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.

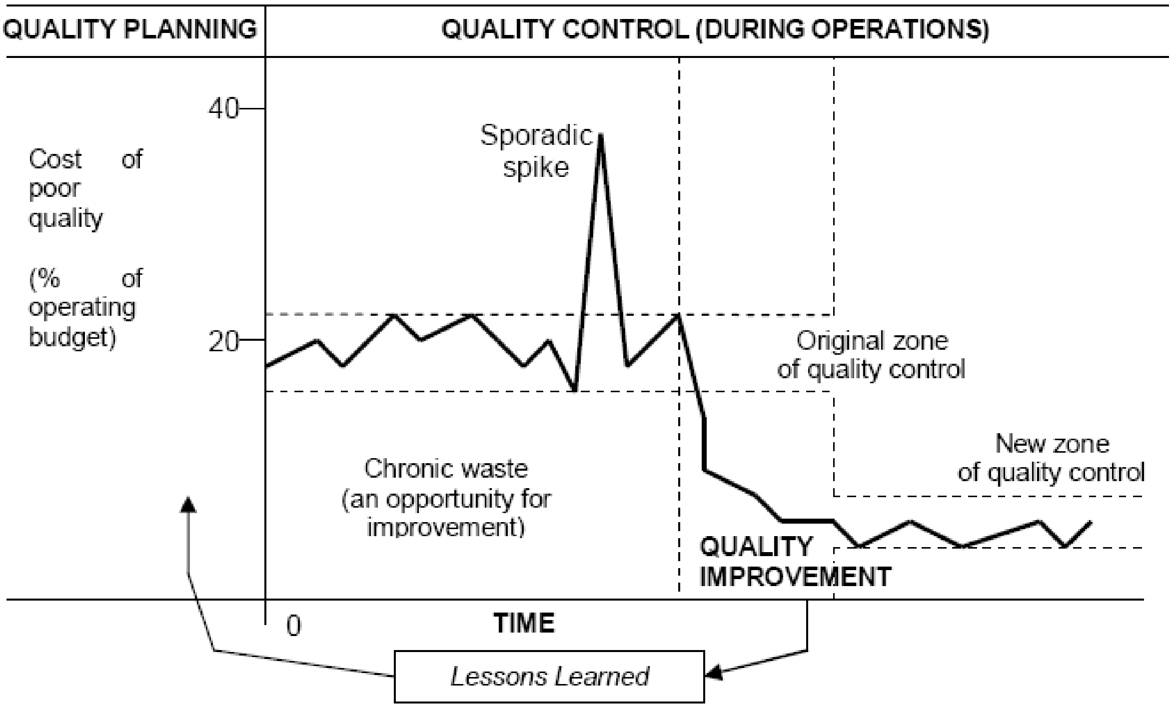
- Identify who are the customers.
- Determine the needs of those customers.
- Translate those needs into our language.
- Develop a product that can respond to those needs.
- Optimize the product features so as to meet our needs and customer needs.

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.

Quality Improvement --- 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

Juran's ten steps to Quality improvement

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

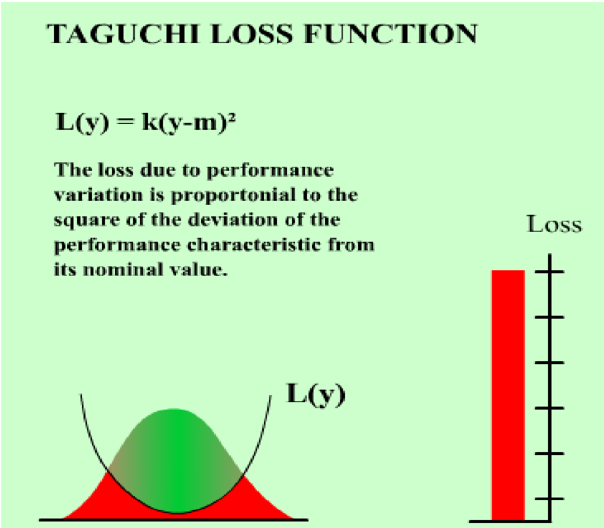
Taguchi Loss Function

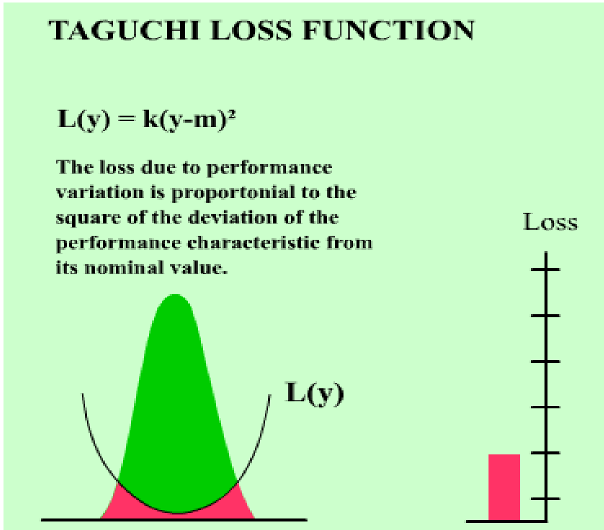
Definition

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:

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

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!