"Introduction to Statistical Quality Control".

: Evolution Of Quality Design And Control

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Quality control
- Learn about the early efforts to control the quality of production
- Learn about the wartime production
- Learn about the Wartime production
- Postwar

Definition/Overview:

Quality control: In engineering and manufacturing, quality control and quality engineering are used in developing systems to ensure products or services are designed and produced to meet or exceed customer requirements. These systems are often developed in conjunction with other business and engineering disciplines using a cross-functional approach.

Key Points:

1. Early efforts to control the quality of production

When the first specialized craftsmen started manufacturing tools and materials for others to purchase and use, the principle of quality was simple: "let the buyer beware" (caveat emptor). Early civil engineering projects needed to be built from specifications, for example the four sides of the base of the Great Pyramid of Giza were required to be perpendicular to within 3.5 arcseconds.

During the middle Ages, guilds adopted responsibility for quality control of their members, setting and maintaining certain standards for guild membership.

Royal governments purchasing material were interested in quality control as customers. For this reason, King John of England appointed William Wrotham to report about the construction and repair of ships. Centuries later, Samuel Pepys, Secretary to the British Admiralty, appointed multiple such overseers.

Prior to the extensive division of labor and mechanization resulting from the Industrial Revolution, it was possible for workers to control the quality of their own products. Working conditions then were arguably more conducive to professional pride.

The Industrial Revolution led to a system in which large groups of people performing a similar type of work were grouped together under the supervision of a foreman who was appointed to control the quality of work manufactured.

1.1 Wartime production

Around the time of World War I, manufacturing processes typically became more complex with larger numbers of workers being supervised. This period saw the widespread introduction of mass production and piecework, which created problems as workmen could now earn more money by the production of extra products, which in turn led to bad workmanship being passed on to the assembly lines.

To counter bad workmanship, full time inspectors were introduced into the factory to identify quarantine and ideally correct product quality failures. Quality control by inspection in the 1920s and 1930s led to the growth of quality inspection functions, separately organised from production and big enough to be headed by superintendents.

The systematic approach to quality started in industrial manufacture during the 1930s, mostly in the USA, when some attention was given to the cost of scrap and rework. With the impact of mass production, which was required during the Second World War, it became necessary to introduce a more appropriate form of quality control which can be identified as Statistical

Quality Control, or SQC. Some of the initial work for SQC is credited to Walter A. Shewhart of Bell Labs, starting with his famous one-page memorandum of 1924.

SQC came about with the realization that quality cannot be fully inspected into an important batch of items. By extending the inspection phase and making inspection organizations more efficient, it provides inspectors with control tools such as sampling and control charts, even where 100 per cent inspection is not practicable. Standard statistical techniques allow the producer to sample and test a certain proportion of the products for quality to achieve the desired level of confidence in the quality of the entire batch or production run.

1.2 Postwar

In the period following World War II, many countries' manufacturing capabilities that had been destroyed during the war were rebuilt. The U.S. sent General Douglas MacArthur to oversee the re-building of Japan. During this time, General MacArthur involved two key individuals in the development of modern quality concepts: W. Edwards Deming and Joseph Juran. Both individuals promoted the collaborative concepts of quality to Japanese business and technical groups, and these groups utilized these concepts in the redevelopment of the Japanese economy.

Although there were many individuals trying to lead United States industries towards a more comprehensive approach to quality, the U.S. continued to apply the QC concepts of inspection and sampling to remove defective product from production lines, essentially ignoring advances in QA for decades.

3. Quality control

3.1 Quality assurance

Quality assurance covers all activities from design, development, production, installation, servicing and documentation. This introduced the rules: "fit for purpose" and "do it right the first time". It includes the regulation of the quality of raw materials, assemblies,

products and components; services related to production; and management, production, and inspection processes.

One of the most widely used paradigms for QA management is the PDCA (Plan-Do-Check-Act) approach, also known as the Shewhart cycle.

3.2 Failure testing

A valuable process to perform on a whole consumer product is failure testing (also known as stress testing), the operation of a product until it fails, often under stresses such as increasing vibration, temperature and humidity. This exposes many unanticipated weaknesses in a product, and the data is used to drive engineering and manufacturing process improvements. Often quite simple changes can dramatically improve product service, such as changing to mold-resistant paint or adding lock washer placement to the training for new assembly personnel. Failure testing or destructive testing is a valuable tool of earthquake engineering.

3.3 Statistical control

Many organizations use statistical process control to bring the organization to Six Sigma levels of quality, in other words, so that the likelihood of an unexpected failure is confined to six standard deviations on the normal distribution. This probability is less than four one-millionths. Items controlled often include clerical tasks such as order-entry as well as conventional manufacturing tasks.

Traditional statistical process controls in manufacturing operations usually proceed by randomly sampling and testing a fraction of the output. Variances of critical tolerances

are continuously tracked, and manufacturing processes are corrected before bad parts can be produced.

3.4 Company quality

During the 1980s, the concept of company quality with the focus on management and people came to the fore. It was realized that, if all departments approached quality with an open mind, success was possible if the management led the quality improvement process.

The company-wide quality approach places an emphasis on three aspects –

- Elements such as controls, job management, adequate processes, performance and integrity criteria and identification of records
- Competence such as knowledge, skills, experience, qualifications
- Soft elements, such as personnel integrity, confidence, organizational culture, motivation, team spirit and quality relationships.

The quality of the outputs is at risk if any of these three aspects is deficient in any way.

The approach to quality management given here is therefore not limited to the manufacturing theatre only but can be applied to any business activity:

- Design work
- Administrative services
- Consulting
- Banking
- Insurance
- Computer software

- Retailing
- Transportation

It comprises a quality improvement process, which is generic in the sense it can be applied to any of these activities and it establishes a behaviour pattern, which supports the achievement of quality.

This in turn is supported by quality management practices which can include a number of business systems and which are usually specific to the activities of the business unit concerned.

In manufacturing and construction activities, these business practices can be equated to the models for quality assurance defined by the International Standards contained in the ISO 9000 series and the specified Specifications for quality systems.

Still, in the system of Company Quality, the work being carried out was shop floor inspection which did not control the major quality problems. This led to quality assurance or total quality control, which has come into being recently.

3.5 Total quality control

Total Quality Control is the most necessary inspection control of all in cases where, despite statistical quality control techniques or quality improvements implemented, sales decrease.

The major problem which leads to a decrease in sales was that the specifications did not include the most important factor, What the customer required.

The major characteristics, ignored during the search to improve manufacture and overall business performance were:

- Reliability
- Maintainability
- Safety

As the most important factor had been ignored, a few refinements had to be introduced:

- Marketing had to carry out their work properly and define the customers specifications.
- Specifications had to be defined to conform to these requirements.
- Conformance to specifications i.e. drawings, standards and other relevant documents, were introduced during manufacturing, planning and control.
- Management had to confirm all operators are equal to the work imposed on them and holidays, celebrations and disputes did not affect any of the quality levels.
- Inspections and tests were carried out, and all components and materials, bought in or otherwise, conformed to the specifications, and the measuring equipment was accurate, this is the responsibility of the QA/QC department.
- Any complaints received from the customers were satisfactorily dealt with in a timely manner.
- Feedback from the user/customer is used to review designs.
- Consistent data recording and assessment and documentation integrity.
- Product and/or process change management and notification.

If the original specification does not reflect the correct quality requirements, quality cannot be inspected or manufactured into the product.

For instance, all parameters for a pressure vessel should include not only the material and dimensions but operating, environmental, safety, reliability and maintainability requirements.

To conclude, the above forms the basis from which the philosophy of Quality Assurance has evolved, and the achievement of quality or the fitness-for-purpose is Quality Awareness throughout the company.

: Statistical Methods And Probability Concepts

Topic Objective:

At the end of this topic student would be able to:

- Learn about the the basic steps of an experiment are;
- Learn about the Statistical Methods
- Learn about the Statistica analysis
- Experimental and observational studies

Definition/Overview:

Statistical Methods: Statistics is a mathematical science pertaining to the collection, analysis, interpretation or explanation, and presentation of data. It also provides tools for prediction and forecasting based on data. It is applicable to a wide variety of academic disciplines, from the natural and social sciences to the humanities, government and business.

Statistical methods can be used to summarize or describe a collection of data; this is called descriptive statistics. In addition, patterns in the data may be modeled in a way that accounts for randomness and uncertainty in the observations, and are then used to draw inferences about the process or population being studied; this is called inferential statistics. Descriptive, predictive, and inferential statistics comprise applied statistics.

There is also a discipline called mathematical statistics, which is concerned with the theoretical basis of the subject. Moreover, there is a branch of statistics called exact statistics that is based on exact probability statements.

The word statistics can either be singular or plural. In its singular form, statistics refers to the mathematical science discussed in this article. In its plural form, statistics is the plural of the word statistic, which refers to a quantity (such as a mean) calculated from a set of data.

Key Points:

1. Analysis

In applying statistics to a scientific, industrial, or societal problem, it is necessary to begin with a process or population to be studied. This might be a population of people in a country, of crystal grains in a rock, or of goods manufactured by a particular factory during a given period. It may instead be a process observed at various times; data collected about this kind of "population" constitute what is called a time series.

For practical reasons, rather than compiling data about an entire population, a chosen subset of the population, called a sample, is studied. Data are collected about the sample in an observational or experimental setting. The data are then subjected to statistical analysis, which serves two related purposes: description and inference.

- Descriptive statistics can be used to summarize the data, either numerically or graphically, to describe the sample. Basic examples of numerical descriptors include the mean and standard deviation.

- Graphical summarizations include various kinds of charts and graphs. Inferential statistics is used to model patterns in the data, accounting for randomness and drawing inferences about the larger population. These inferences may take the form of answers to yes/no questions (hypothesis testing), estimates of numerical characteristics (estimation), descriptions of association (correlation), or modeling of relationships (regression). Other modeling techniques include ANOVA, time series, and data mining.

The concept of correlation is particularly noteworthy. Statistical analysis of a data set may reveal that two variables (that is, two properties of the population under consideration) tend to vary together, as if they are connected. For example, a study of annual income and age of death among people might find that poor people tend to have shorter lives than affluent people. The two variables are said to be correlated (which is a positive correlation in this case). However, one cannot immediately infer the existence of a causal relationship between the two variables. The correlated phenomena could be caused by a third, previously unconsidered phenomenon, called a lurking variable or confounding variable.

If the sample is representative of the population, then inferences and conclusions made from the sample can be extended to the population as a whole. A major problem lies in determining the extent to which the chosen sample is representative. Statistics offers methods to estimate and correct for randomness in the sample and in the data collection procedure, as well as methods for designing robust experiments in the first place

1.1 Experimental and observational studies

A common goal for a statistical research project is to investigate causality, and in particular to draw a conclusion on the effect of changes in the values of predictors or independent variables or dependent variables on response. There are two major types of causal statistical studies: experimental studies and observational studies. In both types of studies, the effect of differences of an independent variable (or variables) on the behavior of the dependent variable are observed. The difference between the two types lies in how the study is actually conducted. Each can be very effective.

An experimental study involves taking measurements of the system under study, manipulating the system, and then taking additional measurements using the same procedure to determine if the manipulation has modified the values of the measurements. In contrast, an observational study does not involve experimental manipulation. Instead, data are gathered and correlations between predictors and response are investigated.

An example of an experimental study is the famous Hawthorne studies, which attempted to test the changes to the working environment at the Hawthorne plant of the Western Electric Company. The researchers were interested in determining whether increased illumination would increase the productivity of the assembly line workers. The researchers first measured the productivity in the plant, then modified the illumination in an area of the plant and checked if the changes in illumination affected the productivity. It turned out that the productivity indeed improved (under the experimental conditions). However, the study is heavily criticized today for errors in experimental procedures, specifically for the lack of a control group and blindness.

An example of an observational study is a study which explores the correlation between smoking and lung cancer. This type of study typically uses a survey to collect observations about the area of interest and then performs statistical analysis. In this case, the researchers would collect observations of both smokers and non-smokers, perhaps through a case-control study, and then look for the number of cases of lung cancer in each group.

1.2 The basic steps of an experiment are;

- Planning the research, including determining information sources, research subject selection, and ethical considerations for the proposed research and method.
- Design of experiments, concentrating on the system model and the interaction of independent and dependent variables.

- Summarizing a collection of observations to feature their commonality by suppressing details. (Descriptive statistics)
- Reaching consensus about what the observations tell about the world being observed. (Statistical inference)
- Documenting / presenting the results of the study.

In Section 2 of this course you will cover these topics: Statistical Process Control
You may take as much time as you want to complete the topic coverd in section 2. There is no time limit to finish any Section, However you must finish All Sections before semester end date.
If you want to c ontinue remaining courses later, you may save the course and leave. You can continue later as per your convenience and this course will be avalible in your area to save and continue later.

: Statistical Process Control

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Statistical Process Control
- Learn about the Statistical Process Control history

Definition/Overview:

Statistical Process Control: (SPC) is an effective method of monitoring a process through the use of control charts. Control charts enable the use of objective criteria for distinguishing

background variation from events of significance based on statistical techniques. Much of its power lies in the ability to monitor both process center and its variation about that center. By collecting data from samples at various points within the process, variations in the process that may affect the quality of the end product or service can be detected and corrected, thus reducing waste as well as the likelihood that problems will be passed on to the customer. With its emphasis on early detection and prevention of problems, SPC has a distinct advantage over quality methods, such as inspection, that apply resources to detecting and correcting problems in the end product or service.

In addition to reducing waste, SPC can lead to a reduction in the time required to produce the product or service from end to end. This is partially due to a diminished likelihood that the final product will have to be reworked, but it may also result from using SPC data to identify bottlenecks, wait times, and other sources of delays within the process. Process cycle time reductions coupled with improvements in yield have made SPC a valuable tool from both a cost reduction and a customer satisfaction standpoint.

Statistical process control (SPC) involves using statistical techniques to measure and analyze the variation in processes. Most often used for manufacturing processes, the intent of SPC is to monitor product quality and maintain processes to fixed targets. Statistical quality control refers to using statistical techniques for measuring and improving the quality of processes and includes SPC in addition to other techniques, such as sampling plans, experimental design, variation reduction, process capability analysis, and process improvement plans.

SPC is used to monitor the consistency of processes used to manufacture a product as designed. It aims to get and keep processes under control. No matter how good or bad the design, SPC can ensure that the product is being manufactured as designed and intended. Thus, SPC will not improve a poorly designed product's reliability, but can be used to maintain the consistency of how the product is made and, therefore, of the manufactured product itself and its as-designed reliability.

A primary tool used for SPC is the control chart, a graphical representation of certain descriptive statistics for specific quantitative measurements of the manufacturing process. These descriptive statistics are displayed in the control chart in comparison to their "in-control" sampling distributions. The comparison detects any unusual variation in the manufacturing process, which could indicate a problem with the process. Several different descriptive statistics can be used in control charts and there are several different types of control charts that can test for different causes, such as how quickly major vs. minor shifts in process means are detected. Control charts are also used with product measurements to analyze process capability and for continuous process improvement efforts.

Key Points:

1. History

Statistical Process Control was pioneered by Walter A. Shewhart in the early 1920s. W. Edwards Deming later applied SPC methods in the United States during World War II, thereby successfully improving quality in the manufacture of munitions and other strategically important products. Deming was also instrumental in introducing SPC methods to Japanese industry after the war had ended.

Shewhart created the basis for the control chart and the concept of a state of statistical control by carefully designed experiments. While Dr. Shewhart drew from pure mathematical statistical theories, he understood that data from physical processes seldom produces a "normal distribution curve" (a Gaussian distribution, also commonly referred to as a "bell curve"). He discovered that observed variation in manufacturing data did not always behave the same way as data in nature (for example, Brownian motion of particles). Dr. Shewhart concluded that while every process displays variation, some processes display controlled variation that is natural to the process (common causes of variation), while others display uncontrolled variation that is not present in the process causal system at all times (special causes of variation).

In 1989, the Software Engineering Institute introduced the notion that SPC can be usefully applied to non-manufacturing processes, such as software engineering processes, in the Capability Maturity Model (CMM). This idea exists today within the Level 4 and Level 5 practices of the Capability Maturity Model Integrated (CMMI). This notion that SPC is a useful tool when applied to non-repetitive, knowledge-intensive processes such as engineering processes has encountered much skepticism, and remains controversial today.

The following description relates to manufacturing rather than to the service industry, although the principles of SPC can be successfully applied to either. For a description and example of how SPC applies to a service environment, refer to Roberts (2005). SPC has also been successfully applied to detecting changes in organizational behavior with Social Network Change Detection introduced by McCulloh (2007).

In mass-manufacturing, the quality of the finished article was traditionally achieved through post-manufacturing inspection of the product; accepting or rejecting each article (or samples from a production lot) based on how well it met its design specifications. In contrast, Statistical Process Control uses statistical tools to observe the performance of the production process in order to predict significant deviations that may later result in rejected product.

Two kinds of variation occur in all manufacturing processes: both these types of process variation cause subsequent variation in the final product. The first is known as natural or common cause variation and may be variation in temperature, properties of raw materials, strength of an electrical current etc. This variation is small, the observed values generally being quite close to the average value. The pattern of variation will be similar to those found in nature, and the distribution forms the bell-shaped normal distribution curve. The second kind of variation is known as special cause variation, and happens less frequently than the first.

For example, a breakfast cereal packaging line may be designed to fill each cereal box with 500 grams of product, but some boxes will have slightly more than 500 grams, and some will have slightly less, in accordance with a distribution of net weights. If the production process, its inputs, or its environment changes (for example, the machines doing the manufacture begin to wear) this distribution can change. For example, as its cams and pulleys wear out, the cereal filling machine may start putting more cereal into each box than specified. If this change is allowed to continue unchecked, more and more product will be produced that fall outside the

tolerances of the manufacturer or consumer, resulting in waste. While in this case, the waste is in the form of "free" product for the consumer, typically waste consists of rework or scrap.
By observing at the right time what happened in the process that led to a change, the quality engineer or any member of the team responsible for the production line can troubleshoot the root cause of the variation that has crept in to the process and correct the problem. SPC indicates when an action should be taken in a process, but it also indicates when NO action should be taken. An example is a person who would like to maintain a constant body weight and takes weight measurements weekly. A person who does not understand SPC concepts might start dieting every time his or her weight increased, or eat more every time his or her weight decreased. This type of action could be harmful and possibly generate even more variation in body weight. SPC would account for normal weight variation and better indicate when the person is in fact gaining or losing weight.

In Section 3 of this course you will cover these topics: Shewhart Control Charts
You may take as much time as you want to complete the topic coverd in section 3. There is no time limit to finish any Section, However you must finish All Sections before semester end date.
If you want to c ontinue remaining courses later, you may save the course and leave. You can continue later as per your convenience and this course will be avalible in your area to save and continue later.

: Shewhart Control Charts

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Overview of chart indicates
- Learn about the control chart
- Learn about the Chart usage

Definition/Overview:

The control chart: also known as the Shewhart chart or process-behaviour chart, in statistical process control is a tool used to determine whether a manufacturing or business process is in a state of statistical control or not.

Key Points:

1. Overview

If the chart indicates that the process is currently under control then it can be used with confidence to predict the future performance of the process. If the chart indicates that the process being monitored is not in control, the pattern it reveals can help determine the source of variation to be eliminated to bring the process back into control. A control chart is a specific kind of run chart that allows significant change to be differentiated from the natural variability of the process. This is key to effective process control and improvement. On a practical level the control chart can be seen as part of an objective disciplined approach that facilitates the decision as to whether process performance warrants attention or not.

The control chart is one of the seven basic tools of quality control (along with the histogram, Pareto chart, check sheet, cause-and-effect diagram, flowchart, and scatter diagram).

1. 1 History

The control chart was invented by Walter A. Shewhart while working for Bell Labs in the 1920s. The company's engineers had been seeking to improve the reliability of their telephony transmission systems. Because amplifiers and other equipment had to be buried underground, there was a business need to reduce the frequency of failures and repairs. By 1920 they had already realized the importance of reducing variation in a

manufacturing process. Moreover, they had realized that continual process-adjustment in reaction to non-conformance actually increased variation and degraded quality. Shewhart framed the problem in terms of Common- and special-causes of variation and, on May 16, 1924, wrote an internal memo introducing the control chart as a tool for distinguishing between the two. Dr. Shewhart's boss, George Edwards, recalled: "Dr. Shewhart prepared a little memorandum only about a page in length. About a third of that page was given over to a simple diagram which we would all recognize today as a schematic control chart. That diagram, and the short text which preceded and followed it, set forth all of the essential principles and considerations which are involved in what we know today as process quality control." Shewhart stressed that bringing a production process into a state of statistical control, where there is only common-cause variation, and keeping it in control, is necessary to predict future output and to manage a process economically.

Dr. Shewhart created the basis for the control chart and the concept of a state of statistical control by carefully designed experiments. While Dr. Shewhart drew from pure mathematical statistical theories, he understood data from physical processes never produce a "normal distribution curve" (a Gaussian distribution, also commonly referred to as a "bell curve"). He discovered that observed variation in manufacturing data did not always behave the same way as data in nature (Brownian motion of particles). Dr. Shewhart concluded that while every process displays variation, some processes display controlled variation that is natural to the process, while others display uncontrolled variation that is not present in the process causal system at all times.

In 1924 or 1925, Shewhart's innovation came to the attention of W. Edwards Deming, then working at the Hawthorne facility. Deming later worked at the United States Department of Agriculture and then became the mathematical advisor to the United States Census Bureau. Over the next half a century, Deming became the foremost champion and proponent of Shewhart's work. After the defeat of Japan at the close of World War II, Deming served as statistical consultant to the Supreme Commander of the Allied Powers. His ensuing involvement in Japanese life, and long career as an industrial

consultant there, spread Shewhart's thinking, and the use of the control chart, widely in Japanese manufacturing industry throughout the 1950s and 1960s.

More recent use and development of control charts in the Shewhart-Deming tradition has been championed by Donald J. Wheeler.

1.2 Chart Details

- A control chart consists of the following:
- Points representing measurements of a quality characteristic in samples taken from the process at different times
- A centre line, drawn at the process characteristic mean which is calculated from the data
- Upper and lower control limits (sometimes called "natural process limits") that indicate the threshold at which the process output is considered statistically 'unlikely'
- The chart may contain other optional features, including:
- Upper and lower warning limits, drawn as separate lines, typically two standard deviations above and below the centre line
- Division into zones, with the addition of rules governing frequencies of observations in each zone
- Annotation with events of interest, as determined by the Quality Engineer in charge of the process's quality
- However in the early stages of use the inclusion of these items may confuse inexperienced chart interpreters.

1.3 Chart usage

If the process is in control, all points will plot within the control limits. Any observations outside the limits, or systematic patterns within, suggest the introduction of a new (and likely unanticipated) source of variation, known as a special-cause variation. Since

increased variation means increased quality costs, a control chart "signaling" the presence of a special-cause requires immediate investigation.

This makes the control limits very important decision aids. The control limits tell you about process behaviour and have no intrinsic relationship to any specification targets or engineering tolerance. In practice, the process mean (and hence the centre line) may not coincide with the specified value (or target) of the quality characteristic because the process' design simply can't deliver the process characteristic at the desired level.

Control charts omit specification limits or targets because of the tendency of those involved with the process (e.g., machine operators) to focus on performing to specification when in fact the least-cost course of action is to keep process variation as low as possible. Attempting to make a process whose natural centre is not the same as the target perform to target specification increases process variability and increases costs significantly and is the cause of much inefficiency in operations. Process capability studies do examine the relationship between the natural process limits (the control limits) and specifications, however.

The purpose of control charts is to allow simple detection of events that are indicative of actual process change. This simple decision can be difficult where the process characteristic is continuously varying; the control chart provides statistically objective criteria of change. When change is detected and considered good its cause should be identified and possibly become the new way of working, where the change is bad then its cause should be identified and eliminated.

The purpose in adding warning limits or subdividing the control chart into zones is to provide early notification if something is amiss. Instead of immediately launching a process improvement effort to determine whether special causes are present, the Quality Engineer may temporarily increase the rate at which samples are taken from the process output until it's clear that the process is truly in control. Note that with three sigma limits, one expects to be signaled approximately once out of every 370 points on average, just due to common-causes.

In Section 4 of this course you will cover these topics: Process Capability Assessment
You may take as much time as you want to complete the topic coverd in section 4. There is no time limit to finish any Section, However you must finish All Sections before semester end date.
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: Process Capability Assessment

Topic Objective:

At the end of this topic student would be able to:

- Learn about the process
- Learn about the Process capability
- Learn about the wartime production
- Learn about Measuring the Process

Definition/Overview:

A process: is a unique combination of tools, materials, methods, and people engaged in producing a measurable output; for example a manufacturing line for machine parts. All processes have inherent statistical variability which can be evaluated by statistical methods. The Process Capability is a measurable property of a process to the specification, expressed as a process capability index (e.g., Cpk or Cpm) or as a process performance index (e.g., Ppk or Ppm). The output of this measurement is usually illustrated by a histogram and calculations that predict how many parts will be produced out of specification.

Process capability: is also defined as the capability of a process to meet its purpose as managed by an organization's management and process definition structures ISO 15504.

Two parts of process capability are: 1) Measure the variability of a process, and 2) Compare that variability with a proposed specification or product tolerance.

Key Points:

1. Measure the Process

The input of a process usually has at least one or more measurable characteristics that are used to specify outputs. These can be analyzed statistically, where the output data shows a normal distribution the process can be described by the process mean (average) and the standard deviation.

A process needs to be established with appropriate process controls in place. A control chart analysis is used to determine whether the process is "in statistical control". If the process is not in statistical control then capability has no meaning. Therefore the process capability involves only special cause variation and not common cause variation.

A batch of data needs to be obtained from the measured output of the process. The more data that is included the more precise the result, however an estimate can be achieved with as few as 17 data points. This should include the normal variety of production conditions, materials, and people in the process. With a manufactured product, it is common to include at least three different production runs, including start-ups.

The process mean (average) and standard deviation are calculated. With a normal distribution, the "tails" can extend well beyond plus and minus three standard deviations, but this interval should contain about 99.73% of production output. Therefore for a normal distribution of data the process capability is often described as the relationship between six standard deviations and the required specification.

The input of a process is expected to meet customer requirements, specifications, or product tolerances. Engineering can conduct a process capability study to determine the extent to which the process can meet these expectations.

The ability of a process to meet specifications can be expressed as a single number using a process capability index or it can be assessed using control charts. Either case requires running the process to obtain enough measurable output so that engineering is confident that the process is stable and so that the process mean and variability can be reliably estimated. Statistical process control defines techniques to properly differentiate between stable processes, processes that are drifting (experiencing a long-term change in the mean of the output), and processes that are growing more variable. Process capability indices are only meaningful for processes that are stable (in a state of statistical control).

For Information Technology, ISO 15504 specifies a process capability measurement framework for assessing process capability. This measurement framework consists of 5.5+0.5 levels of process capability from none (Capability Level 0) to optimizing processes (CL 5). The measurement framework has been generalized so that it can be applied to non IT processes. There are currently two process reference models covering software and systems. The Capability Maturity Model in its latest version (CMMI continuous) also follows this approach.

- In Section 5 of this course you will cover these topics:
  - Design And Improvement

- You may take as much time as you want to complete the topic coverd in section 5. There is no time limit to finish any Section, However you must finish All Sections before semester end date.

- If you want to c ontinue remaining courses later, you may save the course and leave. You can continue later as per your convenience and this course will be avalible in your area to save and continue later.

: Design And Improvement

Topic Objective:

At the end of this topic student would be able to:

- Learn about the organizational development and Improvement

Definition/Overview:

Organizational development and Improvement: In organizational development (OD), Process improvement is a series of actions taken to identify, analyze and improve existing processes within an organization to meet new goals and objectives.

Key Points:

1. Overview

In organizational development (OD), Process improvement is a series of actions taken to identify, analyze and improve existing processes within an organization to meet new goals and objectives. These actions often follow a specific methodology or strategy to create successful results. Samplings of these are listed below.

These actions often follow a specific methodology or strategy to create successful results.

Samplings of these are listed below.

- Benchmarking
- Business Process Improvement
- Business process reengineering
- Capability Maturity Model Integration/Capability Maturity Model
- Goal-Question-Metric
- Hoshin Kanri
- ISO 9000
- Just In Time manufacturing
- Lean manufacturing

- Performance improvement
- Process management
- Process Improvement and Management (PI&M)
- Six Sigma
- Theory of Constraints
- Total Quality Management
- Trillium Model

Twelve leverage points

At the core of OD is the concept of organization, defined as two or more people working together toward one or more shared goals. Development in this context is the notion that an organization may become more effective over time at achieving its goals.

OD is a long range effort to improve organization's problem solving and renewal processes, particularly through more effective and collaborative management of organizational culture, often with the assistance of a change agent or catalyst and the use of the theory and technology of applied behavioral science.

Organization development is a contractual relationship between a change agent and a sponsoring organization entered into for the purpose of using applied behavioral science in a systems context to improve organizational performance and the capacity of the organization to improve itself.

Contractual Relationship. Although neither the sponsoring organization nor the change agent can be sure at the outset of the exact nature of the problem or problems to be dealt with or how long the change agents' help will be needed, it is essential that some tentative agreement on these matters be reached. The sponsoring organization needs to know generally what the change agent's preliminary plan is, what its own commitments are in relation to personal commitments

and responsibility for the program, and what the change agent's fee will be. The change agent must assure himself that the organization's, and particularly the top executives', commitment to change is strong enough to support the kind of self-analysis and personal involvement requisite to success of the program. Recognizing the uncertainties lying ahead on both sides, a termination agreement permitting either side to withdraw at any time is usually included.

Change Agent. A change agent in the sense used here is not a technical expert skilled in such functional areas as accounting, production, or finance. He is a behavioral scientist who knows how to get people in an organization involved in solving their own problems. His main strength is a comprehensive knowledge of human behavior, supported by a number of intervention techniques (to be discussed later). The change agent can be either external or internal to the organization. An internal change agent is usually a staff person who has expertise in the behavioral sciences and in the intervention technology of OD. Beckhard reports several cases in which line people have been trained in OD and have returned to their organizations to engage in successful change assignments. In the natural evolution of change mechanisms in organizations, this would seem to approach the ideal arrangement. Qualified change agents can be found on some university faculties, or they may be private consultants associated with such organizations as the National Training Laboratories Institute for Applied Behavioral Science (Washington, D.C.) or University Associates (San Diego, California), and similar organizations.

The change agent may be a staff or line member of the organization who is schooled in OD theory and technique. In such a case, the "contractual relationship" is an in-house agreement that should probably be explicit with respect to all of the conditions involved except the fee.

Sponsoring Organization. The initiative for OD programs comes from an organization that has a problem. This means that top management or someone authorized by top management is aware that a problem exists and has decided to seek help in solving it. There is a direct analogy here to the practice of psychotherapy: The client or patient must actively seek help in finding a solution

to his problems. This indicates a willingness on the part of the client organization to accept help and assures the organization that management is actively concerned.

Applied Behavioral Science. One of the outstanding characteristics of OD that distinguishes it from most other improvement programs is that it is based on a "helping relationship." The change agent is not a physician to the organization's ills; he does not examine the "patient," make a diagnosis, and write a prescription. Nor does he try to teach organizational members a new inventory of knowledge which they then transfer to the job situation. Using theory and methods drawn from such behavioral sciences as [(industrial/organizational psychology]], industrial sociology, communication, cultural anthropology, administrative theory, organizational behavior, economics, and political science, the change agent's main function is to help the organization define and solve its own problems. The basic method used is known as action research. This approach, which is described in detail later, consists of a preliminary diagnosis, collecting data, feedback of the data to the client, data exploration by the client group, action planning based on the data, and taking action.

Systems Context. OD deals with a total system the organization as a whole, including its relevant environment or with a subsystem or systems departments or work groups in the context of the total system. Parts of systems, for example, individuals, cliques, structures, norms, values, and products are not considered in isolation; the principle of interdependency, that is, that change in one part of a system affects the other parts, is fully recognized. Thus, OD interventions focus on the total culture and cultural processes of organizations. The focus is also on groups, since the relevant behavior of individuals in organizations and groups is generally a product of group influences rather than personality.

Improved Organizational Performance. The objective of OD is to improve the organization's capacity to handle its internal and external functioning and relationships. This would include such things as improved interpersonal and group processes, more effective communication,

enhanced ability to cope with organizational problems of all kinds, more effective decision processes, more appropriate leadership style, improved skill in dealing with destructive conflict, and higher levels of trust and cooperation among organizational members. These objectives stem from a value system based on an optimistic view of the nature of man that man in a supportive environment is capable of achieving higher levels of development and accomplishment. Also essential to organization development and effectiveness is the scientific method inquiry, a rigorous search for causes, experimental testing of hypotheses, and review of results. Finally, the democratic process is viewed as having a legitimate, and perhaps dominant, role in the highly effective organization.

Organizational Self-Renewal. The ultimate aim of the outside OD practitioner is to "work himself out of a job" by leaving the client organization with a set of tools, behaviors, attitudes, and an action plan with which to monitor its own state of health and to take corrective steps toward its own renewal and development. This is consistent with the systems concept of feedback as a regulatory and corrective mechanism.

2. History

2.1 Early development

Kurt Lewin played a key role in the evolution of organization development as it is known today. As early as World War II, Lewin experimented with a collaborative change process (involving himself as consultant and a client group) based on a three-step process of planning, taking action, and measuring results. This was the forerunner of action research, an important element of OD, which will be discussed later. Lewin then participated in the beginnings of laboratory training, or T-groups, and, after his death in 1947, his close associates helped to develop survey-research methods at the University of Michigan. These procedures became important parts of OD as developments in this field continued at the National Training Laboratories and in growing numbers of universities and private consulting firms across the country.

The failure of off-site laboratory training to live up to its early promise was one of the important forces stimulating the development of OD. Laboratory training is learning from a person's "here and now" experience as a member of an ongoing training group. Such groups usually meet without a specific agenda. Their purpose is for the members to learn about themselves from their spontaneous "here and now" responses to an ambiguous hypothetical situation. Problems of leadership, structure, status, communication, and self-serving behavior typically arise in such a group. The members have an opportunity to learn something about themselves and to practice such skills as listening, observing others, and functioning as effective group members.

As formerly practiced (and occasionally still practiced for special purposes), laboratory training was conducted in "stranger groups," or groups composed of individuals from different organizations, situations, and backgrounds. A major difficulty developed, however, in transferring knowledge gained from these "stranger labs" to the actual situation "back home". This required a transfer between two different cultures, the relatively safe and protected environment of the T-group (or training group) and the give-and-take of the organizational environment with its traditional values. This led the early pioneers in this type of learning to begin to apply it to "family groups" that is, groups located within an organization. From this shift in the locale of the training site and the realization that culture was an important factor in influencing group members (along with some other developments in the behavioral sciences) emerged the concept of organization development.

3. Modern development

In recent years, serious questioning has emerged about the relevance of OD to managing change in modern organizations. The need for "reinventing" the field has become a topic that even some of its "founding fathers" are discussing critically.

With this call for reinvention and change, scholars have begun to examine organizational development from an emotion-based standpoint. For example, deKlerk (2007) writes about how emotional trauma can negatively affect performance. Due to downsizing, outsourcing, mergers, restructuring, continual changes, invasions of privacy, harassment, and abuses of power, many employees experience the emotions of aggression, anxiety, apprehension, cynicism, and fear, which can lead to performance decreases. deKlerk (2007) suggests that in order to heal the trauma and increase performance, O.D. practitioners must acknowledge the existence of the trauma, provide a safe place for employees to discuss their feelings, symbolize the trauma and put it into perspective, and then allow for and deal with the emotional responses. One method of achieving this is by having employees draw pictures of what they feel about the situation, and then having them explain their drawings with each other. Drawing pictures is beneficial because it allows employees to express emotions they normally would not be able to put into words. Also, drawings often prompt active participation in the activity, as everyone is required to draw a picture and then discuss its meaning.

4. Action research

Wendell L French and Cecil Bell define organization development (OD) at one point as "organization improvement through action research". If one idea can be said to summarize OD's underlying philosophy, it would be action research as it was conceptualized by Kurt Lewin and later elaborated and expanded on by other behavioral scientists. Concerned with social change and, more particularly, with effective, permanent social change, Lewin believed that the motivation to change was strongly related to action: If people are active in decisions affecting them, they are more likely to adopt new ways. "Rational social management", he said, "proceeds in a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of action".

Lewin's description of the process of change involves three steps:

Unfreezing: Faced with a dilemma or disconfirmation, the individual or group becomes aware of a need to change.

Changing: The situation is diagnosed and new models of behavior are explored and tested.

Refreezing: Application of new behavior is evaluated, and if reinforcing, adopted.

Action research is depicted as a cyclical process of change. The cycle begins with a series of planning actions initiated by the client and the change agent working together. The principal elements of this stage include a preliminary diagnosis, data gathering, feedback of results, and joint action planning. In the language of systems theory, this is the input phase, in which the client system becomes aware of problems as yet unidentified, realizes it may need outside help to effect changes, and shares with the consultant the process of problem diagnosis.

The second stage of action research is the action, or transformation, phase. This stage includes actions relating to learning processes (perhaps in the form of role analysis) and to planning and executing behavioral changes in the client organization. Included in this stage is action-planning activity carried out jointly by the consultant and members of the client system. Following the workshop or learning sessions, these action steps are carried out on the job as part of the transformation stage.

The third stage of action research is the output, or results, phase. This stage includes actual changes in behavior (if any) resulting from corrective action steps taken following the second stage. Data are again gathered from the client system so that progress can be determined and necessary adjustments in learning activities can be made. Minor adjustments of this nature can be

made in learning activities via Feedback Loop B. Major adjustments and reevaluations would return the OD project to the first, or planning, stage for basic changes in the program. The action-research model shown in The action stage is a period of changing, that is, trying out new forms of behavior in an effort to understand and cope with the system's problems. (There is inevitable overlap between the stages, since the boundaries are not clear-cut and cannot be in a continuous process). The results stage is a period of refreezing, in which new behaviors are tried out on the job and, if successful and reinforcing, become a part of the system's repertoire of problem-solving behavior.

Action research is problem centered, client centered, and action oriented. It involves the client system in a diagnostic, active-learning, problem-finding, and problem-solving process. Data are not simply returned in the form of a written report but instead are fed back in open joint sessions, and the client and the change agent collaborate in identifying and ranking specific problems, in devising methods for finding their real causes, and in developing plans for coping with them realistically and practically. Scientific method in the form of data gathering, forming hypotheses, testing hypotheses, and measuring results, although not pursued as rigorously as in the laboratory, is nevertheless an integral part of the process. Action research also sets in motion a long-range, cyclical, self-correcting mechanism for maintaining and enhancing the effectiveness of the client's system by leaving the system with practical and useful tools for self-analysis and self-renewal.