The senior managers must be the ultimate manager of quality .the use of an organizational chart is one method of showing the flow of authority in an easy –to- understands format. A management representative must be appointed and given the authority to implement and maintain the quality system.

Management review is required to ensure that the system remains effective. Reviews should make use of information from customer's feedback and internal audits, as well as process and product performance.

2-The Quality System

This element requires the establishment and maintenance of document quality system .It describes the levels of documentation, such as the policies, procedures, and work instructions. Emphasis is placed on problem prevention, rather than detection, in all activities from sales through installation and servicing after delivery.

3-Contract Review

This review should answer questions. First, are the requirements of the contact clearly defined? Supplier must be sure that the requirements of the customer are understood before quality product

Or service can be supplied Second, are there any unused quality requirements? A deviation from a standard product or service may require especial processing these requirements will have to be passed on to the proper area to ensure meeting the specification. Finally, dose the organization have the capability to meet the requirements? Capability to meet the requirements means not only having material and equipment to perform the necessary operations, but also the technology qualified employees, and the ability to deliver on time.

4- Design Control

The general requirement of design control is the establishment and maintenance of procedures to control the verity that the product design meets specified requirement and aligned with the contract review. The procedure should take into account the sequential parallel activities involved in the design and provide the method to verify that the activities are being performed. Evaluations of safety, dependability, and performance. Documentation is required to ensure that the design output meets the input requirements. Outputs include some things as drawings, instructions, specifications and serving procedures. The comparison of output to input should be carried out through regular reviews during the design process. All design changes are reviewed and evaluated for the effect that will take on the overall product or service.

5-Document and Data Control

This element requires that procedures and a master list be established and maintained to control all documents and data that affect the quality of product or service. Methods must be in place to provide for the review and approval of documents for adequacy before they are issued.

6-Purchasing

The general requirement of this element is to established and maintain documented procedures to ensure that purchased material or products will conform to specified requirements .To meet this requirements, the procurement specifications must clearly describe the material, product, or service being ordered. This element also require procedures for evaluation, approval and monitoring of subcontractors. This evaluation can be accomplished through (1) a review of subcontractors' s past performance, either to the organization involved or through a check of references, or (2) by conducting a survey of the subcontractors' s quality system and facilities.

7-Control of Customer-Supplied Product

There are times when the customer may also supply the raw materials used in the production of a product. Because the organization dose not own items, it must take precaution to ensure the identification and segregation of them any similar organization –owned items. Customer – supplied products are treated the same as other purchased item respect to inspection and test procedures.

8-Product Identification and Traceability

This identification can be accomplished through the use of lot or batch members on smaller. The most important reason for establishing procedures to identify products or services the ability to track material through the production process and facilitate the recall of nonconforming items.

9-Process Control

Controlling the processes used to produced a product or provide a service is the best way of preventing problems and nonconformity. The first step in control is identify and plan the steps necessary to produce the product or service. Document instructions should then be provided to ensure that the plans are carried out. A monitoring system needs to be in place to verify that the instructions are being carried out. The processes must conform to existing codes, standards, and procedures. Finally controls should exist to ensure that the proper equipment is maintained and environmental conditions are adequate. This type of process may requires destructive testing – for example, the testing of a weld for tensile strength. It would be subjected to increasing pressure until it separates from the parent metal.

10-Inspection and Testing

This element addresses three areas –receiving, in-process, and final inspection. Receiving inspection is used to verify that purchased items comply with require standards and to ensure that they are not used prior to such verification .In –process inspection and testing procedures should be designed for early determination of nonconformity. Statistical process control **(SPC)** techniques are the most commonly used techniques for in –process inspection. Final inspection and testing verifies that completed product meets the required specifications. Verification can be accomplished in two ways: acceptance inspection or product quality auditing.

11-Control of Inspection, Measuring, and Test Equipment

This element requires the control calibration, and maintenance of all equipment used to ensure product quality, whether equipment belongs to the organization, is on loan from a customer, or is owned by employee. Calibration must be performed on a regular schedule basis and documented. Procedures must provided for reporting and segregating any equipment that has been damaged.

12-Inspection and Test Status

It also must relate to the written control plan. The status should indicate whether the product has been (1) inspected and accepted, (2) inspected and rejected, and (3) inspected and on hold for a decision as to accept or reject, or (4) not yet inspected. The inspected authority should also be identified through a signature, stamp, or some other identifying mark.

13-Control of Nonconforming Product

When nonconforming product is identified, it must be removed immediately from further processing, clearly marked, and segregated in a manner to produce any possible use until its disposition is decided. There are four ways in which nonconforming material can be handled. It may be reworked to meet the specified requirements, accept without repair by agreement of the customer, regarded for alternative use, or scrapped .All that is repaired or reworked must be re -inspected in accordance with documented procedures before it is released.

14-Corrective and Preventive Action

Corrective action begins with the detection for any suspected nonconformance and ends in talking the appropriate action to correct the deficiency and prevent its recurrence. Preventive actions include the effective analysis of data to eliminate potential causes of nonconformity and the use of control to ensure that it is effective.

15-Handling, Storage, Packaging, Preservation, and Delivery

These activities take place throughout the manufacturing process. . Material and product in storage must be easily identified, and the storage areas should provide for physical security, environmental controls, and rotation of stock. Packaging must provide protection against damage, deterioration, or contamination for as long as the product remains. Preservation of the product is required when under the supplier’s control. Delivery product must be designed to protect the product during the transportation to its destination.

16-Control of Quality Records

Quality records are used to demonstrate the achievement of required quality and verify the effective and economical operation of the quality system. This element requires that the records be maintained for the establish retention period or as prescribed by contractual requirements.

17-Internal Quality Audits

The purpose of this element is to ensure that the quality system is working according to plan and to provide opportunities for improvement .It is an important tool for the management review process. Internal audits must be performed for all organization activities.

18-Training

Most programs include training in plant safety, the quality system, basic statistical concepts, and technical skills. Records must be maintained to document that the training requirements have been fulfilled. This element should be viewed as a strategic issue affecting all employees and should be periodically evaluated.

19-Servicing

After - delivery service on product and verifying, through documentation, that the servicing meet the contract’s specified requirements. Procedures must be established to provide feedback on service information to manufacturing, design, and other appropriate activities.

20- Statistical Techniques

The selection of the appropriate statistical tools is determined during advanced quality planning. Knowledge of basic statistical concepts such as variation, stability, capability, and over adjustment should be evident throughout the supplier's organization.

SECTOR-SPECIFIC REQUIREMENTS

There are three sector –specific requirements: Production Part Approval Process **(PPAP)**, Continuous Improvement, and Manufacturing Capabilities. Production part approval is required for any change in part numbers, engine changes, manufacturing locations, and material. Suppliers must continuously improve their quality, service, and price. Specific plans provide process stability and acceptable capability.

WRITING THE DOCUMENT

When writing the documents is to create simplicity of complicity. To accomplish this objective, the documents must be simple and condense. The first step in writing the documents is to create a format that can be used throughout the documentation hierarchy, although it is required by three ISO. Each document should have a title, a number that is unique to only one document, a date, revision number or letter for control purposes, and number of pages it contains.

INTERNAL AUDITS

All the elements should be audited at least once per year and some more frequency, depending on need

1-Objective

There are five objectives of the internal audit. They are to:

- Determine that the actual performance conforms to the document quality system.
- Initiate corrective action activities in response to deficiencies.
- Follow up on noncompliance items of previous audits.
- Provide continued improvement in the system through feedback to management.
- Cause the auditee to think about the process, thereby creating possible improvements.

2-Auditor

Audits should be performed by qualified individuals who have received training auditing principles and procedures. To be able to audit efficiency, an individual should passes good written and oral communication skills, be good listener, and be good taking notes.

3-Techniques

There are a number of techniques that the auditor should employ. The objective is to collect evidence, and there are three methods: examination of the documents, observation of activities, interview .The easiest method is to examine the documents. For example, the auditor check the purchase orders to determine whether they were accurate and followed procedures, all appropriate attachments were present. Observation of activities is also an easy method that requires an aptitude for detail. For example to evaluate the process control element for suitable working conditions, the auditor observe the processing stations for safety, cleanliness, clear aisles, and so forth. The most difficult method of collecting evidence is by interviewing the employee or auditee. However, there are ways to make the process easier. First, place the auditee in a non-threatening environment by starting with introduction and an explanation of the purpose of the audit.

Examples of open questions:

"When are supplier reviews performed?"

"How is the inspection status identified on this item?"

Examples of closed questions are:

"Do you have a work instruction for this operation?"

"Does this instrument require calibration?"

Examples of clarifying questions are:

"Tell me more about this operation?"

"Please give me more examples?"

An example of a leading question is:

" Do not you agree that the nonconformity was caused by not understanding the purchasing

Order?"

4-Procedure

Before the audit takes place, an audit plan and check list should be prepared. The contents of an audit plan should identify the activity or department; list the procedures, documents, and regulatory requirements involved, the audit team; and list who is to be notified of the audit and who will receive audit reports .The plan also contain a schedule similar to Figure. In addition an audit matrix can be very helpful. It determine the most affected areas and elements .The audit itself has three parts, the preaudit meeting, performing the audit, and closing meeting. During the preaudit, the audit process and timetable are discussed and prior audits are reviewed. Minutes of the meeting should be recorded and included with the audit documentation. A list of this attending the meeting is recorded in the minutes. The object of the auditing process is to provide for continuous improvement and increased customer specification. The audit findings should be written out in detail from auditors' notes should include the conforming as well as the nonconforming items. Separate reports prepared for each nonconformance and should include:

1. The element title and a unique identification number such as NC-4.3.2.2.1, which the NC stands for nonconformance and the other numbers give the clause number.
2. Where the nonconformance was observed.
3. Objective evidence used as a basis for the nonconformance.
4. The nonconformance worded as a closely as possible to the language of requirement.

At the closing meeting, the lead auditor presents a summary of the audit finding along with the evidence that supports them. An estimate is made of when the final report will be issued .The audit report will:

1. Have a cover sheet that includes the audit date, names of the audit team, and a statement that the audit is only a sample, and it will be signed by the lead auditor.
2. List the non-conformances and copies of all nonconformance reports.
3. Outline procedures for corrective action and subsequent follow –up.

Registration

Quality system registration is the assessment and audit of a quality system by a third party, known as a registrar. There are tow parts: selecting a registrar and the registration process.

A-selecting a registrar

A registrar accreditation Board (RAB) was established in 1989 as an affiliate of the American society of quality (ASQ) to develop a program to evaluate the quality of the services offered by the registrars .The **RAB** maintains the list of approved registrars. Registrar selection can be based on four general criteria:

1-Qualifications and Experience

Of particular importance is the number of companies that have been registered, their experience in particular industry sectors, and their customer's structure such as size and location. Also important are their auditor qualification and continued training of auditors.

2-Certificate recognition

The registrar must be approved by a regulatory agency such as **RAB** .It must be recognized by existing and potential customers.

3-The Registration Process

The registrar should have a structured registration procedure that is tailored to your needs. They should be responsive to requests. The registrar should not only evaluate the system but also identify opportunities for more efficient practices. Of future importance is the ability of registrar to perform audit combination environmental, quality, and workplace safety.

4-Time and Cost Constraints

The evaluation should include the lead-time necessary prior to the audit. In addition you will want to know the time and cost required for the initial audit.

Registration Process

The registration process has six basic steps:

1. application for registration,
2. document review,

3. preassessment,
4. assessment,
5. registration, and
6. follow –up surveillance.

Malcolm Baldrige National Quality Award

Organizational Profile

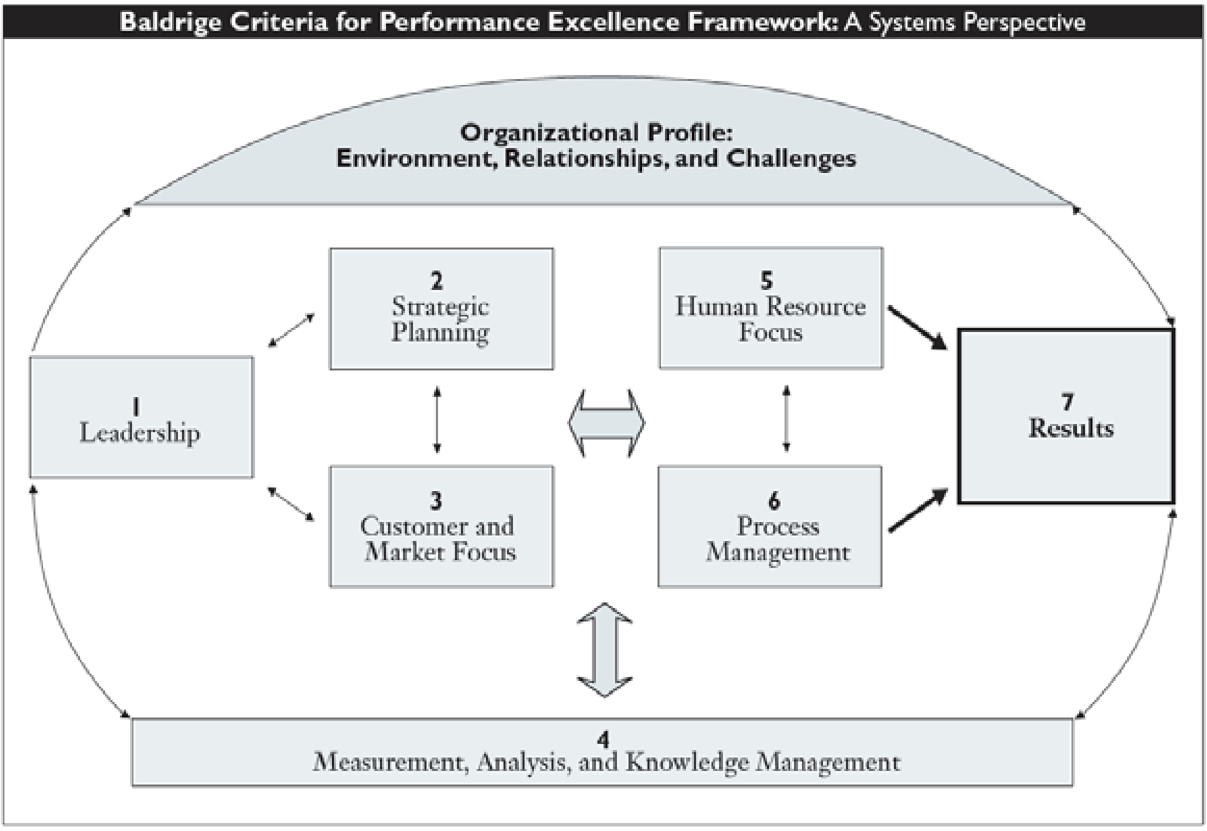
Your Organizational Profile (top of figure) sets the context for the way your organization operates. Your environment, key working relationships, and strategic challenges serve as an overarching guide for your organizational performance management system.

System Operations

The system operations are composed of the six Baldrige Categories in the center of the figure that define your operations and the results you achieve.

Leadership (Category 1), Strategic Planning (Category 2), and Customer and Market Focus (Category 3) represent the leadership triad. These Categories are placed together to emphasize the importance of a leadership focus on strategy and customers. Senior leaders set your organizational direction and seek future opportunities for your organization. Human Resource Focus (Category 5), Process Management (Category 6), and Results (Category 7) represent the results triad. Your organization's employees and key processes accomplish the work of the organization that yields your overall performance results.

All actions point toward Results—a composite of product and service, customer and market, financial, and internal operational performance results, including human resource, governance, and social responsibility results.



The horizontal arrow in the center of the framework links the leadership triad to the results triad, a linkage critical to organizational success. Furthermore, the arrow indicates the central relationship between Leadership (Category 1) and Results (Category 7). The two-headed arrows indicate the importance of feedback in an effective performance management system.

System Foundation

Measurement, Analysis, and Knowledge Management (Category 4) are critical to the effective management of your organization and to a fact-based, knowledge-driven system for improving performance and competitiveness. Measurement, analysis, and knowledge management serve as a foundation for the performance management system.

Categories and Items		Point Values	
Leadership			**120**
1.1 Senior Leadership		70	
1.2 Governance and Social Responsibilities		50	
Strategic Planning			**85**
2.1 Strategy Development		40	
2.2 Strategy Deployment		45	
Customer and Market Focus			**85**
3.1 Customer and Market Knowledge		40	
3.2 Customer Relationships and Satisfaction		45	
Measurement, Analysis, and Knowledge Management			**90**
4.1 Measurement, Analysis, and Review of Organizational Performance		45	
4.2 Information and Knowledge Management		45	
Human Resource Focus			**85**
5.1 Work Systems		35	
5.2 Employee Learning and Motivation		25	
5.3 Employee Well-Being and Satisfaction		25	
Process Management			**85**
6.1 Value Creation Processes		45	
6.2 Support Processes and Operational Planning		40	
Results			**450**
7.1	Product and Service Outcomes	100	
7.2	Customer-Focused Outcomes	70	
7.3	Financial and Market Outcomes	70	
7.4	Human Resource Outcomes	70	
7.5	Organizational Effectiveness Outcomes	70	
7.6	Leadership and Social Responsibility Outcomes	70	
	TOTAL POINTS		**1,000**

1.1 Senior Leadership: How do your senior leaders lead?

Describe HOW SENIOR LEADERS guide and sustain your organization. Describe HOW SENIOR LEADERS communicate with EMPLOYEES and encourage high PERFORMANCE.

a. VISION and VALUES

(1) HOW do SENIOR LEADERS set organizational VISION and VALUES? HOW do SENIOR LEADERS deploy your organization's VISION and VALUES through your LEADERSHIP SYSTEM, to all EMPLOYEES, to KEY suppliers and PARTNERS, and to CUSTOMERS and other STAKEHOLDERS, as appropriate? HOW do their personal actions reflect a commitment to the organization's VALUES?

(2) HOW do SENIOR LEADERS promote an environment that fosters and requires legal and ETHICAL BEHAVIOR?

(3) HOW do SENIOR LEADERS create a SUSTAINABLE organization? HOW do SENIOR LEADERS create an environment for PERFORMANCE improvement, accomplishment of your MISSION and STRATEGIC OBJECTIVES, INNOVATION, and organizational agility? HOW do they create an environment for organizational and EMPLOYEE LEARNING? HOW do they personally participate in succession planning and the development of future organizational leaders?

b. Communication and Organizational PERFORMANCE

(1) HOW do SENIOR LEADERS communicate with, empower, and motivate all EMPLOYEES throughout the organization? HOW do SENIOR LEADERS encourage frank, two-way communication throughout the organization? HOW do SENIOR LEADERS take an active role in EMPLOYEE reward and recognition to reinforce high PERFORMANCE and a CUSTOMER and business focus?

(2) HOW do SENIOR LEADERS create a focus on action to accomplish the organization's objectives, improve PERFORMANCE, and attain your VISION? HOW do SENIOR LEADERS include a focus on creating and balancing VALUE for CUSTOMERS and other STAKEHOLDERS in their organizational PERFORMANCE expectations?

1.2 Governance and Social Responsibilities: How do you govern and address your social responsibilities?

Describe your organization's GOVERNANCE system. Describe HOW your organization addresses its responsibilities to the public, ensures ETHICAL BEHAVIOR, and practices good citizenship.

a. Organizational GOVERNANCE

(1) HOW does your organization address the following KEY factors in your GOVERNANCE system:

- accountability for management's actions
- fiscal accountability
- transparency in operations and selection and disclosure policies for GOVERNANCE board members, as appropriate
- independence in internal and external audits
- protection of STAKEHOLDER and stockholder interests, as appropriate

(2) HOW do you evaluate the PERFORMANCE of your SENIOR LEADERS, including the chief executive? HOW do you evaluate the PERFORMANCE of members of the GOVERNANCE board, as appropriate? HOW do SENIOR LEADERS and the GOVERNANCE board use these PERFORMANCE reviews to improve both their personal leadership EFFECTIVENESS and that of your board and LEADERSHIP SYSTEM, as appropriate?

b. Legal and ETHICAL BEHAVIOR

(1) HOW do you address any adverse impacts on society of your products, services, and operations? HOW do you anticipate public concerns with current and future products, services, and operations? HOW do you prepare for these concerns in a proactive manner, including using resource-sustaining PROCESSES, as appropriate? What are your KEY compliance PROCESSES, MEASURES, and GOALS for achieving and surpassing regulatory and legal requirements, as appropriate? What are your KEY PROCESSES, MEASURES, and GOALS for addressing risks associated with your products, services, and operations?

(2) HOW does your organization promote and ensure ETHICAL BEHAVIOR in all your interactions? What are your KEY PROCESSES and MEASURES or INDICATORS for enabling and monitoring ETHICAL BEHAVIOR in your GOVERNANCE structure, throughout your organization, and in interactions with CUSTOMERS, PARTNERS, and other STAKEHOLDERS? HOW do you monitor and respond to breaches of ETHICAL BEHAVIOR?

c. Support of KEY Communities

HOW does your organization actively support and strengthen your KEY communities? HOW do you identify KEY communities and determine areas of emphasis for organizational involvement and support? What are your KEY communities? HOW do your SENIOR LEADERS and your EMPLOYEES contribute to improving these communities?

2.1 Strategy Development: How do you develop your strategy?

Describe HOW your organization establishes its strategy and STRATEGIC OBJECTIVES, including HOW you address your STRATEGIC CHALLENGES. Summarize your organization's KEY STRATEGIC OBJECTIVES and their related GOALS.

a. Strategy Development PROCESS

(1) HOW does your organization conduct its strategic planning? What are the KEY PROCESS steps? Who are the KEY participants? HOW does your PROCESS identify potential blind spots? What are your short- and longer-term planning time

horizons? HOW are these time horizons set? HOW does your strategic planning PROCESS address these time horizons?

(2) HOW do you ensure that strategic planning addresses the KEY factors listed below? HOW do you collect and analyze relevant data and information pertaining to these factors as part of your strategic planning PROCESS:

- your organization's strengths, weaknesses, opportunities, and threats
- early indications of major shifts in technology, markets, competition, or the regulatory environment
- long-term organizational SUSTAINABILITY and continuity in emergencies
- your ability to execute the strategic plan

b. STRATEGIC OBJECTIVES

(1) What are your KEY STRATEGIC OBJECTIVES and your timetable for accomplishing them? What are your most important GOALS for these STRATEGIC OBJECTIVES?

(2) HOW do your STRATEGIC OBJECTIVES address the challenges identified in response to P.2 in your Organizational Profile? HOW do you ensure that your STRATEGIC OBJECTIVES balance short- and longer-term challenges and opportunities? HOW do you ensure that your STRATEGIC OBJECTIVES balance the needs of all KEY STAKEHOLDERS?

2.2 Strategy Deployment: How do you deploy your strategy?

Describe HOW your organization converts its STRATEGIC OBJECTIVES into ACTION PLANS. Summarize your organization's ACTION PLANS and related KEY PERFORMANCE MEASURES or INDICATORS. Project your organization's future PERFORMANCE on these KEY PERFORMANCE MEASURES or INDICATORS.

a. ACTION PLAN Development and DEPLOYMENT

(1) HOW do you develop and deploy ACTION PLANS to achieve your KEY STRATEGIC OBJECTIVES? HOW do you allocate resources to ensure accomplishment of your ACTION PLANS? HOW do you ensure that the KEY changes resulting from your ACTION PLANS can be sustained?

(2) HOW do you establish and deploy modified ACTION PLANS if circumstances require a shift in plans and rapid execution of new plans?

(3) What are your KEY short- and longer-term ACTION PLANS? What are the KEY changes, if any, in your products and services and your CUSTOMERS and markets, and how you will operate?

(4) What are your KEY human resource plans that derive from your short- and longer-term STRATEGIC OBJECTIVES and ACTION PLANS?

(5) What are your KEY PERFORMANCE MEASURES or INDICATORS for tracking progress on your ACTION PLANS? HOW do you ensure that your overall ACTION PLAN measurement system reinforces organizational ALIGNMENT? HOW do you ensure that the measurement system covers all KEY DEPLOYMENT areas and STAKEHOLDERS?

b. PERFORMANCE PROJECTION

For the KEY PERFORMANCE MEASURES or INDICATORS identified in 2.2a(5), what are your PERFORMANCE PROJECTIONS for both your short- and longer-term planning time horizons? How does your projected PERFORMANCE compare with the projected PERFORMANCE of your competitors or comparable organizations? How does it compare with KEY BENCHMARKS, GOALS, and past PERFORMANCE, as appropriate? If there are current or projected gaps in PERFORMANCE against your competitors or comparable organizations, HOW will you address them?

3.1 Customer and Market Knowledge: How do you use customer and market knowledge?

Describe HOW your organization determines requirements, needs, expectations, and preferences of CUSTOMERS and markets to ensure the continuing relevance of your products and services and to develop new business opportunities.

a. CUSTOMER and Market Knowledge

(1) HOW do you identify CUSTOMERS, CUSTOMER groups, and market SEGMENTS? HOW do you determine which CUSTOMERS, CUSTOMER groups, and market EGMENTS to pursue for current and future products and services? HOW do you include CUSTOMERS of competitors and other potential CUSTOMERS and markets in this determination?

(2) HOW do you listen and learn to determine KEY CUSTOMER requirements, needs, and changing expectations (including product and service features) and their relative importance to CUSTOMERS' purchasing or relationship decisions? How do your determination methods vary for different CUSTOMERS or CUSTOMER groups? HOW do you use relevant information and feedback from current and former CUSTOMERS, including marketing and sales information, CUSTOMER loyalty and retention data, win/loss ANALYSIS, and complaint data for PURPOSES of planning products and services, marketing, making PROCESS improvements, and developing new business opportunities? HOW do you use this information and feedback to become more CUSTOMER-focused and to better satisfy CUSTOMER needs and desires?

(3) HOW do you keep your listening and LEARNING methods current with business needs and directions, including changes in your marketplace?

3.2 Customer Relationships and Satisfaction: How do you build relationships and grow customer satisfaction and loyalty?

Describe HOW your organization builds relationships to acquire, satisfy, and retain CUSTOMERS and to increase CUSTOMER loyalty. Describe also HOW your organization determines CUSTOMER satisfaction.

a. CUSTOMER Relationship Building

(1) HOW do you build relationships to acquire CUSTOMERS, to meet and exceed their expectations, to increase loyalty and repeat business, and to gain positive referrals?

(2) HOW do your KEY access mechanisms enable CUSTOMERS to seek information, conduct business, and make complaints? What are your KEY access mechanisms? HOW do you determine KEY CUSTOMER contact requirements for each mode of CUSTOMER access? HOW do you ensure that these contact requirements are deployed to all people and PROCESSES involved in the CUSTOMER response chain?

(3) HOW do you manage CUSTOMER complaints? HOW do you ensure that complaints are resolved EFFECTIVELY and promptly? HOW do you minimize CUSTOMER dissatisfaction and, as appropriate, loss of repeat business? HOW are complaints aggregated and analyzed for use in improvement throughout your organization and by your PARTNERS?

(4) HOW do you keep your APPROACHES to building relationships and providing CUSTOMER access current with business needs and directions?

b. CUSTOMER Satisfaction Determination

(1) HOW do you determine CUSTOMER satisfaction, dissatisfaction, and loyalty? How do these determination methods differ among CUSTOMER groups? HOW do you ensure that your measurements capture actionable information for use in exceeding your CUSTOMERS' expectations? HOW do you ensure that your measurements capture actionable information for use in securing your CUSTOMERS' future business and gaining positive referrals, as appropriate? HOW do you use CUSTOMER satisfaction and dissatisfaction information for improvement?

(2) HOW do you follow up with CUSTOMERS on the quality of products, services, and transactions to receive prompt and actionable feedback?

(3) HOW do you obtain and use information on your CUSTOMERS' satisfaction relative to their satisfaction with your competitors, other organizations providing similar products or services, and/or industry BENCHMARKS?

(4) HOW do you keep your APPROACHES to determining satisfaction current with business needs and directions?

4.1 Measurement, Analysis, and Review of Organizational Performance: How do you measure, analyze, and review organizational performance?

Describe HOW your organization measures, analyzes, aligns, reviews, and improves its PERFORMANCE data and information at all LEVELS and in all parts of your organization.

a. PERFORMANCE Measurement

(1) HOW do you select, collect, align, and integrate data and information for tracking daily operations and for tracking overall organizational PERFORMANCE, including progress relative to STRATEGIC OBJECTIVES and ACTION PLANS? What are your KEY organizational PERFORMANCE MEASURES? HOW do you use these data and information to support organizational decision making and INNOVATION?

(2) HOW do you select and ensure the EFFECTIVE use of KEY comparative data and information to support operational and strategic decision making and INNOVATION?

(3) HOW do you keep your PERFORMANCE measurement system current with business needs and directions? HOW do you ensure that your PERFORMANCE measurement system is sensitive to rapid or unexpected organizational or external changes?

b. PERFORMANCE ANALYSIS and Review

(1) HOW do you review organizational PERFORMANCE and capabilities? HOW do your SENIOR LEADERS participate in these reviews? What ANALYSES do you perform to support these reviews and to ensure that conclusions are valid? HOW do you use these reviews to assess organizational success, competitive PERFORMANCE, and progress relative to STRATEGIC OBJECTIVES and ACTION PLANS? HOW do you use these reviews to assess your organization's ability to rapidly respond to changing organizational needs and challenges in your operating environment?

(2) HOW do you translate organizational PERFORMANCE review findings into priorities for continuous and breakthrough improvement and into opportunities for INNOVATION? HOW are these priorities and opportunities deployed to work group- and functional-level operations throughout your organization to enable EFFECTIVE support for their decision making? When appropriate, HOW are the priorities and opportunities deployed to your suppliers, PARTNERS, and collaborators to ensure organizational ALIGNMENT?

4.2 Information and Knowledge Management: How do you manage organizational information and knowledge?

Describe HOW your organization ensures the quality and availability of needed data and information for EMPLOYEES, suppliers, PARTNERS, collaborators, and CUSTOMERS. Describe HOW your organization builds and manages its KNOWLEDGE ASSETS.

a. Data and Information Availability

(1) HOW do you make needed data and information available? HOW do you make them accessible to EMPLOYEES, suppliers, PARTNERS, collaborators, and CUSTOMERS, as appropriate?

(2) HOW do you ensure that hardware and software are reliable, secure, and user-friendly?

(3) HOW do you ensure the continued availability of data and information, including the availability of hardware and software systems, in the event of an emergency?

(4) HOW do you keep your data and information availability mechanisms, including your software and hardware systems, current with business needs and directions and with technological changes in your operating environment?

b. Organizational Knowledge Management

HOW do you manage organizational knowledge to accomplish the following:

- the collection and transfer of EMPLOYEE knowledge
- the transfer of relevant knowledge from and to CUSTOMERS, suppliers, PARTNERS, and collaborators
- the rapid identification, sharing, and implementation of best practices

c. Data, Information, and Knowledge Quality

HOW do you ensure the following properties of your data, information, and organizational knowledge:

- accuracy
- integrity and reliability
- timeliness
- security and confidentiality

5.1 Work Systems: How do you enable employees to accomplish the work of your organization?

Describe HOW your organization's work and jobs enable all EMPLOYEES and the organization to achieve HIGH PERFORMANCE. Describe HOW compensation, career progression, and related workforce practices enable EMPLOYEES and the organization to achieve HIGH PERFORMANCE.

a. Organization and Management of Work

(1) HOW do you organize and manage work and jobs, including skills, to promote cooperation, initiative, EMPOWERMENT, INNOVATION, and your organizational culture? HOW do you organize and manage work and jobs, including skills, to achieve the agility to keep current with business needs and to achieve your ACTION PLANS?

(2) HOW do your WORK SYSTEMS capitalize on the diverse ideas, cultures, and thinking of your EMPLOYEES and the communities with which you interact (your EMPLOYEE hiring and your CUSTOMER communities)?

(3) HOW do you achieve EFFECTIVE communication and skill sharing across work units, jobs, and locations?

b. EMPLOYEE PERFORMANCE Management System

HOW does your EMPLOYEE PERFORMANCE management system, including feedback to EMPLOYEES, support HIGHPERFORMANCE WORK and contribute to the achievement of your ACTION PLANS? HOW does your EMPLOYEE PERFORMANCE management system support a CUSTOMER and business focus? HOW do your compensation, recognition, and related reward and incentive practices reinforce HIGH-PERFORMANCE WORK and a CUSTOMER and business focus?

c. Hiring and Career Progression

(1) HOW do you identify characteristics and skills needed by potential EMPLOYEES?

(2) HOW do you recruit, hire, and retain new EMPLOYEES? HOW do you ensure EMPLOYEES represent the diverse ideas, cultures, and thinking of your hiring community?

(3) HOW do you accomplish EFFECTIVE succession planning for leadership and management positions? HOW do you manage EFFECTIVE career progression for all EMPLOYEES throughout the organization?

5.2 Employee Learning and Motivation: How do you contribute to employee learning and motivate employees?

Describe HOW your organization's EMPLOYEE education, training, and career development support the achievement of your overall objectives and contribute to HIGH PERFORMANCE. Describe HOW your organization's education, training, and career development build EMPLOYEE knowledge, skills, and capabilities.

a. EMPLOYEE Education, Training, and Development

(1) HOW do EMPLOYEE education and training contribute to the achievement of your ACTION PLANS? HOW do your EMPLOYEE education, training, and development address your KEY needs associated with organizational PERFORMANCE measurement, PERFORMANCE improvement, and technological change? HOW does your education and training APPROACH balance short- and longer-term organizational objectives with EMPLOYEE needs for development, ongoing LEARNING, and career progression?

(2) HOW do EMPLOYEE education, training, and development address your KEY organizational needs associated with new EMPLOYEE orientation, DIVERSITY, ethical business practices, and management and leadership development? HOW do EMPLOYEE education, training, and development address your KEY organizational needs associated with EMPLOYEE, workplace, and environmental safety?

(3) HOW do you seek and use input from EMPLOYEES and their supervisors and managers on education, training, and development needs? HOW do you incorporate your organizational LEARNING and KNOWLEDGE ASSETS into your education and training?

(4) HOW do you deliver education and training? HOW do you seek and use input from EMPLOYEES and their supervisors and managers in determining your delivery APPROACHES? HOW do you use both formal and informal delivery APPROACHES, including mentoring and other APPROACHES, as appropriate?

(5) HOW do you reinforce the use of new knowledge and skills on the job and retain this knowledge for long-term organizational use? HOW do you SYSTEMATICALLY transfer knowledge from departing or retiring EMPLOYEES?

(6) HOW do you evaluate the EFFECTIVENESS of education and training, taking into account individual and organizational PERFORMANCE?

b. Motivation and Career Development

HOW do you motivate EMPLOYEES to develop and utilize their full potential? HOW does your organization use formal and informal mechanisms to help EMPLOYEES attain job- and career-related development and LEARNING objectives? HOW do managers and supervisors help EMPLOYEES attain job- and career-related development and LEARNING objectives?

5.3 Employee Well-Being and Satisfaction: How do you contribute to employee well-being and grow employee satisfaction?

Describe HOW your organization maintains a work environment and an EMPLOYEE support climate that contribute to the well-being, satisfaction, and motivation of all EMPLOYEES.

a. Work Environment

(1) HOW do you ensure and improve workplace health, safety, security, and ergonomics in a proactive manner? HOW do EMPLOYEES take part in these improvement efforts? What are your PERFORMANCE MEASURES or improvement goals for each of these KEY workplace factors? What are the significant differences in these workplace factors and PERFORMANCE MEASURES or targets if different EMPLOYEE groups and work units have different work environments?

(2) HOW do you ensure workplace preparedness for disasters or emergencies?

b. EMPLOYEE Support and Satisfaction

(1) HOW do you determine the KEY factors that affect EMPLOYEE well-being, satisfaction, and motivation? HOW are these factors SEGMENTED for a diverse workforce and for different categories and types of EMPLOYEES?

(2) HOW do you support your EMPLOYEES via services, benefits, and policies? HOW are these tailored to the needs of a diverse workforce and different categories and types of EMPLOYEES?

(3) What formal and informal assessment methods and MEASURES do you use to determine EMPLOYEE wellbeing, satisfaction, and motivation? How do these methods and MEASURES differ across a diverse workforce and different categories and types of EMPLOYEES? HOW do you use other INDICATORS, such as EMPLOYEE retention, absenteeism, grievances, safety, and PRODUCTIVITY, to assess and improve EMPLOYEE well-being, satisfaction, and motivation?

(4) HOW do you relate assessment findings to KEY business RESULTS to identify priorities for improving the work environment and EMPLOYEE support climate?

6.1 Value Creation Processes: How do you identify and manage your key processes?

Describe HOW your organization identifies and manages its KEY VALUE CREATION PROCESSES for delivering CUSTOMER VALUE and achieving organizational success and growth.

a. VALUE CREATION PROCESSES

(1) HOW does your organization determine its KEY VALUE CREATION PROCESSES? What are your organization's KEY product, service, and business PROCESSES for creating or adding VALUE? How do these PROCESSES contribute to profitability, SUSTAINABILITY, and organizational success, as appropriate?

(2) HOW do you determine KEY VALUE CREATION PROCESS requirements, incorporating input from CUSTOMERS, suppliers, PARTNERS, and collaborators, as appropriate? What are the KEY requirements for these PROCESSES?

(3) HOW do you design these PROCESSES to meet all the KEY requirements? HOW do you incorporate new technology, organizational knowledge, and the potential need for agility into the design of these PROCESSES? HOW do you incorporate CYCLE TIME, PRODUCTIVITY, cost control, and other efficiency and EFFECTIVENESS factors into the design of these PROCESSES? HOW do you implement these PROCESSES to ensure they meet design requirements?

(4) What are your KEY PERFORMANCE MEASURES or INDICATORS used for the control and improvement of your VALUE CREATION PROCESSES? HOW does your day-to-day operation of these PROCESSES ensure meeting KEY PROCESS requirements? HOW are in-process MEASURES used in managing these PROCESSES? HOW is CUSTOMER, supplier, PARTNER, and collaborator input used in managing these PROCESSES, as appropriate?

(5) HOW do you minimize overall costs associated with inspections, tests, and PROCESS or PERFORMANCE audits, as appropriate? HOW do you prevent defects, service errors, and rework, and minimize warranty costs, as appropriate?

(6) HOW do you improve your VALUE CREATION PROCESSES to achieve better PERFORMANCE, to reduce variability, to improve products and services, and to keep the PROCESSES current with business needs and directions? HOW are improvements and lessons learned shared with other organizational units and PROCESSES to drive organizational LEARNING and INNOVATION?

6.2 Support Processes and Operational Planning: How do you identify and manage your support processes and accomplish operational planning?

Describe HOW your organization manages its KEY PROCESSES that support your VALUE CREATION PROCESSES. Describe your PROCESSES for financial management and continuity of operations in an emergency.

a. Support PROCESSES

(1) HOW does your organization determine its KEY support PROCESSES? What are your KEY PROCESSES for supporting your VALUE CREATION PROCESSES?

(2) HOW do you determine KEY support PROCESS requirements, incorporating input from internal and external CUSTOMERS, suppliers, PARTNERS, and collaborators, as appropriate? What are the KEY requirements for these PROCESSES?

(3) HOW do you design these PROCESSES to meet all the KEY requirements? HOW do you incorporate new technology, organizational knowledge, and the potential need for agility into the design of these PROCESSES? HOW do you incorporate CYCLE TIME, PRODUCTIVITY, cost control, and other efficiency and EFFECTIVENESS factors into the design of these PROCESSES? HOW do you implement these PROCESSES to ensure they meet design requirements?

(4) What are your KEY PERFORMANCE MEASURES or INDICATORS used for the control and improvement of your support PROCESSES? HOW does your day-to-day operation of KEY support PROCESSES ensure meeting KEY PERFORMANCE requirements? HOW are in-process MEASURES used in managing these PROCESSES? HOW is CUSTOMER, supplier, PARTNER, and collaborator input used in managing these PROCESSES, as appropriate?

(5) HOW do you minimize overall costs associated with inspections, tests, and PROCESS or PERFORMANCE audits, as appropriate? HOW do you prevent defects, service errors, and rework?

(6) HOW do you improve your support PROCESSES to achieve better PERFORMANCE, to reduce variability, and to keep the PROCESSES current with business needs and directions? HOW are improvements and lessons learned shared with other organizational units and PROCESSES to drive organizational LEARNING and INNOVATION?

b. Operational Planning

(1) HOW does your organization ensure adequate financial resources are available to support your operations? HOW do you determine the resources needed to meet current financial obligations? HOW do you ensure adequate resources are available to support major new business investments, as appropriate? HOW do you assess the financial risks associated with your current operations and major new business investments?

(2) HOW do you ensure continuity of operations in the event of an emergency?

7.1 Product and Service Outcomes: What are your product and service performance results?

Summarize your organization's KEY product and service PERFORMANCE RESULTS. SEGMENT your RESULTS by product and service types and groups, CUSTOMER groups, and market SEGMENTS, as appropriate. Include appropriate comparative data.

a. Product and Service RESULTS

What are your current LEVELS and TRENDS in KEY MEASURES or INDICATORS of product and service PERFORMANCE that are important to your CUSTOMERS? How do these RESULTS compare with the PERFORMANCE of your competitors and other organizations providing similar products and services?

7.2 Customer-Focused Outcomes: What are your customer-focused performance results?

Summarize your organization's KEY CUSTOMER-focused RESULTS, including CUSTOMER satisfaction and CUSTOMER perceived VALUE. SEGMENT your RESULTS by product and service types or groups, CUSTOMER groups, and market SEGMENTS, as appropriate. Include appropriate comparative data.

a. CUSTOMER-Focused RESULTS

(1) What are your current LEVELS and TRENDS in KEY MEASURES or INDICATORS of CUSTOMER satisfaction and dissatisfaction? How do these RESULTS compare with the customer satisfaction levels of your competitors and other organizations providing similar products and services?

(2) What are your current LEVELS and TRENDS in KEY MEASURES or INDICATORS of CUSTOMER-perceived VALUE, including CUSTOMER loyalty and retention, positive referral, and other aspects of building relationships with CUSTOMERS, as appropriate?

7.3 Financial and Market Outcomes: What are your financial and market results?

Summarize your organization's KEY financial and marketplace PERFORMANCE RESULTS by CUSTOMER or market SEGMENTS, as appropriate. Include appropriate comparative data.

a. Financial and Market RESULTS

(1) What are your current LEVELS and TRENDS in KEY MEASURES or INDICATORS of financial PERFORMANCE, including aggregate MEASURES of financial return and economic VALUE or budgetary MEASURES, as appropriate?

(2) What are your current LEVELS and TRENDS in KEY MEASURES or INDICATORS of marketplace PERFORMANCE, including market share or position, growth, and new markets entered, as appropriate?

7.3 Human Resource Outcomes: What are your human resource results?

Summarize your organization's KEY human resource RESULTS, including WORK SYSTEM PERFORMANCE and EMPLOYEE LEARNING, development, well-being, and satisfaction. SEGMENT your RESULTS to address the DIVERSITY of your workforce and the different types and categories of EMPLOYEES, as appropriate. Include appropriate comparative data.

a. Human Resource RESULTS

(1) What are your current LEVELS and TRENDS in KEY MEASURES or INDICATORS of WORK SYSTEM PERFORMANCE and EFFECTIVENESS?

(2) What are your current LEVELS and TRENDS in KEY MEASURES of EMPLOYEE LEARNING and development?

(3) What are your current LEVELS and TRENDS in KEY MEASURES or INDICATORS of EMPLOYEE well-being, satisfaction, and dissatisfaction?

SIX SIGMA

The core of Six Sigma engineering was developed at Motorola, GE, and a few other companies. Six Sigma became a movement when Jack Welch, GE's legendary CEO, announced an initiative to bring all divisions of the company to the Six Sigma level of quality. At that point, Six Sigma moved from an engineering approach to a quality management system in its own right, and also, unfortunately, became a confusing buzzword as well.

The confusion is created by the fact that Six Sigma can be defined as a goal (measured in number of defects per million opportunities), or as a management or executive initiative that includes commitments to Six Sigma or other breakthrough goals, or as a set of processes to achieve those goals.

Three sigma rule

In statistics, the **68-95-99.7 rule,** or **three-sigma rule,** or **empirical rule,** states that for a normal distribution, almost all values lie within 3 standard deviations of the mean.

About 68% of the values lie within 1 standard deviation of the mean (or between the mean minus 1 times the standard deviation, and the mean plus 1 times the standard deviation). In statistical notation, this is represented as: $\mu \pm \sigma$.

About 95% of the values lie within 2 standard deviations of the mean (or between the mean minus 2 times the standard deviation, and the mean plus 2 times the standard deviation). The statistical notation for this is: $\mu \pm 2\sigma$.

Almost all (99.7%) of the values lie within 3 standard deviations of the mean (or between the mean minus 3 times the standard deviation and the mean plus 3 times the standard deviation). Statisticians use the following notation to represent this: $\mu \pm 3\sigma$.

range	fraction in range	expected frequency outside range	approximate frequency for daily event
$\mu \pm 1\sigma$	0.682689492137	1 in 3	twice a week
$\mu \pm 2\sigma$	0.954499736104	1 in 22	monthly
$\mu \pm 3\sigma$	0.997300203937	1 in 370	yearly
$\mu \pm 4\sigma$	0.999936657516	1 in 15,787	every 60 years (once in a lifetime)
$\mu \pm 5\sigma$	0.999999426697	1 in 1,744,278	every 5,000 years (once in history)
$\mu \pm 6\sigma$	0.999999998027	1 in 506,842,372	every 1.5 million years (essentially never)

PRINCIPLES OF SIX SIGMA

These principles can be extracted from texts on Six Sigma:

1. *Senior executive support.* Note the distinction between support, required for Six Sigma, and leadership, required for TQM.

2. *Top-down training.* As in any quality management improvement effort, the need for training must be evaluated, and enough resources provided.
3. *Include the voice of the customer.* This is a reminder to make sure that improvements really benefit the customer so that we avoid meaningless change or change that goes in the wrong direction because it is based on what we think the customer wants.
4. *Create an infrastructure to support success.* The organization will need a structure that integrates Six Sigma methods into processes and allows discoveries through Six Sigma analysis to lead to process change.
5. *Develop short-term projects with specific goals.* This is perhaps Six Sigma's most significant innovation. While some TQM companies naturally discovered the value of setting goals and deadlines, the project-oriented approach became a specific component of Six Sigma. Projects can have both minimum goals and *stretch targets* which motivate the team to think outside the box.
6. *Focus on process improvement.* Just because Six Sigma uses projects to achieve results does not mean that the end of the project is the end of the improvement. Project definition is often based on an evaluation of the process identifying defined, measurable elements that are *critical to quality (CTQ).* Project results are usually internal changes—process improvements that should be maintained by ongoing Six Sigma quality control.
7. *Clear and consistent methodology.* Although there are many variations of Six Sigma, a very consistent approach must be developed by each business.
8. *Decisions based on fact and data.* Six Sigma reasserts the importance of an empirical basis for decisions, just like every quality management movement since Taylor in 1911. Greg Brue, in *Six Sigma for Managers* (2002) emphasizes this with these directives: "Ask questions. Challenge answers. Put assumptions to the test. Confront conventions."
9. *Focus on people and processes.* Six Sigma realizes that our team is a corporate asset we need to invest in, and that team can only benefit the company if it can improve processes by defining CTQ elements that make changes to quality, time, or cost in business processes, products, services, and the bottom line.

SIX SIGMA METHODOLOGY

DMAIC

The core of Six Sigma methodology is DMAIC, a minor modification of PDCA which, when spelled out, looks like this:

1. *Define.* We need to turn customer requirements or executive directives for improvements into clearly defined goals, and use a project charter to define the project's purpose; business needs objectives, stakeholders, team members, and sponsor.
2. *Measure.* In this stage, processes and CTQ factors are identified, and the current situation—our starting point for the project—is defined. Logical elements of factors are defined, establishing the factors critical to the success of significant business measures. Processes are defined in such a way as to allow effective statistical measurement, and the initial measurements are made.

3. *Analyze.* We then analyze work processes to identify improvements. There are three main areas to analyze:
   - *Value stream analysis* is borrowed from lean manufacturing. The focus is on eliminating waste, especially wasted time, by eliminating unnecessary steps and improving poorly designed steps.
   - *Analyze sources of variation* using statistical process control techniques.
   - *Determine process drivers,* that is, figure out which inputs or variables change the CTQ elements of a process in key ways. This is done through advanced statistical techniques such as regression analysis, and by designing and performing experiments.
4. *Improve.* First, we define a new process that we think will be better than the current process. Then we evaluate its benefits and look closely at how it might fail so that we don't make things worse. Then, with executive approval, we implement the new process, improving the way work is done. Lastly, we verify that the new process is working. If it fails, we either fix it or roll back to the process we started with.
5. *Control.* To maintain control of the new process: we document the process; we eliminate sources of human error; we provide updated training; and, we bring the new process under statistical process control by updating control procedures and eliminating special causes of variation. When the new process is stable, we document the actual business value achieved. If goals were not met, we begin the DMAIC cycle over again as corrective action. We create a lessons learned document to assist with continuous improvement.

DMADV

The basic method consists of the following five steps:

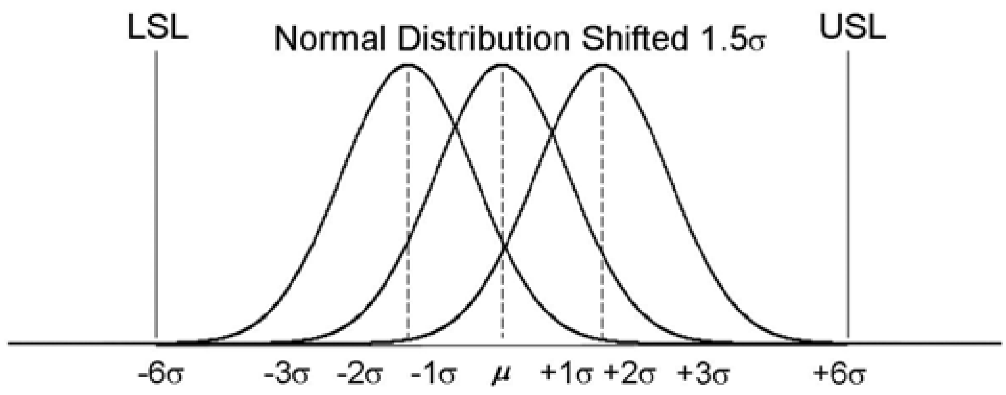
- ***D**efine* design goals that are consistent with customer demands and the enterprise strategy.
- ***M**easure* and identify CTQs (characteristics that are **C**ritical **T**o **Q**uality), product capabilities, production process capability, and risks.
- ***A**nalyze* to develop and design alternatives, create a high-level design and evaluate design capability to select the best design.
- ***D**esign* details, optimize the design, and plan for design verification. This phase may require simulations.
- ***V**erify* the design, set up pilot runs, implement the production process and hand it over to the process owners.

DMADV is also known as DFSS, an abbreviation of "**D**esign **F**or **S**ix **S**igma".

WHY SIX SIGMA = 4.5 SIGMA

It all started at Motorola. An engineer named Bill Smith—considered the father of Six Sigma—found that, at Motorola, internal quality levels of statistical Six Sigma—two defects per billion opportunities—resulted in external failure rates (customer quality levels) around 4.5 sigma—seven thousand defects per billion opportunities, or seven defects per million opportunities. He called this the *1.5 sigma shift,* and attributed it to a difference between short-term internal QC measurements and long-term product results.

If his investigation into the cause of the 1.5 sigma shift has ever been published outside of Motorola or verified, I have been unable to find it. The 1.5 sigma shift may be rooted in a fundamental statistical principle. If so, it would be nice to understand that principle and how it applies in different settings. It may be a rule of thumb that applied only at Motorola, or only in electronics manufacturing, or only in manufacturing and not in service industries. And we simply don't know.



Spec limit	Percent	Defective PPM
+/- 1 sigma	30.23	697700
+/- 2 sigma	69.13	308700
+/- 3 sigma	93.32	66810
+/- 4 sigma	99.3790	6210
+/- 5 sigma	99.97670	233
+/- 6 sigma	99.9996600	3.4

Quiz

1. The true statistical value of Six Sigma quality is

(a) fewer than 7 defects per million events.

(b) about 2 defects per million events.

(c) fewer than 7 defects per billion events.

(d) about 2 defects per billion events.

2. DMAIC stands for

(a) Develop, Meter, Assess, Initialize, Conform.

(b) Draconian Managers Anger Intelligent Computer-geeks.

(c) Define, Measure, Analyze, Improve, Control.

(d) Dubious Methods Aggravate Intelligent Critics.

3. Two key companies involved in the development of Six Sigma were

(a) Motorola and GM.

(b) Motorola and GE.

(c) GE and GM.

(d) Ford and GM.

4. Which of these is *not* a key benefit of executives setting stretch or breakthrough goals?

(a) Customers get excited about the company.

(b) Engineers are pushed to think outside the box.

(c) Stretch goals, when achieved, put the company further ahead than incremental improvements.

(d) Without stretch goals, quality management effort tends to level off.

5. Which of these is the most accurate statement about the relationship between a project and a process in Six Sigma?

(a) A project becomes a process when it is maintained over time.

(b) A project improves a process, and then the process must be maintained at a new level.

(c) Projects are implemented only when there is a problem with a process.

(d) Six Sigma focuses on the processes inside a project.

COST OF QUALITY

CATEGORIES OF QUALITY COSTS

Many companies summarize these costs into four categories. Some practitioners also call these categories the "cost of quality." These categories and examples of typical subcategories are discussed below.

Internal Failure Costs.

These are costs of deficiencies discovered before delivery which are associated with the failure (nonconformities) to meet explicit requirements or implicit needs of external or internal customers. Also included are avoidable process losses and inefficiencies that occur even when requirements and needs are met. These are costs that would disappear if no deficiencies existed.

Failure to Meet Customer Requirements and Needs.

Examples of subcategories are costs associated with:

- *Scrap:* The labor, material, and (usually) overhead on defective product that cannot economically be repaired. The titles are numerous—scrap, spoilage, defectives, etc.
- *Rework:* Correcting defectives in physical products or errors in service products.
- *Lost or missing information:* Retrieving information that should have been supplied.
- *Failure analysis:* Analyzing nonconforming goods or services to determine causes.
- *Scrap and rework—supplier:* Scrap and rework due to nonconforming product received from suppliers. This also includes the costs to the buyer of resolving supplier quality problems.
- *One hundred percent sorting inspection:* Finding defective units in product lots which c unacceptably high levels of defectives.
- *Reinspection, retest:* Reinspection and retest of products that have undergone rework or other revision.
- *Changing processes:* Modifying manufacturing or service processes to correct deficiencies.
- *Redesign:* Changing designs to correct deficiencies.
- *Scrapping of obsolete product:* Disposing of products that have been superseded.
- *Scrap in support operations:* Defective items in indirect operations.
- *Rework in internal support operations:* Correcting defective items in indirect operations.
- *Downgrading:* The difference between the normal selling price and the reduced price due to quality reasons.

Cost of Inefficient Processes.

Examples of subcategories are

- *Variability of product characteristics:* Losses that occur even with conforming product (e.g., overfill of packages due to variability of filling and measuring equipment).
- *Unplanned downtime of equipment:* Loss of capacity of equipment due to failures.
- *Inventory shrinkage:* Loss due to the difference between actual and recorded inventory amounts.
- *Variation of process characteristics from "best practice":* Losses due to cycle time and costs of processes as compared to best practices in providing the same output. The best-practice process may be internal or external to the organization.
- *Non-value-added activities:* Redundant operations, sorting inspections, and other non-valueadded activities. A value-added activity increases the usefulness of a product to the customer; a non-value-added activity does not. (The concept is similar to the 1950s concept of value engineering and value analysis.)

External Failure Costs

These are costs associated with deficiencies that are found after product is received by the customer. Also included are lost opportunities for sales revenue. These costs also would disappear if there were no deficiencies.

Failure to Meet Customer Requirements and Needs

Examples of subcategories are

- *Warranty charges: The costs involved in replacing or making repairs to products that are still within the warranty period.*
- *Complaint adjustment: The costs of investigation and adjustment of justified complaints attributable to defective product or installation.*
- *Returned material: The costs associated with receipt and replacement of defective product received from the field.*
- *Allowances: The costs of concessions made to customers due to substandard products accepted by the customer as is or to conforming product that does not meet customer needs.*
- *Penalties due to poor quality: This applies to goods or services delivered or to internal processes such as late payment of an invoice resulting in a lost discount for paying on time.*
- *Rework on support operations: Correcting errors on billing and other external processes.*
- *Revenue losses in support operations:* An example is the failure to collect on receivables from some customers.

Lost Opportunities for Sales Revenue

Examples are

- *Customer defections: Profit margin on current revenue lost due to customers who switch for reasons of quality. An important example of this category is current contracts that are canceled due to quality.*
- *New customers lost because of quality: Profit on potential customers lost because of poor quality.*

- *New customers lost because of lack of capability to meet customer needs:* Profit on potential revenue lost because of inadequate processes to meet customer needs.

Appraisal Costs

These are the costs incurred to determine the degree of conformance to quality requirements. Examples are

- *Incoming inspection and test: Determining the quality of purchased product, whether by inspection on receipt, by inspection at the source, or by surveillance.*
- *In-process inspection and test: In-process evaluation of conformance to requirements.*
- *Final inspection and test: Evaluation of conformance to requirements for product acceptance.*
- *Document review: Examination of paperwork to be sent to customer.*
- *Balancing: Examination of various accounts to assure internal consistency.*
- *Product quality audits: Performing quality audits on in-process or finished products.*
- *Maintaining accuracy of test equipment: Keeping measuring instruments and equipment in calibration.*
- *Inspection and test materials and services: Materials and supplies in inspection and test work (e.g., x-ray film) and services (e.g., electric power) where significant.*
- *Evaluation of stocks:* Testing products in field storage or in stock to evaluate degradation.

In collecting appraisal costs, what is decisive is the kind of work done and not the department name (the work may be done by chemists in the laboratory, by sorters in Operations, by testers in Inspection, or by an external firm engaged for the purpose of testing). Also note that industries use a variety of terms for "appraisal," e.g., checking, balancing, reconciliation, review.

Prevention Costs

These are costs incurred to keep failure and appraisal costs to a minimum.

Examples are:

- *Quality planning: This includes the broad array of activities which collectively create the overall quality plan and the numerous specialized plans. It includes also the preparation of procedures needed to communicate these plans to all concerned.*
- *New-products review: Reliability engineering and other quality-related activities associated with the launching of new design.*
- *Process planning: Process capability studies, inspection planning, and other activities associated with the manufacturing and service processes.*
- *Process control: In-process inspection and test to determine the status of the process (rather than for product acceptance).*
- *Quality audits: Evaluating the execution of activities in the overall quality plan.*
- *Supplier quality evaluation: Evaluating supplier quality activities prior to supplier selection, auditing the activities during the contract, and associated effort with suppliers.*

- *Training: Preparing and conducting quality-related training programs. As in the case of appraisal costs, some of this work may be done by personnel who are not on the payroll of the Quality department. T*he decisive criterion is again the type of work, not the name of the department performing the work.

Note that prevention costs are costs of special planning, review, and analysis activities for quality.

Prevention costs do *not* include basic activities such as product design, process design, process maintenance, and customer service.

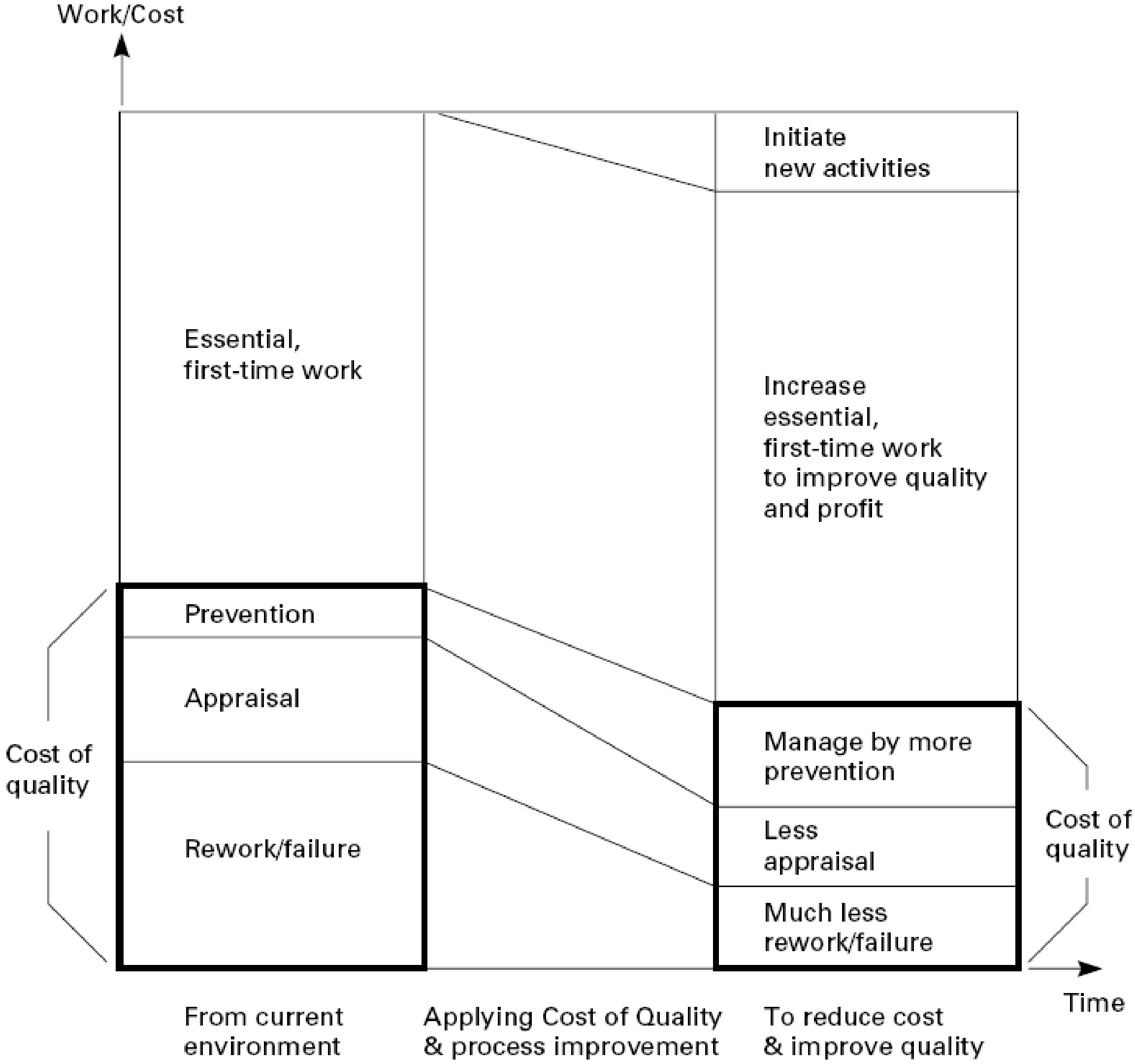
Hidden Costs.

The cost of poor quality may be understated because of costs which are difficult to estimate. The "hidden" costs occur in both manufacturing and service industries and include:

1. Potential lost sales (see above under External Failure Costs).
2. Costs of redesign of products due to poor quality.
3. Costs of changing processes due to inability to meet quality requirements for products.
4. Costs of software changes due to quality reasons.
5. Costs of downtime of equipment and systems including computer information systems.
6. Costs included in standards because history shows that a certain level of defects is inevitable and allowances should be included in standards:
   - ***a.*** *Extra material purchased:* The purchasing buyer orders 6 percent more than the production quantity needed.
   - ***b.*** *Allowances for scrap and rework during production:* History shows that 3 percent is "normal" and accountants have built this into the cost standards. One accountant said, "Our scrap cost is zero. The production departments are able to stay within the 3 percent that we have added in the standard cost and therefore the scrap cost is zero." Ah, for the make-believe "numbers game."
   - ***c.*** *Allowances in time standards for scrap and rework:* One manufacturer allows 9.6 percent in the time standard for certain operations to cover scrap and rework.
   - ***d.*** *Extra process equipment capacity:* One manufacturer plans for 5 percent unscheduled downtime of equipment and provides extra equipment to cover the downtime. In such cases, the alarm signals ring only when the standard value is exceeded. Even when operating within those standards, however, the costs should be a part of the cost of poor quality. They represent opportunities for improvement.
7. Extra indirect costs due to defects and errors. Examples are space charges and inventory charges.
8. Scrap and errors not reported. One example is scrap that is never reported because of fear of reprisals, or scrap that is charged to a general ledger account without an identification as scrap.
9. Extra process costs due to excessive product variability (even though within specification limits):

For example, a process for filling packages with a dry soap mix meets requirements for label weight on the contents. The process aim, however, is set above label weight to account for variability in the filling process. See Cost of Inefficient Processes above under Internal Failure Costs.

10. Cost of errors made in support operations, e.g., order filling, shipping, customer service, billing.
11. Cost of poor quality within a supplier's company. Such costs are included in the purchase price.

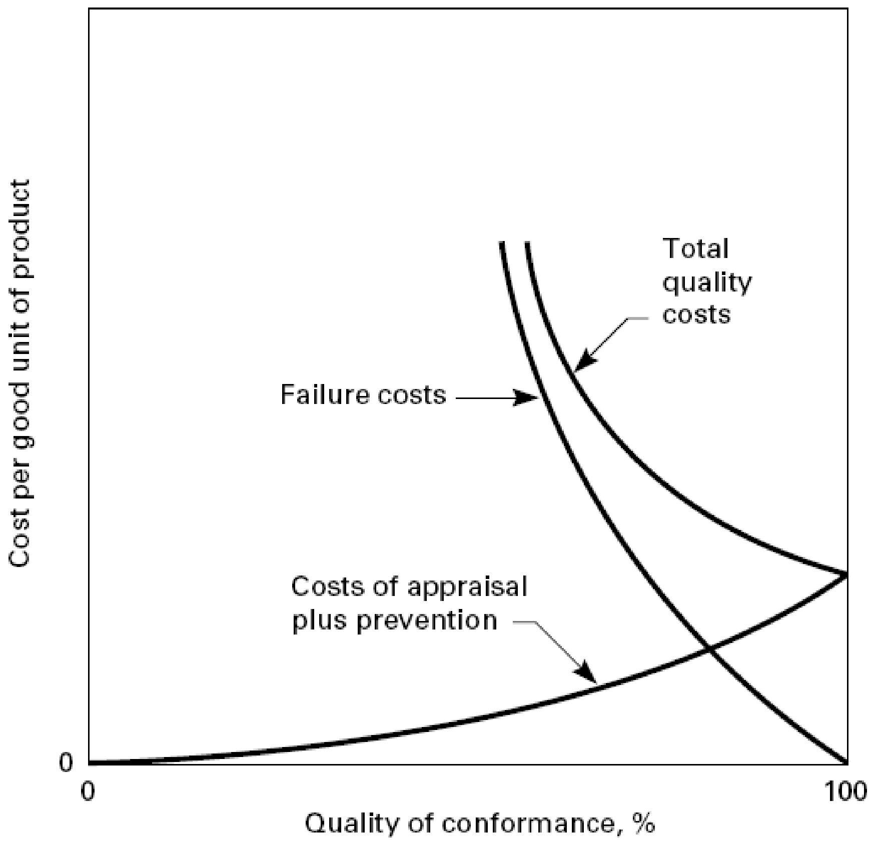


Effect of identifying cost of quality

Optimum Quality Cost Model

The model shows three curves:

1. *The failure costs:* These equal zero when the product is 100 percent good, and rise to infinity when the product is 100 percent defective. (Note that the vertical scale is cost per good unit of product. At 100 percent defective, the number of good units is zero, and hence the cost per good unit is infinity.)
2. *The costs of appraisal plus prevention:* These costs are zero at 100 percent defective, and rise as perfection is approached.
3. *The sum of curves 1 and 2:* This third curve is marked "total quality costs" and represents the total cost of quality per good unit of product.



The previous figure suggests that the minimum level of total quality costs occurs when the quality of conformance is 100 percent, i.e., perfection. This has not always been the case. During most of the twentieth century the predominant role of (fallible) human beings limited the efforts to attain perfection at finite costs. Also, the inability to quantify the impact of quality failures on sales revenue resulted in underestimating the failure costs. The result was to view the optimum value of quality of conformance as less than 100 percent.

REPORTING ON THE COST OF POOR QUALITY

When managers use a scoreboard on the cost of poor quality, they are not content to look at the gross dollar figures. They want, in addition, to compare the costs with some base which is an index of the opportunity for creating these costs. A summary of some widely used bases, along with the advantages and disadvantages of each, is presented in the following table. The base used can greatly influence the interpretation of the cost data.

Measurement Bases for Quality Costs

Base	Advantages	Disadvantages
Direct labor hour	Readily available and understood	Can be drastically influenced by automation
Direct labor dollars	Available and understood; tends to balance any inflation effect	Can be drastically influenced by automation
Standard manufacturing cost dollars	More stability than above	Includes overhead costs both fixed and variable
Value-added dollars	Useful when processing costs are important	Not useful for comparing different types of manufacturing departments
Sales dollars	Appeals to higher management	Sales dollars can be influenced by changes in prices, marketing costs, demand, etc.
Product units	Simplicity	Not appropriate when different products are made unless "equivalent" item can be defined

QUALITY CONTROL TOOLS

Scatter Diagrams

Scatter diagrams are used to study possible relationships between two variables. Although these diagrams cannot prove that one variable causes the other, they do indicate the existence of a relationship, as well as the strength of that relationship.

A scatter diagram is composed of a horizontal axis containing the measured values of one variable and a vertical axis representing the measurements of the other variable.

The purpose of the scatter diagram is to display what happens to one variables when another variable is changed. The diagram is used to test a theory that the two variables are related. The type of relationship that exits is indicated by the slope of the diagram.

Key Terms

- **Variable** - a quality characteristic that can be measured and expressed as a number on some continuous scale of measurement.
- **Relationship** - Relationships between variables exist when one variable depends on the other and changing one variable will affect the other.
- **Data Sheet** - contains the measurements that were collected for plotting the diagram.
- **Correlation** - an analysis method used to decide whether there is a statistically significant relationship between two variables.
- **Regression** - an analysis method used to identify the exact nature of the relationship between two variables.

History

The Guide to Quality Control and The Statistical Quality Control Handbook, written by a Japanese quality consultant named Kaoru Ishikawa are useful in providing an understanding on how to use and interpret a scatter diagram. Ishikawa believed that there was no end to quality improvement and in 1985 suggested that seven base tools be used for collection and analysis of quality data. Among the tools was the scatter diagram.

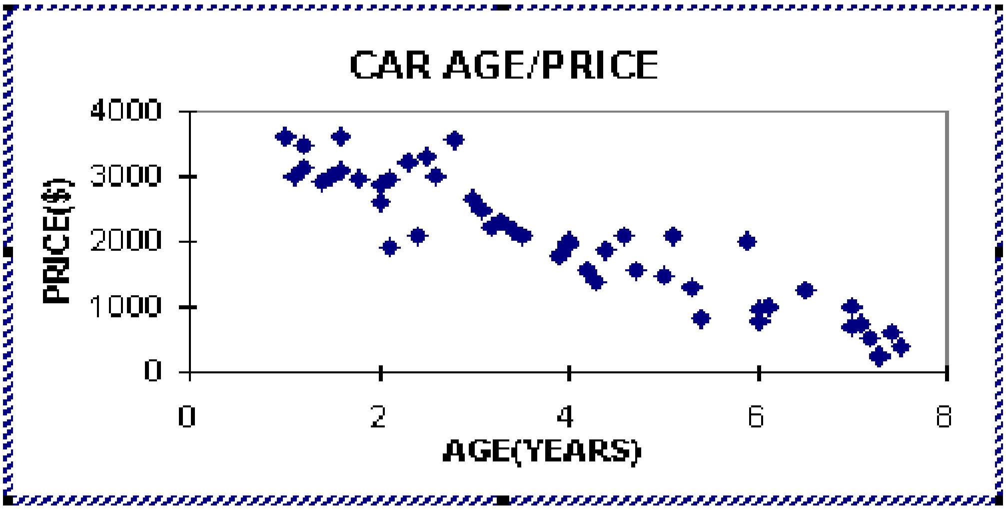
Construction of Scatter Diagrams

- Collect and construct a data sheet of 50 to 100 paired samples of data, which you suspect to be related. Construct your data sheet as follows:

Car	Age(In Years)	Price(In Dollars)
1	2	4000
2	4	2500
3	1	5000
4	5	1250
:	:	:
:	:	:
:	:	:
:	:	:
100	7	1000

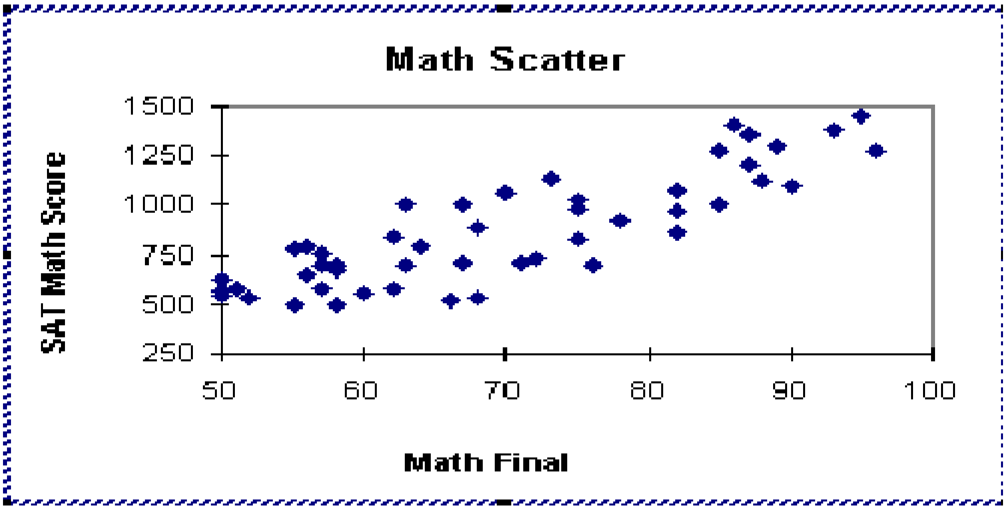
- Draw the axes of the diagram. The first variable (the independent variable) is usually located on the horizontal axis and its values should increase as you move to the right. The vertical axis usually contains the second variable (the dependent variable) and its values should increase as you move up the axis.

- Plot the data on the diagram. The resulting scatter diagram may look as follows:

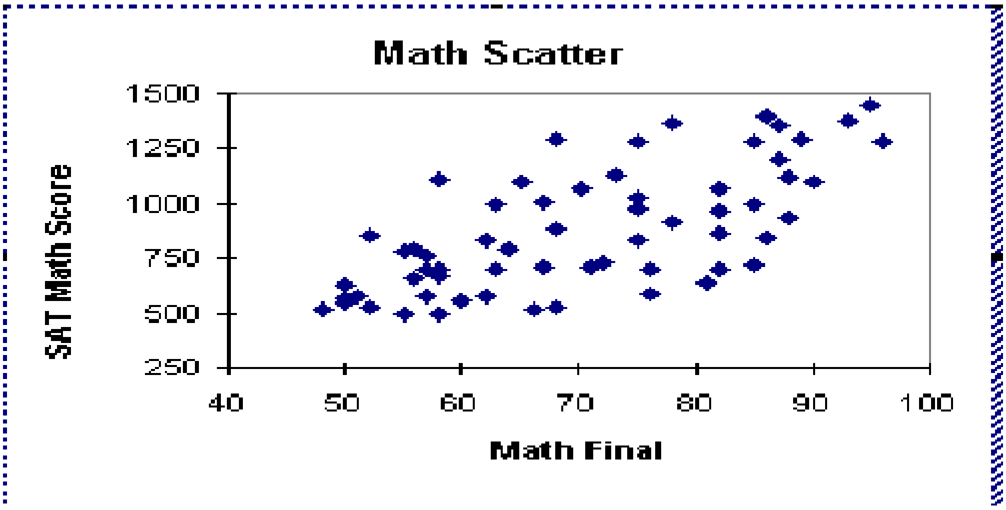


Interpretations

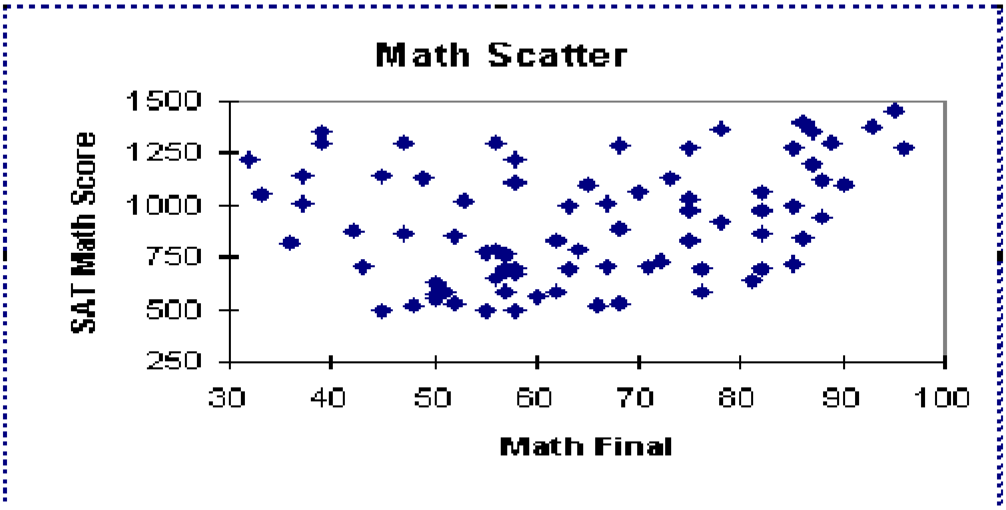
The scatter diagram is a useful tool for identifying a potential relationship between two variables. The shape of the scatter diagram presents valuable information about the graph. It shows the type of relationship which may be occurring between the two variables. There are several different patterns (meanings) that scatter diagrams can have. The following describe five of the most common scenarios:



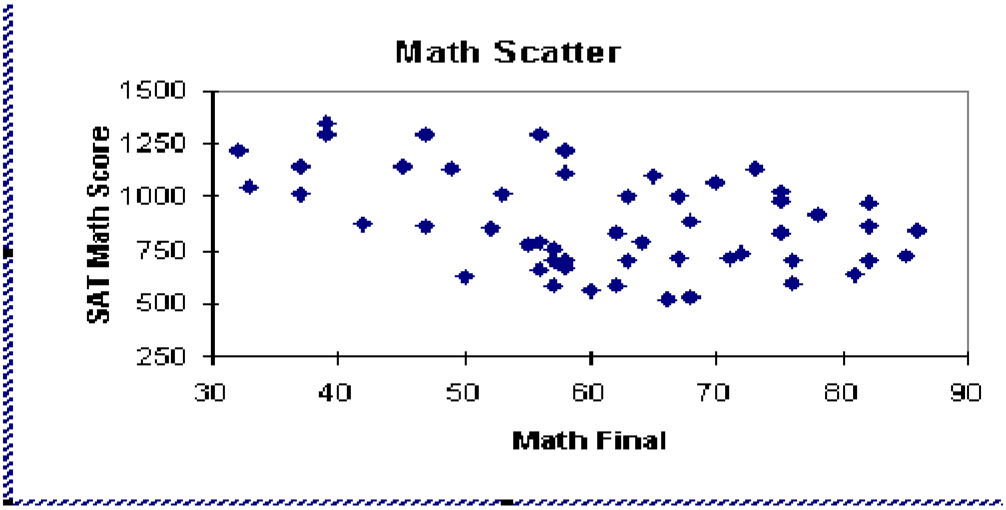
1. The first pattern is positive correlation, that is, as the amount of variable x increases, the variable y also increases. It is tempting to think this is a cause/effect relationship. This is an incorrect thinking pattern, because correlation does not necessarily mean causality. This simple relationship could be caused by something totally different. For instance, the two variables could be related to a third, such as curing time or stamping temperature. Theoretically, if x is controlled, we have a chance of controlling y.



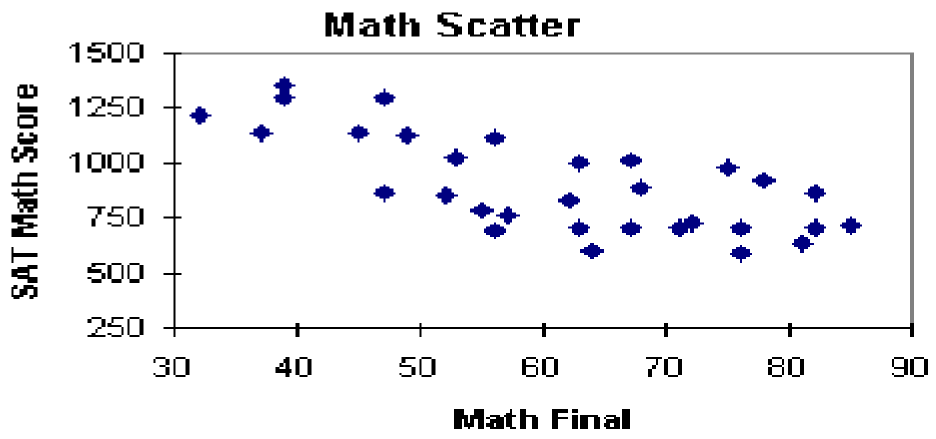
2. Secondly, we have possible positive correlation, that is, if x increases, y will increase somewhat, but y seems to be caused by something other than x. Designed experiments must be utilized to verify causality.



3. We also have the no correlation category. The diagram is so random that there is no apparent correlation between the two variables.



4. There is also possible negative correlation, that is, an increase in x will cause a tendency for a decrease in y, but y seems to have causes other than x.

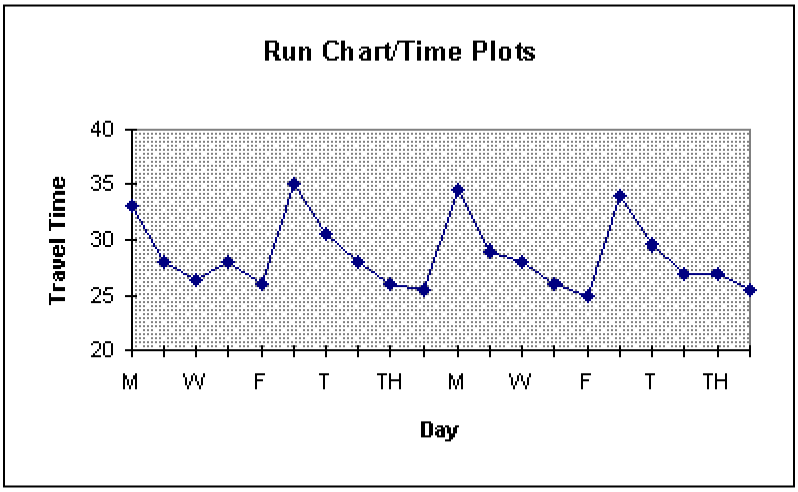


5. Finally, we have the negative correlation category. An increase in x will cause a decrease in y. Therefore, if y is controlled, we have a good chance of controlling x.

Key Observations

- ✓ A strong relationship between the two variables is observed when most of the points fall along an imaginary straight line with either a positive or negative slope.
- ✓ No relationship between the two variables is observed when the points are randomly scattered about the graph.

RUN CHARTS/TIME PLOT/TREND CHART



To access the information that you are interested in, select the topic from the Tutorial outline. At the end of each section is hypertext to enable a user to jump to any section of the tutorial, or if they wish, they can continue on to the next section by scrolling down.

PURPOSE

In-depth view into Run Charts--a quality improvement technique; how Run charts are used to monitor processes; how using Run charts can lead to improved process quality

USAGE

Run charts are used to analyze processes according to time or order. Run charts are useful in discovering patterns that occur over time.

KEY TERMS

Trends: Trends are patterns or shifts according to time. An upward trend, for instance, would contain a section of data points that increased as time passed.

Population: A population is the entire data set of the process. If a process produces one thousand parts a day, the population would be the one thousand items.

Sample: A sample is a subgroup or small portion of the population that is examined when the entire population cannot be evaluated. For instance, if the process does produce one thousand items a day, the sample size could be perhaps three hundred.

HISTORY

Run charts originated from control charts, which were initially designed by Walter Shewhart. Walter Shewhart was a statistician at Bell Telephone Laboratories in New York. Shewhart developed a system for bringing processes into statistical control by developing ideas which would allow for a system to be controlled using control charts. Run charts evolved from the development of these control charts, but run charts focus more on time patterns while a control chart focuses more on acceptable limits of the process. Shewhart's discoveries are the basis of what as known as SQC or Statistical Quality Control.

INSTRUCTIONS FOR CREATING A CHART

Step 1 : Gathering Data

To begin any run chart, some type of process or operation must be available to take measurements for analysis. Measurements must be taken over a period of time. The data must be collected in a chronological or sequential form. You may start at any point and end at any point. For best results, at least 25 or more samples must be taken in order to get an accurate run chart.

Step 2 : Organizing Data

Once the data has been placed in chronological or sequential form, it must be divided into two sets of values x and y. The values for x represent time and the values for y represent the measurements taken from the manufacturing process or operation.

Step 3 : Charting Data

Plot the y values versus the x values by hand or by computer, using an appropriate scale that will make the points on the graph visible. Next, draw vertical lines for the x values to separate time intervals such as weeks. Draw horizontal lines to show where trends in the process or operation occur or will occur.

Step 4 : Interpreting Data

After drawing the horizontal and vertical lines to segment data, interpret the data and draw any conclusions that will be beneficial to the process or operation. Some possible outcomes are:

- Trends in the chart
- Cyclical patterns in the data
- Observations from each time interval are consistent

RUN CHART EXAMPLE

Problem Scenario

You have just moved into a new area that you are not familiar with. Your desire is to arrive at work on time, but you have noticed over your first couple of weeks on the job that it doesn't take the same amount of time each day of the week. You decide to monitor the amount of time it takes to get to work over the next four weeks and construct a run chart.

Step 1: Gathering Data

Collect measurements each day over the next four weeks. Organize and record the data in chronological or sequential form.

	M	T	W	TH	F
WEEK 1	33	28	26.5	28	26
WEEK 2	35	30.5	28	26	25.5
WEEK 3	34.5	29	28	26	25
WEEK 4	34	29.5	27	27	25.5

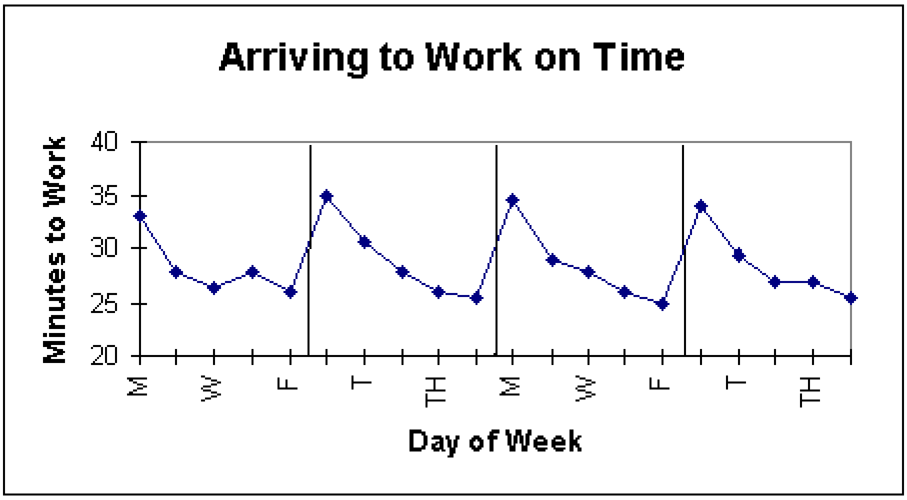
Step 2: Organizing Data

Determine what the values for the x (time, day of week) and day (data, minutes to work) axis will be.

	Day	Travel Time	
WEEK 1	M	33	
	T	28	
	W	26.5	
	TH	28	
	F	26	
WEEK 2	M	35	
	T	30.5	
	W	28	
	TH	26	
	F	25.5	
WEEK 3	M	34.5	
	T	29	
	W	28	
	TH	26	
	F	25	
WEEK 4	M	34	
	T	29.5	
	W	27	
	TH	27	
	F	25.5	

Step 3: Charting Data

Plot the y values versus the x values by hand or by computer using the appropriate scale. Draw horizontal or vertical lines on the graph where trends or inconsistencies occur.

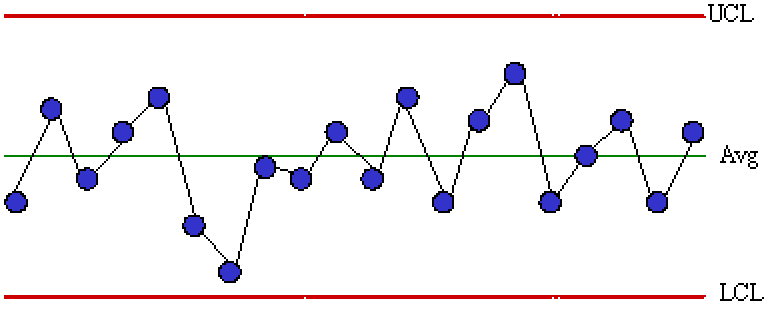


Step 4: Interpreting Data

Interpret results and draw any conclusions that are important. An overall decreasing trend occurs each week with Mondays taking the most amount of time and Fridays generally taking the least amount of time. Therefore you accordingly allow yourself more time on Mondays to arrive to work on time.

Control Chart

A control chart represents a picture of a process over time. To effectively use control charts, one must be able to interpret the picture. What is this control chart telling me about my process? Is this picture telling me that everything is all right and I can relax? Is this picture telling me that something is wrong and I should get up and find out what has happened? A control chart tells you if your process is in statistical control. The chart above is an example of a stable (in statistical control) process.



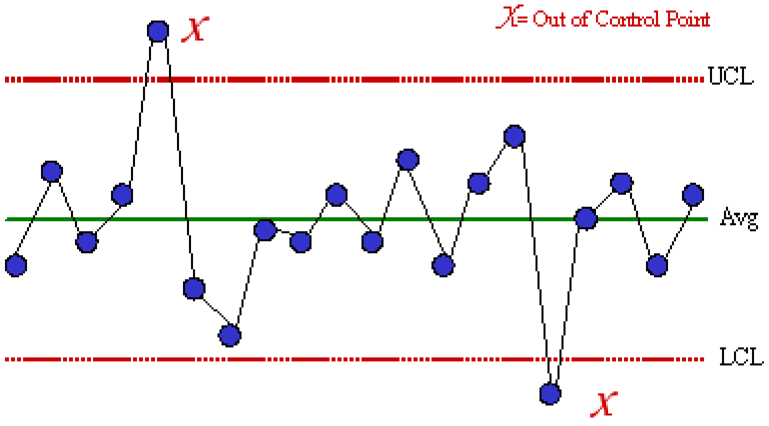
This pattern is typical of processes that are stable. Three characteristics of a process that is in control are:

- Most points are near the average
- A few points are near the control limits
- No points are beyond the control limits

If a control chart does not look similar to the one above, there is probably a special cause present. Various tests for determining if a special cause is present are given below.

Points Beyond the Control Limits

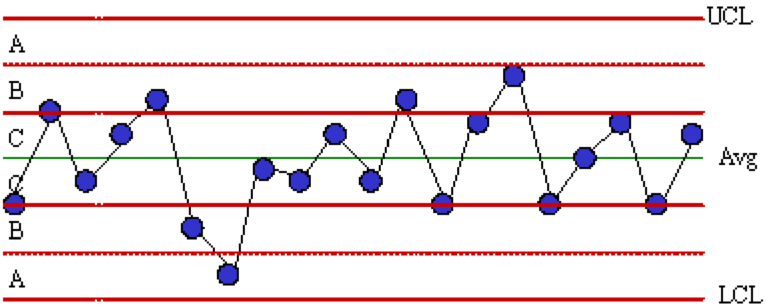
A special cause is present in the process if any points fall above the upper control limit or below the lower control limit. Action should be taken to find the special cause and permanently remove it from the process. If there is a point beyond the control



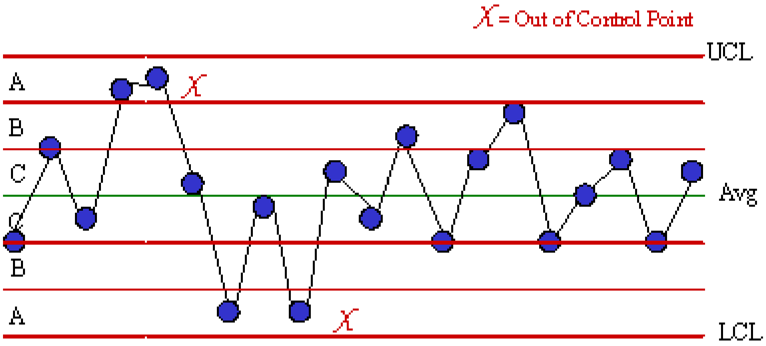
limits, there is no need to apply the other tests for out of control situations. Points on the control limits are not considered to be out of statistical control.

Zone Tests: Setting the Zones and Zone A

The zone tests are valuable tests for enhancing the ability of control charts to detect small shifts quickly. The first step in using these tests is to divide the control chart into zones. This is done by dividing the area between the average and the upper control limit into three equally spaced areas. This is then repeated for the area between the average and the lower control limit.



The zones are called zones A, B, and C. There is a zone A for the top half of the chart and a zone A for the bottom half of the chart. The same is true for zones B and C. Control charts are based on 3 sigma limits of the variable being plotted. Thus, each zone is one standard deviation in width. For example, considering the top half of the chart, zone C is the region from the average to the average plus one standard deviation. Zone B is the region between the average plus one standard deviation and the average plus two standard deviations. Zone A is the region between the average plus two standard deviations and the average plus three standard deviations

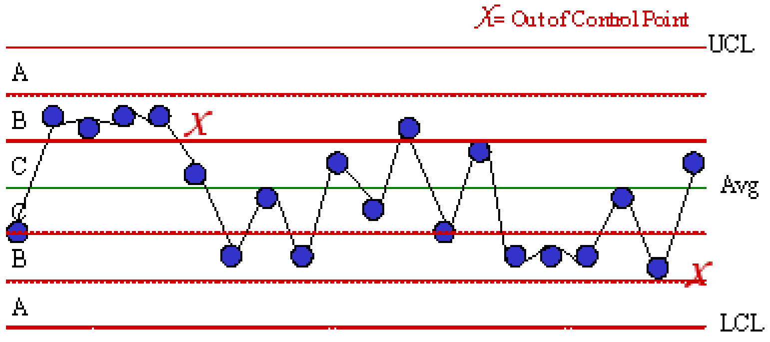


A special cause exists if two out of three consecutive points fall in zone A or beyond. The figure below shows an example of this test. The test is applied for the zone A above the average and then for the zone A below the average.

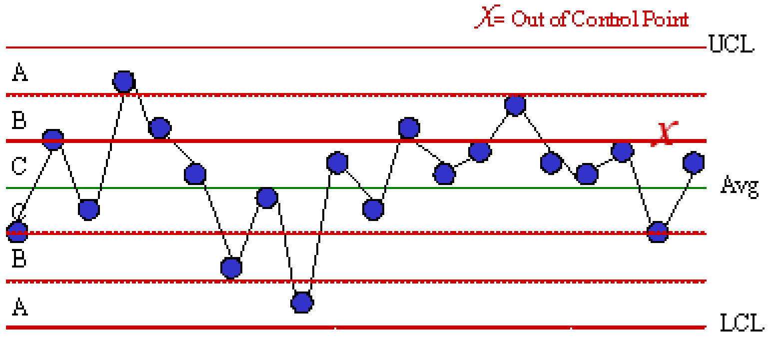
This test, like those below, is applied to both halves of the chart. However, only one half is considered at a time. For example, if one point falls in the zone A above the average and the next point falls in zone A below the average, this is not two out of three consecutive points in zone A or beyond. The two points in zone A must be on the same side of the average.

Zone Tests: Zones B and C

A special cause exists if four out five consecutive points fall in zone B or beyond. The figure to the left shows an example of this test. This test is applied for zone B above the average and then for zone B below the average.

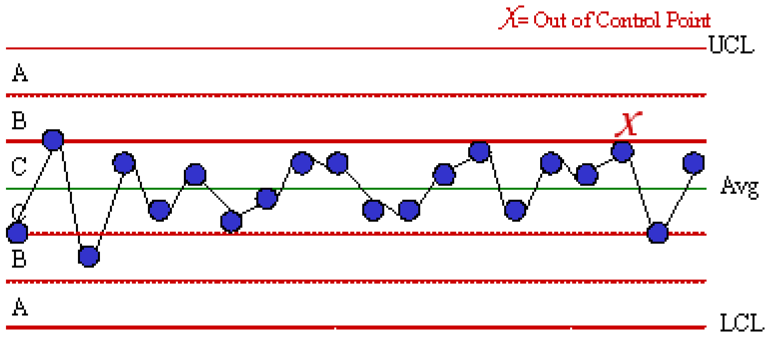


A special cause exists if seven consecutive points fall in zone C or beyond. An example of this test is shown below. The test should be applied for the zone C above the average and then for the zone C below the average.



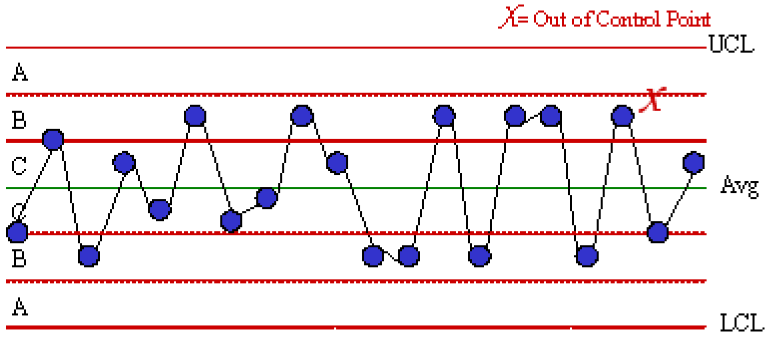
Test for Stratification

Stratification occurs if two or more processes (distributions) are being sampled systematically. For example, stratification can occur if samples are taken once a shift and a subgroup size of 3 is formed based on the results from three shifts. It is possible that the shifts are operating at a different average or variability. Stratification (a special cause) exists if fifteen or more consecutive points fall in zone C either above or below the average. Note that the points tend to hug the centerline. This test involves the use of the zones but is applied to the entire chart and not one-half of the chart at a time.



Test for Mixtures

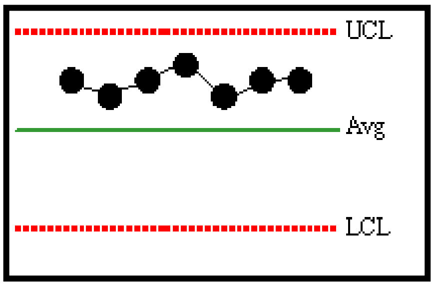
A mixture exists when there is more than one process present but sampling is done for each process separately. For example, suppose you take three samples per shift and form a subgroup based on these three samples. If different shifts are operating at different averages, a mixture can occur. A mixture (a special cause) is present if eight or more consecutive points lie on both sides of the average with none of the points in zone C. The figure shows an example of this test. Note the absence of points in zone C. This test is applied to the entire chart.



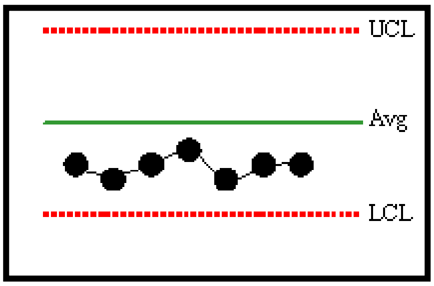
Rule of Seven Tests

These tests are often taught initially to employees as the method for interpreting control charts (along with points beyond the limits). The tests state that an out of control situation is present if one of the following conditions is true:

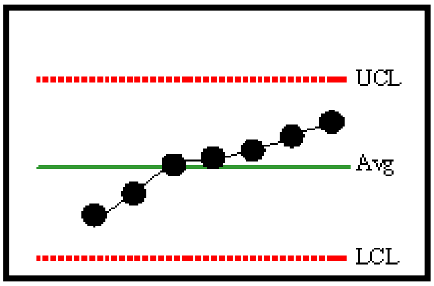
1) Seven points in a row above the average,



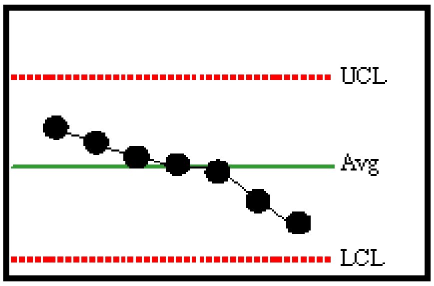
2) Seven points in a row below the average,



3) Seven points in a row trending up, or



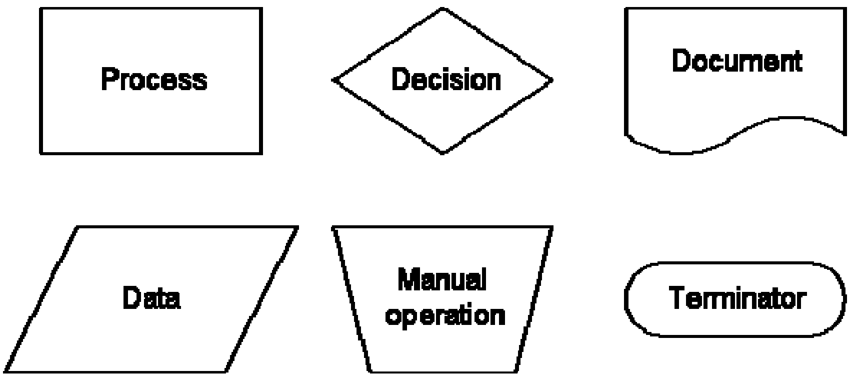
4) Seven points in a row trending down. These four conditions are shown in the figure above.



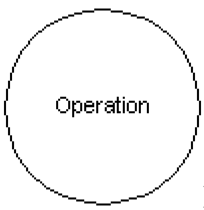
FLOW CHARTS

OVERVIEW

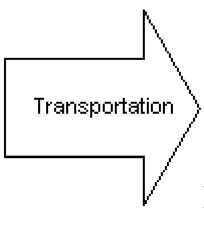
- Quality Improvement Tool: Flow charts used specifically for a process.
- A flow chart is defined as a pictorial representation describing a process being studied or even used to plan stages of a project. Flow charts tend to provide people with a common language or reference point when dealing with a project or process.
- Four particular types of flow charts have proven useful when dealing with a process analysis: top-down flow chart, detailed flow chart, work flow diagrams, and a deployment chart. Each of the different types of flow charts tend to provide a different aspect to a process or a task. Flow charts provide an excellent form of documentation for a process, and quite often are useful when examining how various steps in a process work together.
- When dealing with a process flow chart, two separate stages of the process should be considered: the finished product and the making of the product. In order to analyze the finished product or how to operate the process, flow charts tend to use simple and easily recognizable symbols. The basic flow chart symbols below are used when analyzing how to operate a process.



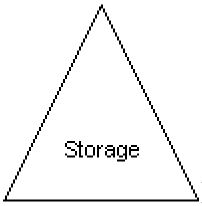
In order to analyze the second condition for a flow process chart, one should use the ANSI standard symbols. The ANSI standard symbols used most often include the following:



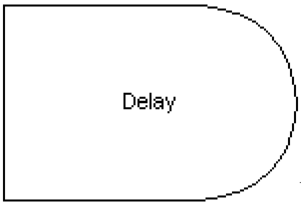
Drive Nail, Cement, Type Letter.



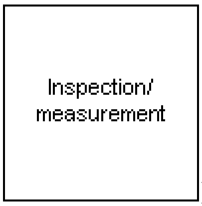
Move Material by truck, conveyor, or hand.



Raw Material in bins, finished product on pallets, or filed documents.



Wait for elevator, papers waiting, material waiting



Read gages, read papers for information, or check quality of goods.

Any combination of two or more of these symbols show an understanding for a joint process.

INSTRUCTIONS

Step-by-Step process of how to develop a flow chart.

- Gather information of how the process flows: use a)conservation, b)experience, or c)product development codes.
- Trial process flow.
- Allow other more familiar personnel to check for accuracy.
- Make changes if necessary.
- Compare final actual flow with best possible flow.

Note: Process should follow the flow of Step1, Step 2, ... , Step N.

Step N= End of Process

CONSTRUCTION/INTERPRETATION tip for a flow chart.

- Define the boundaries of the process clearly.
- Use the simplest symbols possible.
- Make sure every feedback loop has an escape.

- There is usually only one output arrow out of a process box. Otherwise, it may require a decision diamond.

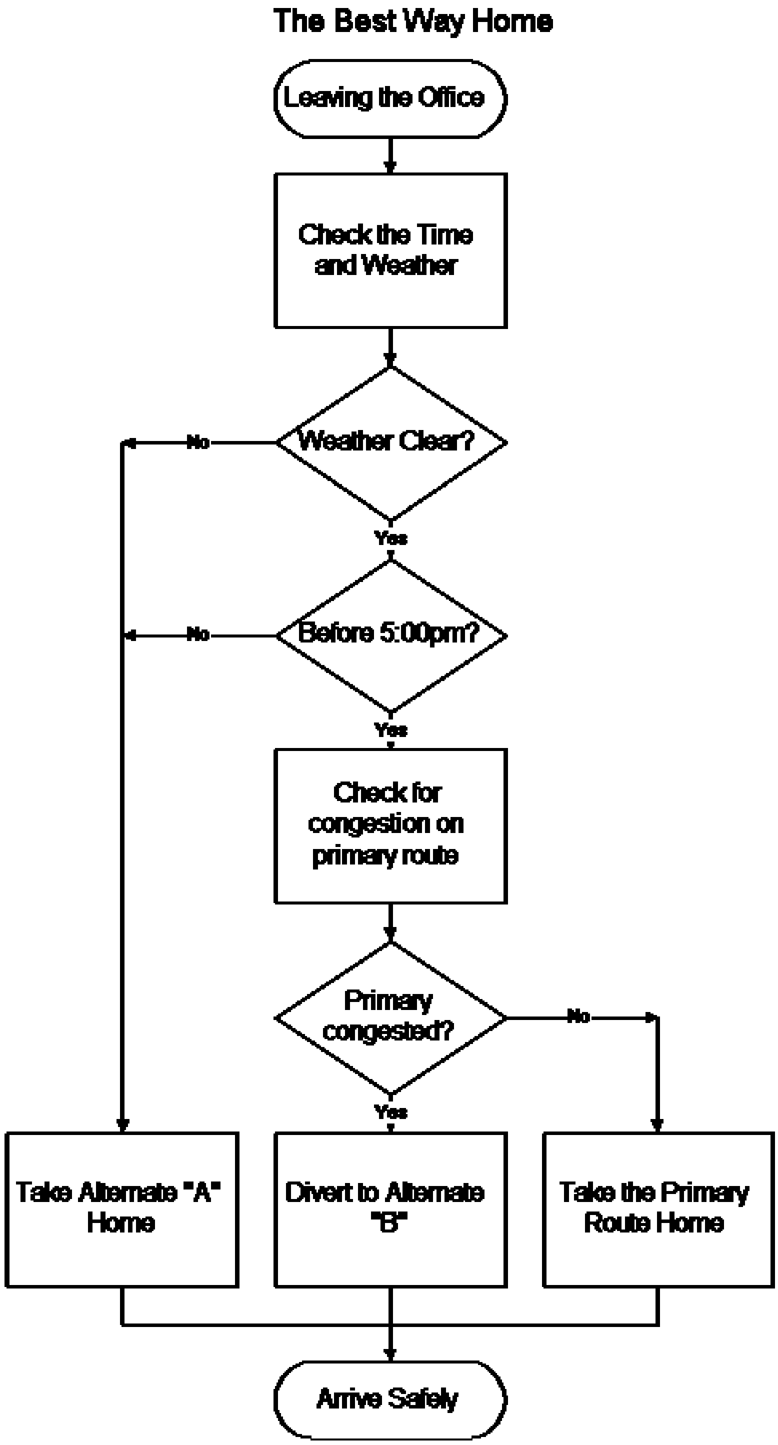
INTERPRETATION

- Analyze flow chart of actual process.
- Analyze flow chart of best process.
- Compare both charts, looking for areas where they are different. Most of the time, the stages where differences occur is considered to be the problem area or process.
- Take appropriate in-house steps to correct the differences between the two seperate flows.

EXAMPLE

Process Flow Chart- Finding the best way home

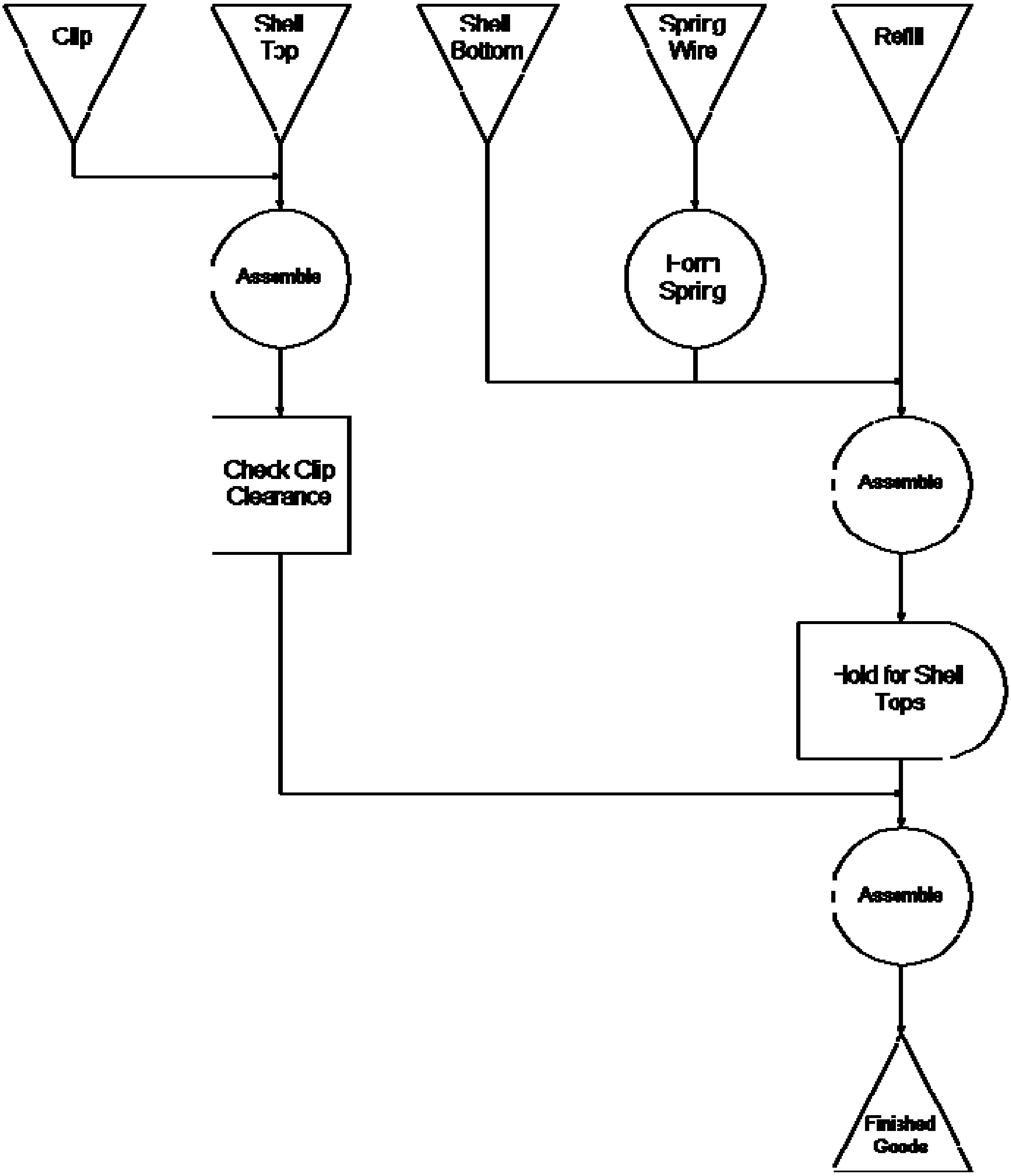
This is a simple case of processes and decisions in finding the best route home at the end of the working day.



Process Flow Chart- How a process works

(Assembling a ballpoint pen)

Ball-Point Pen Assembly



Cause and Effect Diagram

PURPOSE and USAGE

To provide a pictorial display of a list in which you identify and organize possible causes of problems, or factors needed to ensure success of some effort.

It is an effective tool that allows people to easily see the relationship between factors to study processes, situations, and for planning.

HISTORICAL BACKGROUND

The cause-and-effect diagram is also called the Ishikawa diagram (after its creator, Kaoru Ishikawa of Japan), or the fishbone diagram (due to its shape).

This diagram was adopted by Dr. W. Edwards Deming as a helpful tool in improving quality. Dr. Deming has taught Total Quality Management in Japan since World War II. He has also helped develop statistical tools to be used for the census and taught the military his methods of quality management. Both Ishikawa and Deming use this diagram as one the first tools in the quality management process.

Fishbone Diagram Example

This fishbone diagram was drawn by a manufacturing team to try to understand the source of periodic iron contamination. The team used the six generic headings to prompt ideas. Layers of branches show thorough thinking about the causes of the problem.

For example, under the heading "Machines," the idea "materials of construction" shows four kinds of equipment and then several specific machine numbers.

Note that some ideas appear in two different places. "Calibration" shows up under "Methods" as a factor in the analytical procedure, and also under "Measurement" as a cause of lab error. "Iron tools" can be considered a "Methods" problem when taking samples or a "Manpower" problem with maintenance personnel.

Example: Copier Problem

I. PEOPLE
- A. Employees
  - 1. Full time
  - 2. Part-time
- B. Training
  - 1. Formal
    - a. Recent
    - b. Adequate
    - c. Consistent
  - 2. On-the-Job
    - a. Recent
    - b. Frequent

II. METHODS
- A. Manufacturer's recommended procedures
- B. Manufacturer's recommended materials
- C. Consistent

III. MATERIALS
- A. Paper

1. Size
2. Thickness
    a. Too thick
    b. Too thin
3. Condition of originals
    a. Creased
    b. Poor quality

B. Toner
1. Too little
2. Too much
3. Lumpy
4. Too thin

IV. ENVIRONMENT

A. Temperature
1. Too hot
2. Too cold

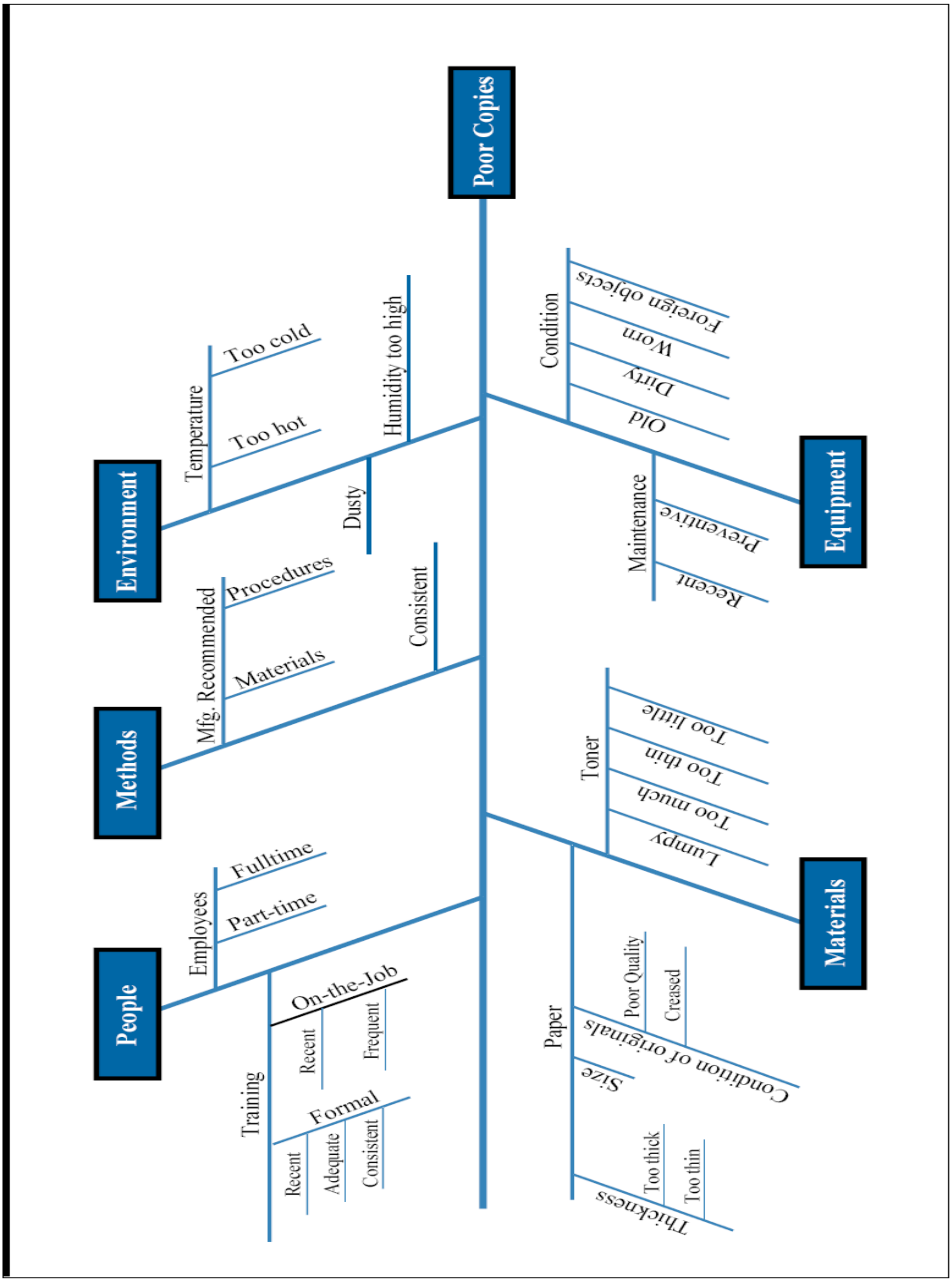
B. Humidity too high

C. Dusty

V. EQUIPMENT

A. Condition
1. Dirty
2. Foreign objects
3. Old
4. Worn

B. Maintenance agreement
1. Recent maintenance
2. Preventive maintenance


Poor Copies
Environment
Temperature
Too cold
Too hot
Humidity too high
Dusty
Methods
Mfg. Recommended
Procedures
Materials
Consistent
People
Employees
Fulltime
Part-time
Training
On-the-Job
Recent
Frequent
Formal
Recent
Adequate
Consistent
Equipment
Condition
Foreign objects
Worn
Dirty
Old
Maintenance
Preventive
Recent
Materials
Toner
Too little
Too thin
Too much
Lumpy
Paper
Poor Quality
Creased
Condition of originals
Size
Thickness
Too thick
Too thin

Histograms

Overview

Overview: This histogram tutorial will provide information on how to construct and interpret histograms for use in quality process control (Q.C.). The main areas that will be covered in this tutorial are the following:

- Tutorial Instructions
- Histogram Background
- Creating a Histogram (interactively by example)
- Interpreting Histograms
- Recommended Additional Q.C. Topics and Software

Purpose: The purpose of this tutorial is to let you become familiar with graphical histograms which are used widely in quality control (Q.C.). Histograms are effective Q.C. tools which are used in the analysis of data. They are used as a check on specific process parameters to determine where the greatest amount of variation occurs in the process, or to determine if process specifications are exceeded. This statistical method does not prove that a process is in a state of control. Nonetheless, histograms alone have been used to solve many problems in quality control.

Key Terms:

Histogram - a vertical bar chart of a frequency distribution of data

Q.C. Methodology - a statistical tool used in the analysis and determination of possible solutions to quality control problems in industry

Frequency Distribution - a variation in a numeric sample of data

Creating a Histogram

1. Determine the range of the data by subtracting the smallest observed measurement from the largest and designate it as R.

   Example:

   Largest observed measurement = 1.1185 inches

   Smallest observed measurement = 1.1030 inches

   R = 1.1185 inches - 1.1030 inches =.0155 inch

2. Record the measurement unit (MU) used. This is usually controlled by the measuring instrument least count.

   Example: MU = .0001 inch

3. Determine the number of classes and the class width. The number of classes, k, should be no lower than six and no higher than fifteen for practical purposes. Trial and error may be done to achieve the best distribution for analysis.

   Example: k=8

4. Determine the class width (H) by dividing the range, R, by the preferred number of classes, k.

   Example: R/k = .0155/8 = .0019375 inch

   The class width selected should be an odd-numbered multiple of the

   measurement unit, MU. This value should be close to the H value:

   MU = .0001 inch

   Class width = .0019 inch or .0021 inch

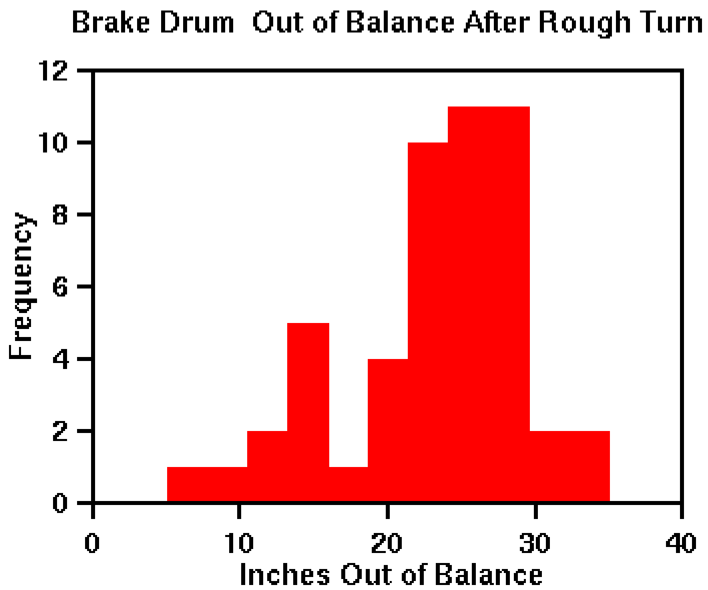
5. Establish the class midpoints and class limits. The first class midpoint should be located near the largest observed measurement. If possible, it should also be a convenient increment. Always make the class widths equal in size, and express the class limits in terms which are one-half unit beyond the accuracy of the original measurement unit. This avoids plotting an observed measurement on a class limit.

   Example: First class midpoint = 1.1185 inches, and the

   class width is .0019 inch. Therefore, limits would be

   1.1185 + or - .0019/2.

6. Determine the axes for the graph. The frequency scale on the vertical axis should slightly exceed the largest class frequency, and the measurement scale along the horizontal axis should be at regular intervals which are independent of the class width. (See example below steps.)



7. Draw the graph. Mark off the classes, and draw rectangles with heights corresponding to the measurement frequencies in that class.

8. Title the histogram. Give an overall title and identify each axis.

Now you have a histogram!!

Interpretations

When combined with the concept of the normal curve and the knowledge of a particular process, the histogram becomes an effective, practical working tool in the early stages of data analysis. A histogram may be interpreted by asking three questions:

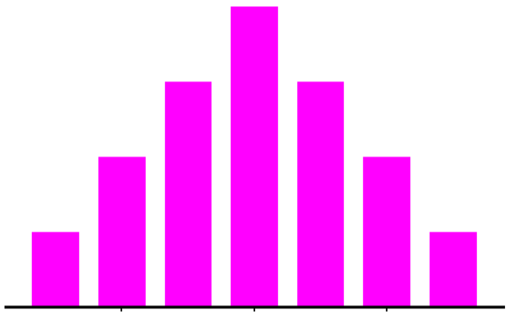
1. Is the process performing within specification limits?
2. Does the process seem to exhibit wide variation?
3. If action needs to be taken on the process, what action is appropriate?

The answer to these three questions lies in analyzing three characteristics of the histogram.

1. How well is the histogram centered? The centering of the data provides information on the process aim about some mean or nominal value.
2. How wide is the histogram? Looking at histogram width defines the variability of the process about the aim.
3. What is the shape of the histogram? Remember that the data is expected to form a normal or bell-shaped curve. Any significant change or anomaly usually indicates that there is something going on in the process which is causing the quality problem.

Examples of Typical Distributions

NORMAL



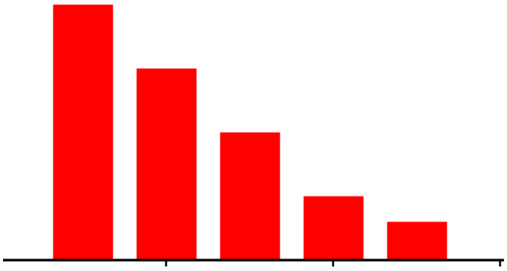
- Depicted by a bell-shaped curve
  - most frequent measurement appears as center of distribution
  - less frequent measurements taper gradually at both ends of distribution
- Indicates that a process is running normally (only common causes are present).

BI-MODAL

- Distribution appears to have two peaks
- May indicate that data from more than process are mixed together

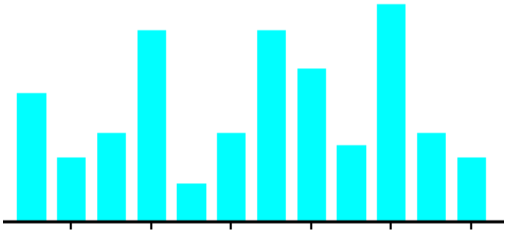
    - materials may come from two separate vendors
    - samples may have come from two separate machines.

CLIFF-LIKE



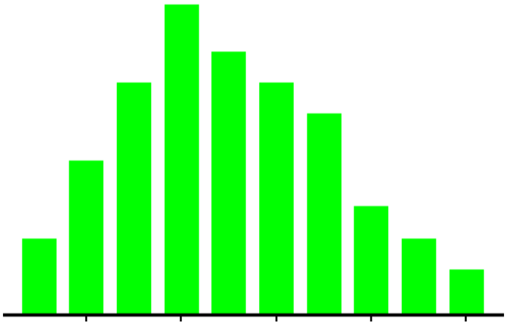
- Appears to end sharply or abruptly at one end
- Indicates possible sorting or inspection of non-conforming parts.

SAW-TOOTHED



- Also commonly referred to as a comb distribution, appears as an alternating jagged pattern
- Often indicates a measuring problem
    - improper gage readings
    - gage not sensitive enough for readings.

SKEWED



- Appears as an uneven curve; values seem to taper to one side.

It is worth mentioning again that this or any other phase of histogram analysis must be married to knowledge of the process being studied to have any real value. Knowledge of the data analysis itself does not provide sufficient insight into the quality problem.

OTHER CONSIDERATIONS

Number of samples.

For the histogram to be representative of the true process behavior, as a general rule, at least fifty (50) samples should be measured.

Limitations of technique.

Histograms are limited in their use due to the random order in which samples are taken and lack of information about the state of control of the process. Because samples are gathered without regard to order, the time-dependent or time-related trends in the process are not captured. So, what may appear to be the central tendency of the data may be deceiving. With respect to process statistical control, the histogram gives no indication whether the process was operating at its best when the data was collected. This lack of information on process control may lead to incorrect conclusions being drawn and, hence, inappropriate decisions being made. Still, with these considerations in mind, the histogram's simplicity of construction and ease of use make it an invaluable tool in the elementary stages of data analysis.

Pareto Analysis

Vilfredo Pareto was an Italian economist who noted that approximately 80% of wealth was owned by only 20% of the population. This was true in almost all the societies he studied. This is only one application of this important 80/20 principle. It shows the lack of symmetry that almost always appears between work put in and results achieved. This can be seen in area after area of competitive activity. The figures 80 and 20 are illustrative – for example, 13% of work could generate 92% of returns.

Pareto analysis is a very simple technique that helps you to choose the most effective changes to make. It uses the Pareto principle – the idea that by doing 20% of work you can generate 80% of the advantage of doing the entire job. Pareto analysis is a formal technique for finding the changes that will give the biggest benefits. It is useful where many possible courses of action are competing for your attention.

How to Use the Tool:

To start using the tool, write out a list of the changes you could make. If you have a long list, group it into related changes.

Then score the items or groups. The scoring method you use depends on the sort of problem you are trying to solve. For example, if you are trying to improve profitability, you would score options on the basis of the profit each group might generate. If you are trying to improve customer satisfaction, you might score on the basis of the number of complaints eliminated by each change.

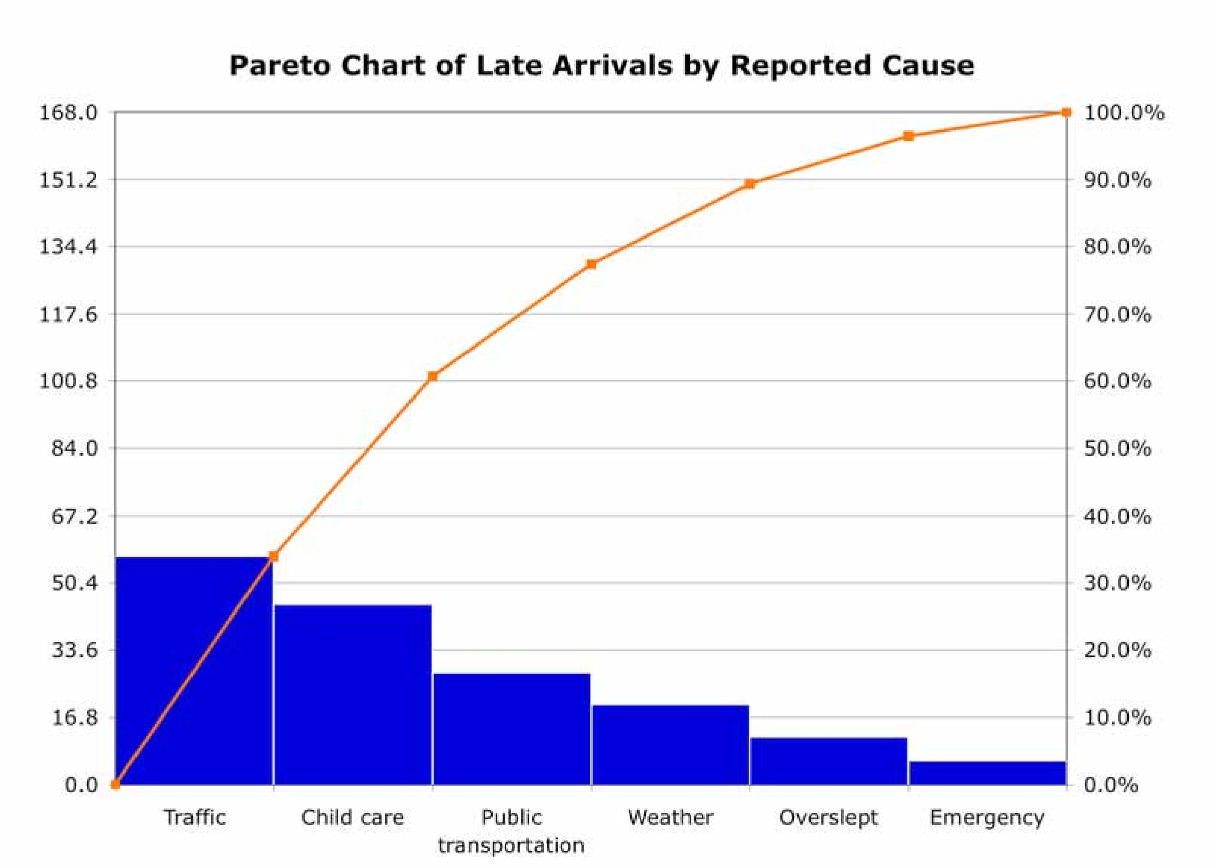
The first change to tackle is the one that has the highest score. This one will give you the biggest benefit if you solve it.

The options with the lowest scores will probably not even be worth bothering with – solving these problems may cost you more than the solutions are worth.

Key points:

To use it:

- ✓ List the problems you face, or the options you have available
- ✓ Group options where they are facets of the same larger problem
- ✓ Apply an appropriate score to each group
- ✓ Work on the group with the highest score


Pareto Chart of Late Arrivals by Reported Cause
168.0
151.2
134.4
117.6
100.8
84.0
67.2
50.4
33.6
16.8
0.0
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Traffic
Child care
Public transportation
Weather
Overslept
Emergency