K.L.N. College of Engineering (An Autonomous Institution)
Pottapalayam, Sivagangai
20HS7A2 TOTAL QUALITY MANAGEMENT

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UNIT III TQM TOOLS AND TECHNIQUES I

Traditional tools of quality, New management tools, Six sigma: Concepts, Methodology, applications to manufacturing, service sector including IT, Bench marking, Reason to bench mark, Bench marking process - FMEA - Stages, Types.

UNIT III

Seven statistical tools

- **Seven QC tools**
- Data collection sheet (Check sheet)
- Histogram
- Cause and effect diagram
- Pareto diagram
- Scatter Diagram
- Stratification Analysis
- Control chart

Introduction

Japanese believe that

- Employees are little scientists.
- Employees know how to apply the basic tools of science.
- Statistical method taught by U.S. experts was too sophisticated too hard to understand.
- People started thinking that the statistical method was a very difficult thing and that therefore Quality control was also something difficult to implement.

To teach SQC two different approaches followed.

- Teach simpler statistical method to everyone from top management to line workers. (7 statistical tools)
- Teach the sophisticated statistical methods to engineers end quality control specialists.

Advantage

- Simplification gave rise to statistical thinking
- Workers can constantly apply this QC tools for all types of problems.

<u>The data collection sheet (and graph):</u>

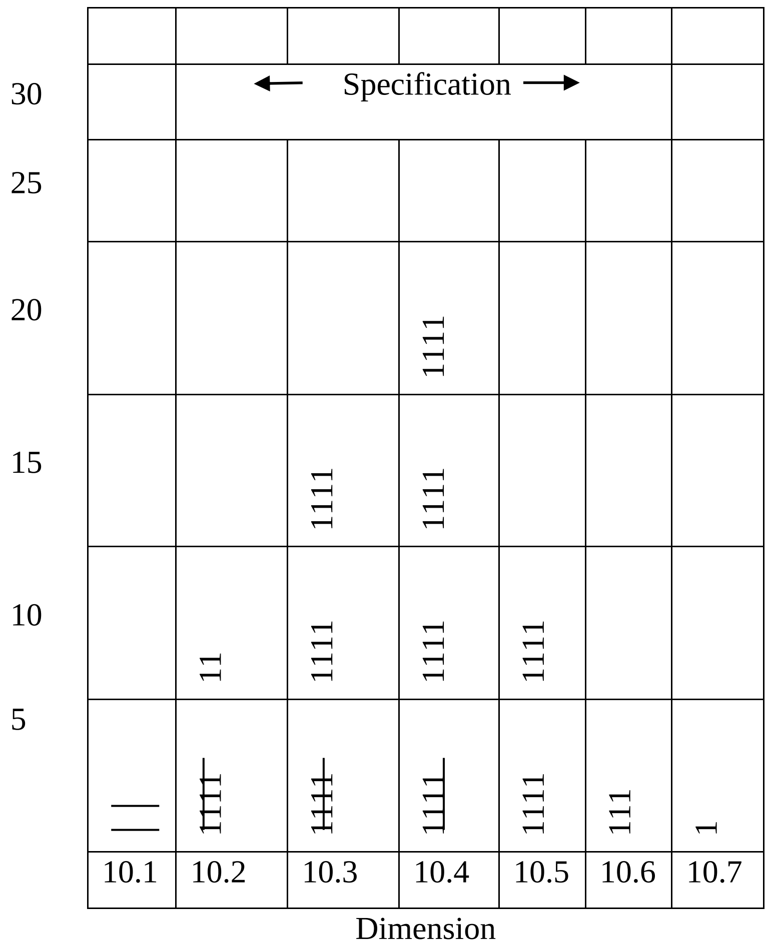
Scientist relies on data and without data there is no science only approximation and empiricism.

An employee should know how to collect data.

This tool employed in data evaluation and diagnostic exercises.

Graphs include single and multi line bar charts and pie diagrams which give visual display of source wise contributions to variations or defects in quality evaluation and improvement exercises.

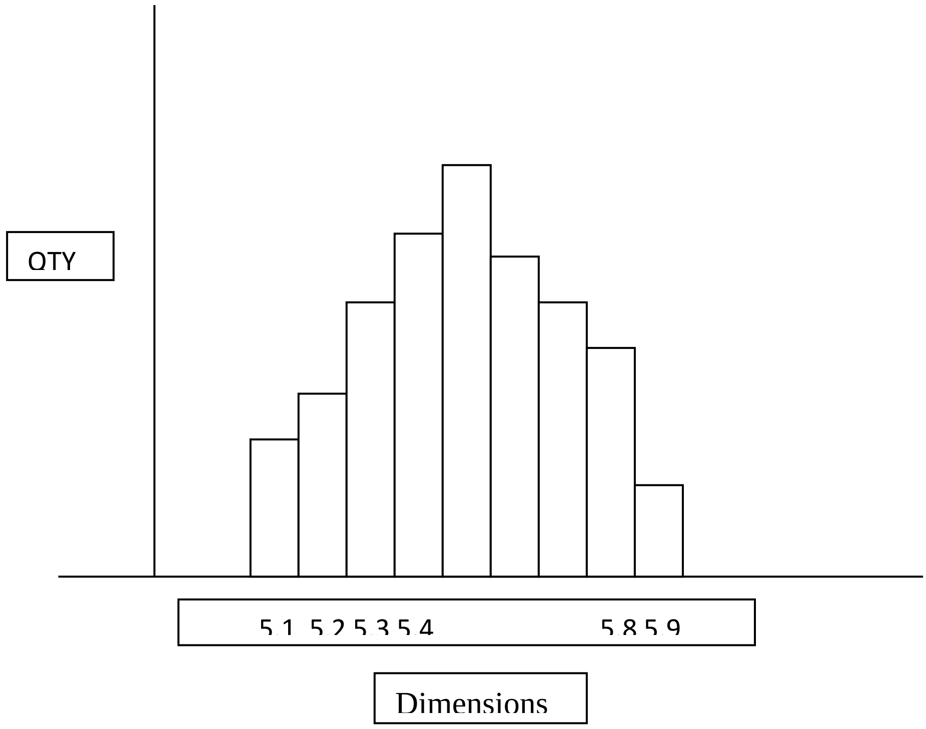
Product No :	Date:
No of parts inspected	Department:
Total No of parts	Operator
Lot	Shift:



The Histogram

After scientists have collected their data they face the problem of reading those data. The problem is they have only two eyes, while the data gathered are numerous.

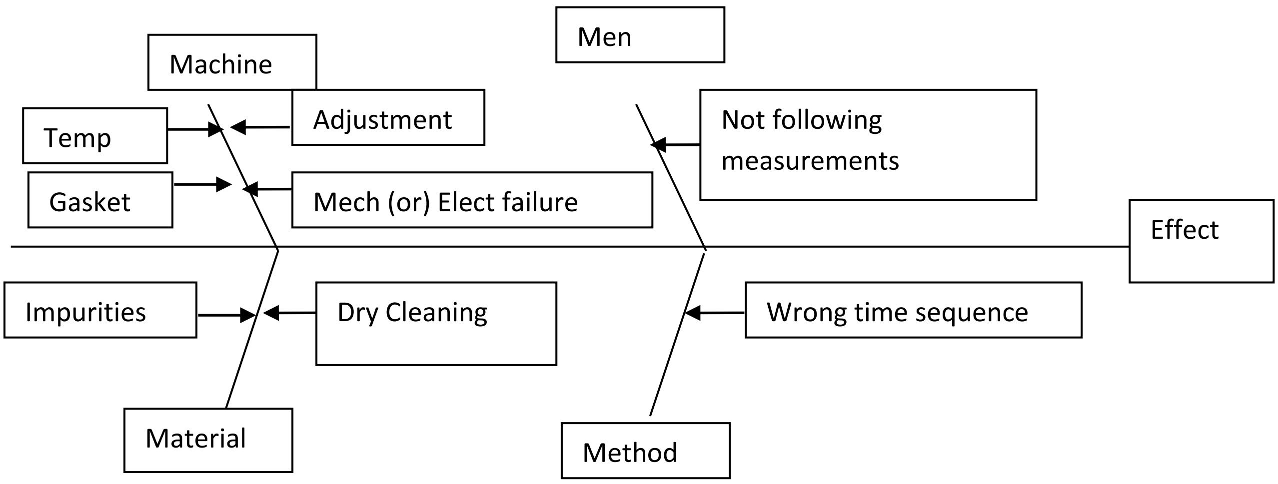
With this tool the concept of dispersion and frequency they can understand. The statistical structure of the data gathered and its meaning is interpreted



The cause and effect diagram (or) ISHIKAWA DIAGRAM (or) FISH BONE DIAGRAM:

This is the study of relationship between cause and effect.

This is a tool employed in a diagnostic exercise in quality improvement. It expresses the breakup of causes known to affect the end result (usually a defect) interrelated diagram.

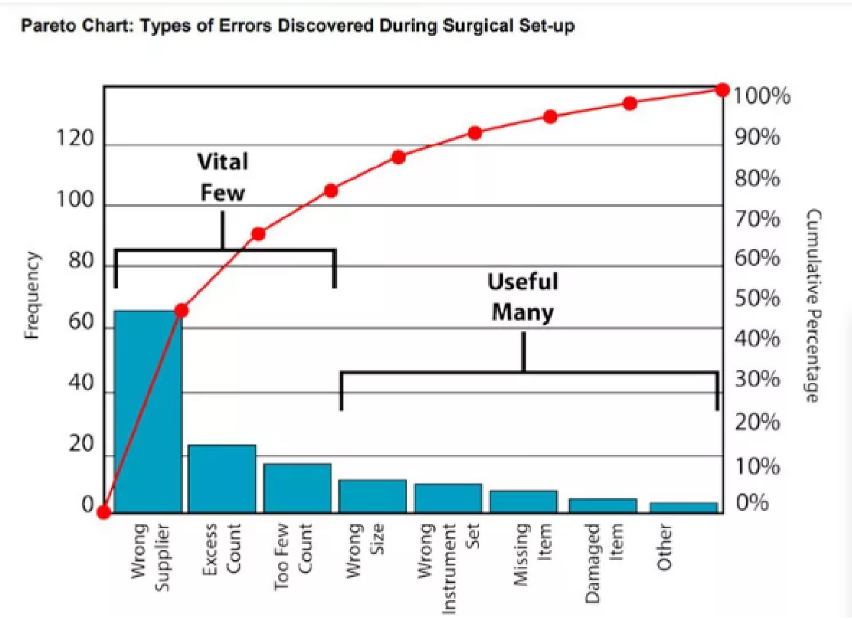


The Pareto diagram:

This chart aims at highlighting universal law of priorities.

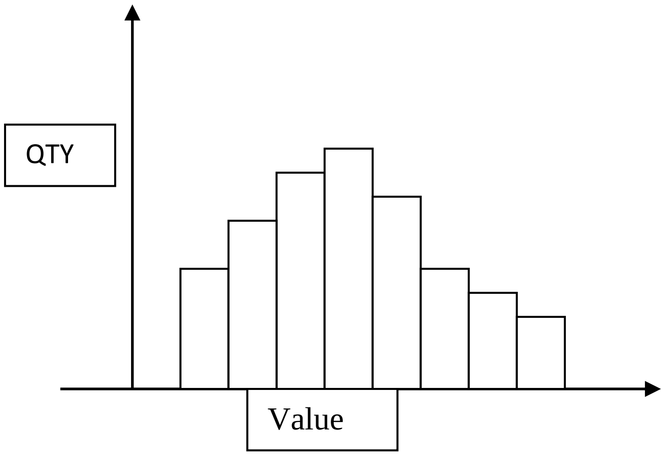
Construct the diagram by organizing the data in decreasing order of importance. This exercise helps to focus on the relevant items.

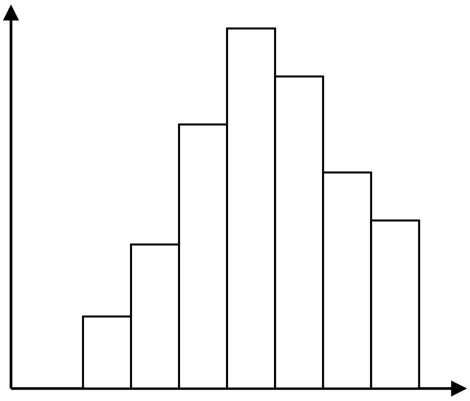
This is a diagnostic tool commonly used for separating the vital few causes that account for a dominant share of quality loss. It is an analogue to the classical ABC Analysis employed in inventory and financial management.



5. Stratification Analysis

This is a process by which data collection is structured with respect to the possible sources of variation or defects in the product or process, machine, suppliers, operators, tools, gauges or time dependent sources like shifts,pre-post lunch , start or end of shifts etc or strata with respect to which the study of variation is conducted for diagnosis and possible prevention of variation or its control.





Scatter diagram,

This diagram used to determine whether two parameters are correlated with each other,

To verity whether a correlation exists between two characteristics or two factors, i.e. whether one is related to the other.

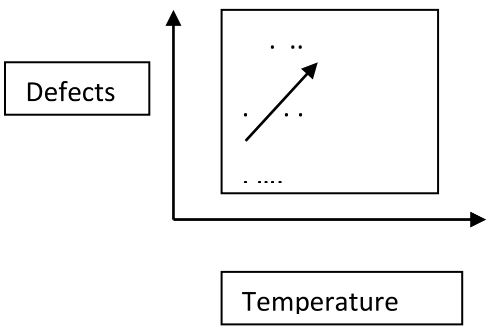
First data pertaining to the two factors are collected and a graph is build charting the pairs of data.

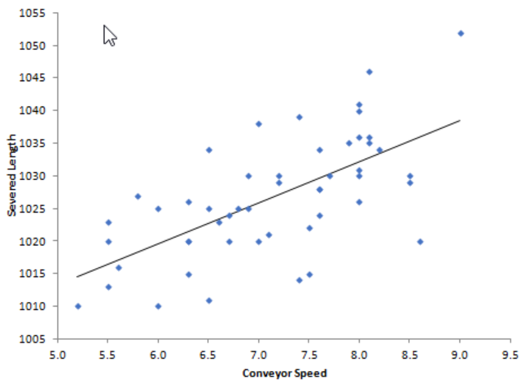
The points may fell into “cloud” like pattern with a particular statistical significance Once this cloud has been obtained, it is easy to tell whether there is any correlation.

Correlation measures the strength of relationship.

Knowledge to such relationship helps to

(a) replace expensive and time consuming inspection and tests.
(b) Replace destructive tests with non destructive ones
(c) Find optimal factor levels from an assessment of relationship with the quality or output characteristic.
(d) Evaluate the relative importance of process factors

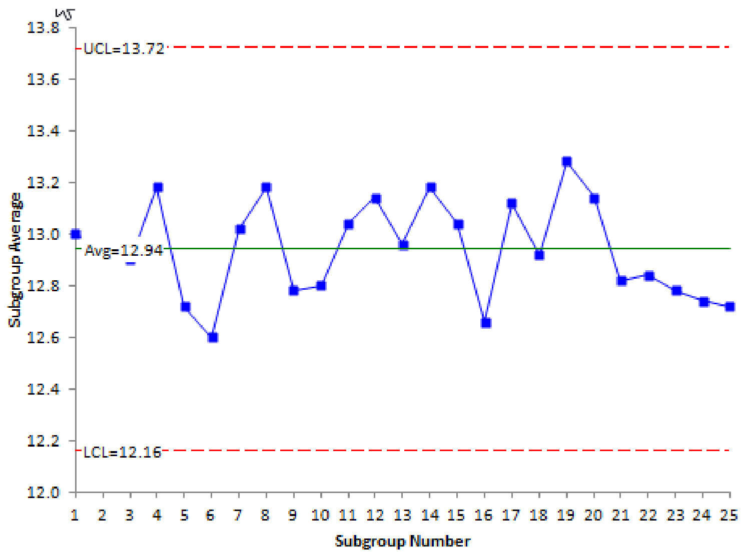




Control Chart

The purpose of a control chart is to determine whether each of the points on the graph is normal or abnormal, and thus know the changes in the process from which the data has been collected.

The **control chart** is a graph used to study how a process changes over time. Data are plotted in time order. A **control chart** always has a central line for the average, an upper line for the upper **control** limit and a lower line for the lower **control** limit. These lines are determined from historical data. E.g. X bar Chart, R Chart, P Chart, U Chart etc



SEVEN MANAGEMENT TOOLS

Introduction

- Quantitative tools enable companies to obtain significance improvements by eliminating process defects, excessive time, useless procedures and so on.
- In long run, however improvement by elimination of causes will not be sufficient.

Reasons

- Complaints represent the tip to the iceberg in terms of customer dissatisfaction
- Eliminating negative quality.
- Eg., (Excessive downtime for a machine, too high rate of defective products)
- Important factors that don’t translate to numbers but cannot be ignored.
- Areas-not closely linked to production- Fiancé Marketing, Human resources Management
- Qualitative factors – impressions, Comments, Judgments and personalities.

Characteristic of seven management Tools

- They allow the elaboration not only of numerical Information, but also of verbal information.
- Addressed to company management.
- Used for the resolution of more complex or less defined problems. (QC Tools are aimed at all employees)
- These tools in addition to being based on mathematics and statistics are also based on semantics (study of language and verbal Expression).

The seven Management Tools

- Affinity (KJ) diagram - for synthesizing, classifying, organizing indefinite Ideas
- Relationship diagram - for isolating cause and effect relationships.
- Tree-shaped diagram - for deploying general concepts into details
- Matrix diagram - for correlating in a logical form, in order to Evaluate, select, decide.
- Decision tree (PDPC) - for identifying alternatives.
- Arrow diagram(PERT) - for planning
- Matrix data analysis - for quantifying relationships.

1. **Affinity Diagram (OR) KJ (Jirokawakita)** (Relationship, Similarity)

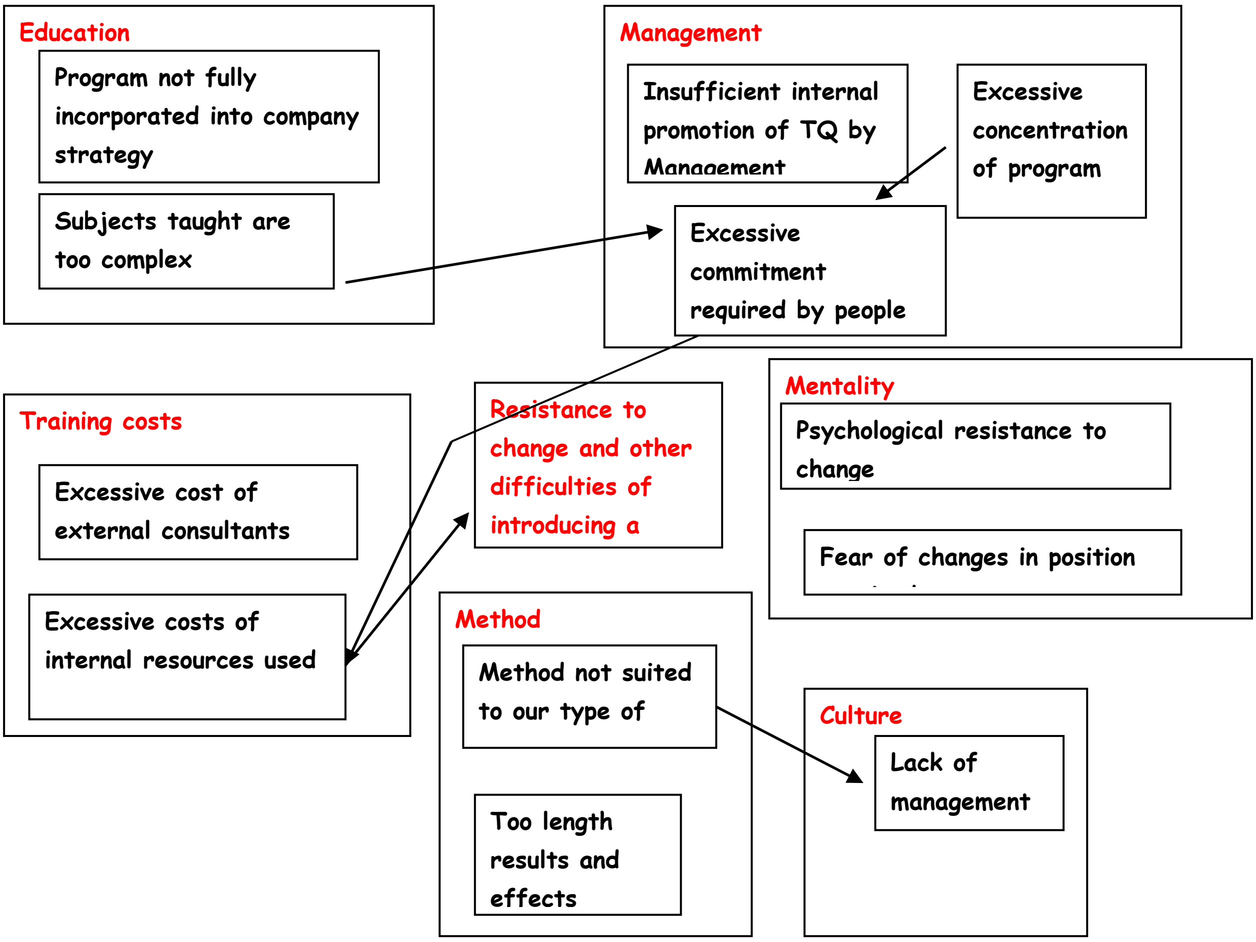
- Affinity diagram is used to collect a great number of verbal expressions (ideas, opinions, observation etc) and organize them in groups according to natural relationships between individual items.
- Due to its extreme conceptual and logical simplicity it allows the clear view of the largest and most complex problems.
- It is a way to structure and classify unclear or vague ideas
- Tool organizes information into homogeneous classes ordered according to importance on the basis of their affinities.

Benefits.

1. Determine logical priorities, especially where it is not possible of restrictive
2. Extra the greatest amount of useful information from few or scattered data.
3. Understand and organize problems that are not clear.
4. Create new concepts.
5. Making use of verbal information even in confused situations.
6. Idenfifying problems by synthesizing the available data.
7. Developing new ideas through innovative thinking
8. Identifying the essential issues of a problem
9. Transforming ideas into action
10. Used to understand priorities

Drawback

Involves several people and consume more house, it should be used only for only important matters.



2. Relationship Diagram:

Definition:

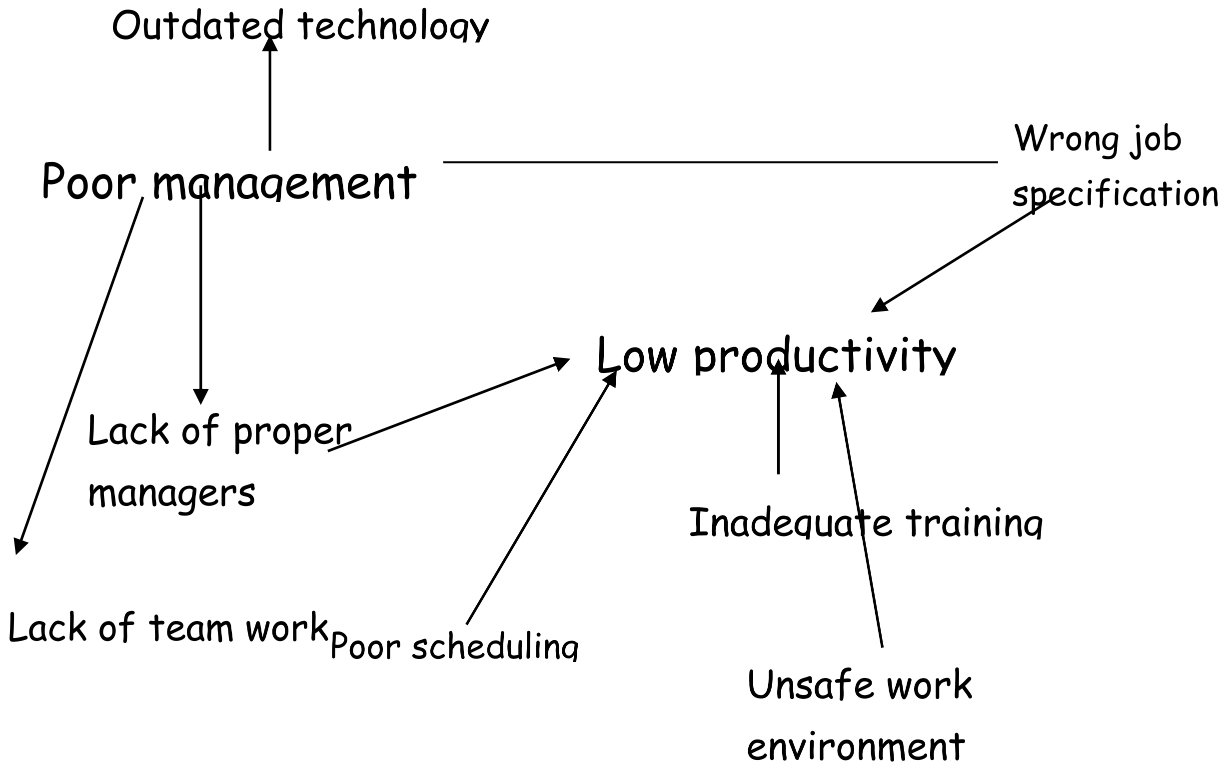
This tad takes a central idea issue or problem and maps out the logical or sequential links among related items.

<u>When to use:</u>

1. An issue is sufficiently complex that the interrelationship between ideas is difficult to determine.
2. The correct sequencing of management actions is critical.
3. There is a feeling that the problem under discussion is only a symptom.(

Advantages:

1. In encourages creativity in identifying new relationships.
2. It helps one to isolate vital problems and relationships, thus promoting a shared understanding of the problem.
3. It allows one to examine causes that interact among themselves and reveals the relationships that exist among all causes.



3. Tree shaped diagram:

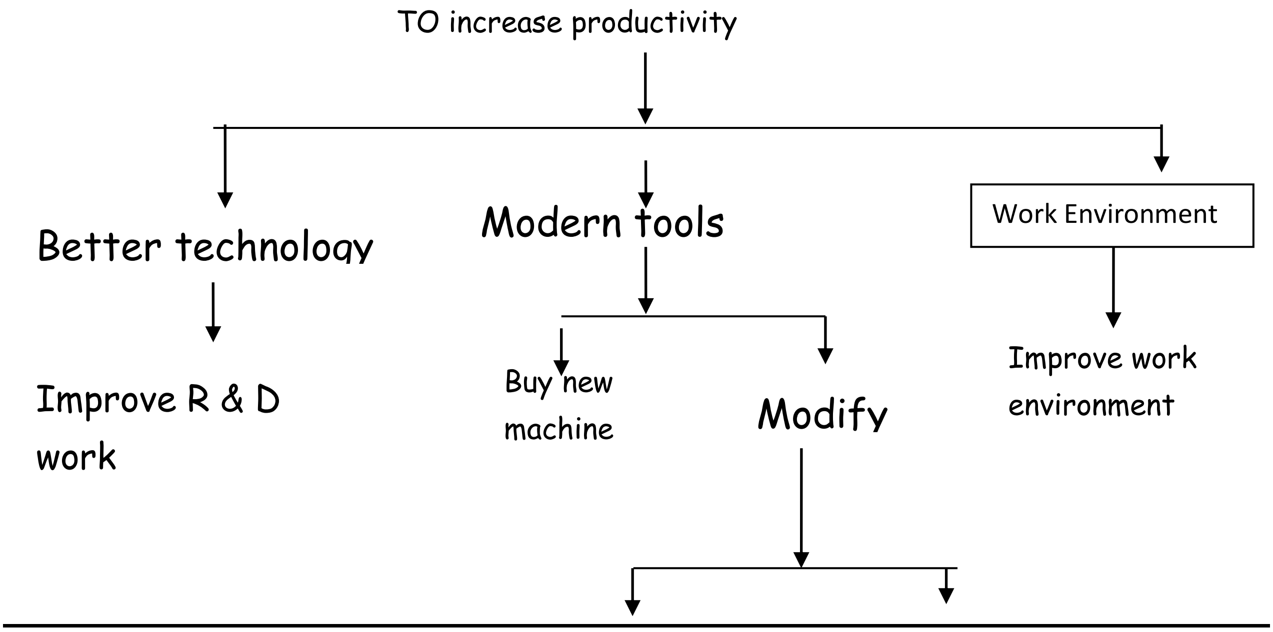
The tree shaped diagram systematically outlines the complete (Spectrum range) paths and tasks that must be carried out in order to achieve a primary goal and its sub goals.

Use of this tool takes one from generalities to details.

(Tree diagram resembles the cause & effect diagram)

Advantages:

It identifies the most appropriate methods by which to achieve the established Goals in order to solve a problem. It brings the process from a broad level of concern to the lowest practical level of detail.



4. Matrix Diagram:

This tool organizes large groups of characteristics, functions and tasks in such a may that logical connecting points between each one are graphically displayed. It also shows the importance of each connecting point relative to every other correlation.

Principle:

It is based on the principle that whenever a series of items are placed in a line (Horizontal) and whenever a series of items are placed in a row (vertical) there will be intersecting points that indicate a relationship.

Further more the matrix diagram features highly visible symbols that indicate the strength of the relationship between the items that intersect at that point.

One following are the most commonly used matrix formats.

L shaped matrix diagram

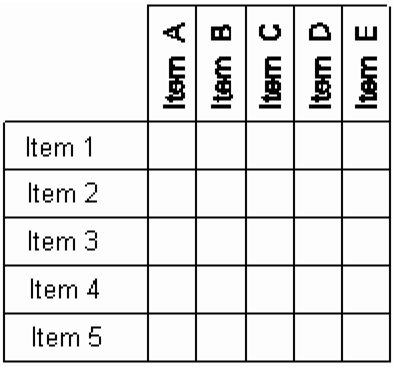
T shaped matrix diagram

Y shaped matrix diagram

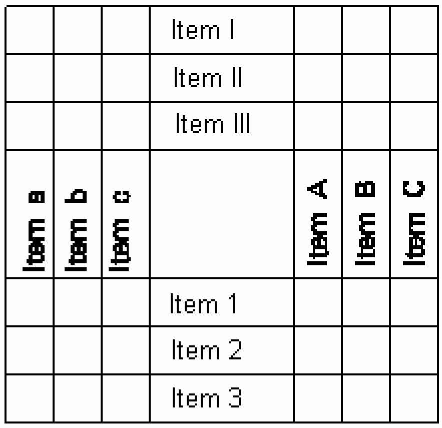
X shaped matrix diagram

L shaped :

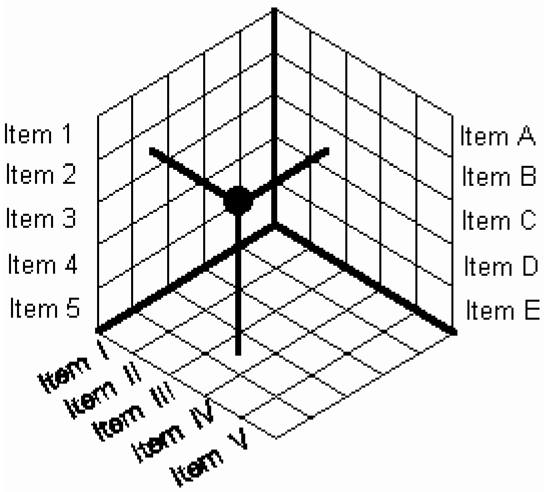
It can be used to display relationships between items in countless operational areas such as administration, manufacturing, personal, R&D etc.



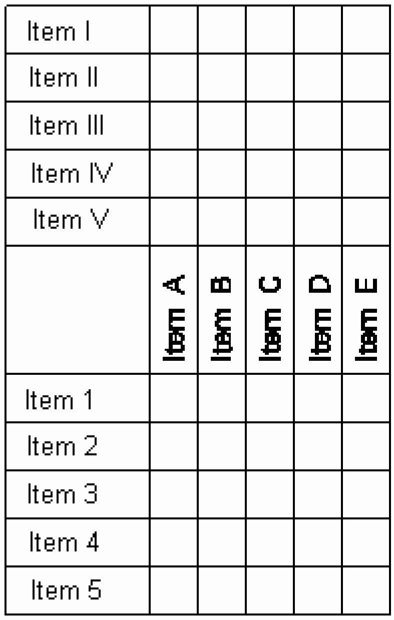
L-matrix
Compares one list against one other



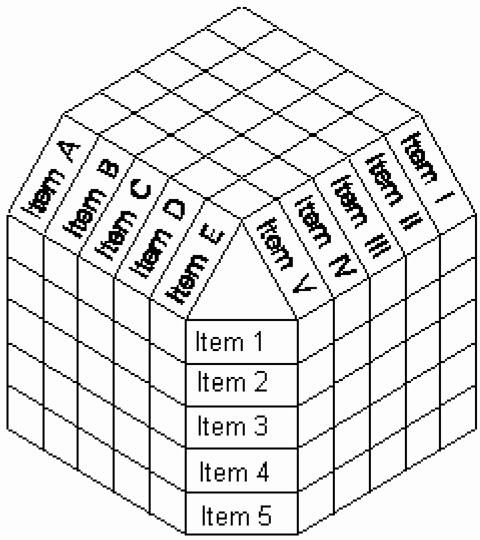
X-matrix
Compares four lists, each against two others, in pairs



C-matrix
Compares three lists against one another, simultaneously



T-matrix
Compares one list against two others in pairs



Y-matrix
Compares three lists, each against one another, in pairs

The L-Matrix compares two lists, allowing a many-to-many relationship comparison. The matrix can be easily extended with such as weighting factors. It is the main matrix used in Quality Function Deployment (QFD).

The C-matrix compares three lists simultaneously, such as the people, products and processes in a factory. Being three-dimensional, it is difficult and complex to produce and draw. It becomes easier if there are few relationships to map.

The T-matrix is useful when there are two distinct sets of questions about a core list, for example comparing school subjects against students and against teachers. An indirect relationship can be inferred between the two side lists

The X-matrix is useful for comparing two pairs of complementary lists, with each pair occupying diagonally opposite lists (as they have nothing in common and need not be compared). For example comparing men and women against activities in athletic and intellectual pastimes, with men and women opposite.

The Y-matrix closes the loop on the T-matrix, and is useful for comparing three tightly coupled lists. It can also be used as a practical simplification of the C-matrix

5. Decision Tree (or) PDPC

Process decision program chart:

The decision tree outlines every conceivable (that can be pictured in one's mind) occurrence as one progresses from definition of a problem to possible solutions.

It is useful when one wants to plan all possible chains of events that might occur during a project.

It is useful therefore when one is not familiar with the problem or goal.

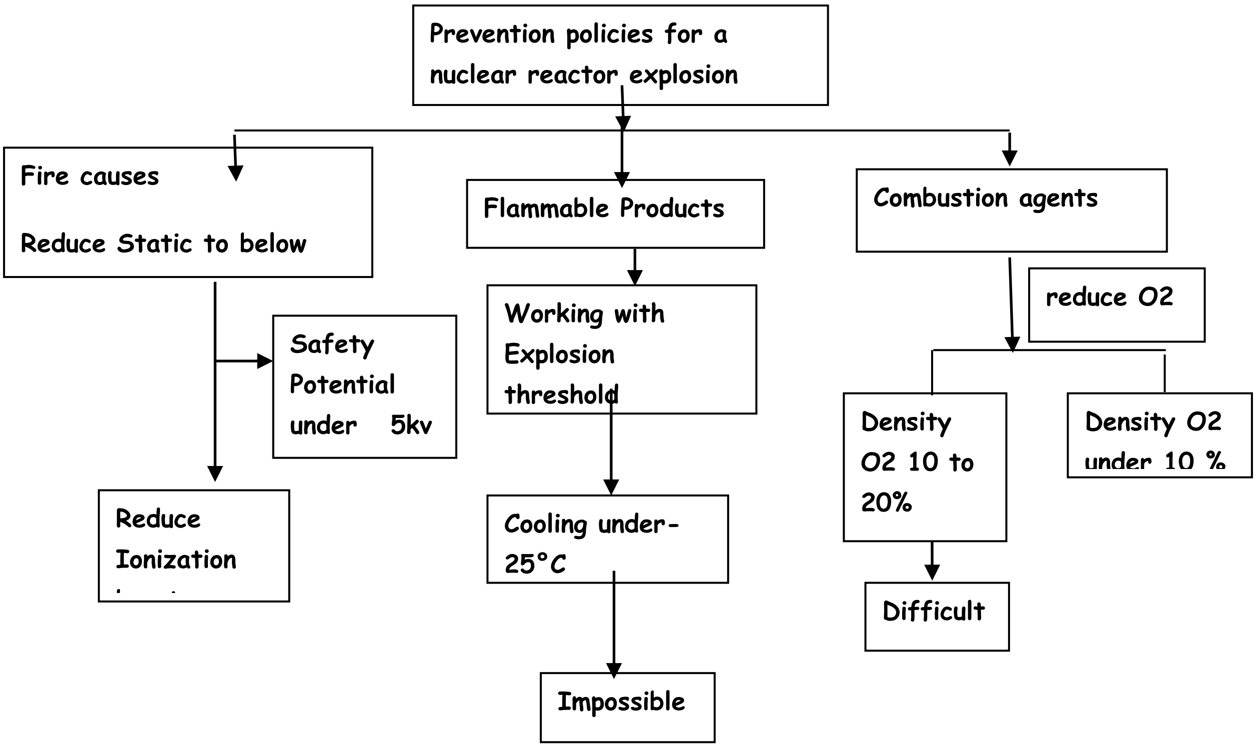
The PDPC diagram is a support tool to establish which procedures and action are most appropriate to a project.

It is used during the planning stage to forecast all circumstances that may be encountered during the course of a project and to indicate the means of preventing them, weighing various alternatives.

PDPC is widely used in decision making when sufficient information is lacking, or when a particularly unstable environment exists in order to identify useful methods or procedures to solve difficult problems.

It is typically used in new product development building and equipment and data processing programs.

The principle behind the PDPC is that the path toward virtually any goal is stilled with uncertainty and an imperfect environment.



6. Arrow Diagram:

This tool is used to plan the most appropriate schedule for any task and to control it effectively during its progress.

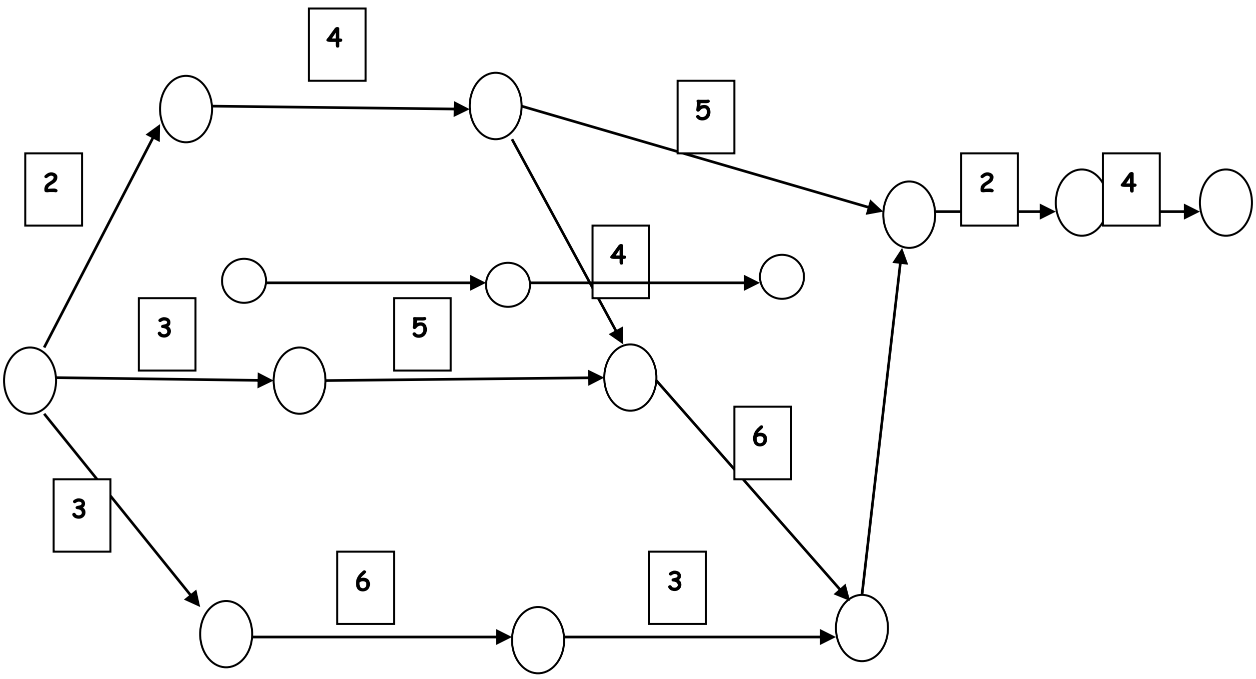
This is closely related to the CPM and PERT Diagram methods. This is used when the task at hand is a familiar one with subtasks that are of a known duration.

Arrow diagram has widespread use in such areas as

- New product Development
- Construction Projects
- Marketing plans
- Complex negotiations

Arrow diagram is used to represent at work program through a network of activities and events hose interdependence is fully displayed.

It allows the establishment of a critical path that is the sequence of the total length of execution. It can also be used to effectively control work progress and optimize work schedules and procedures



7. Matrix Data Analysis Diagram

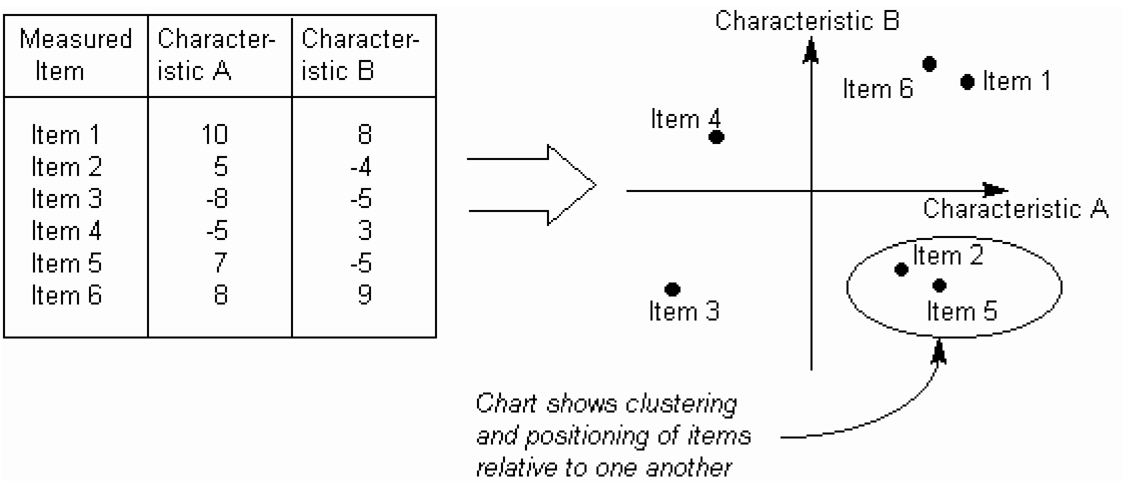
The matrix data analysis diagram is applied when one wants to analysis the data shown in a matrix diagram, so that each variable can be easily examined, and the real strength of relationships between variables revealed.

It appears advantageous in studying the parameters of production process , in analyzing market information, in finding links between numerical and non-numerical variables and so on.

It allows clear interpretation of great amounts of numerical data, isolating the principle variables, that is, it seeks the principal components.

When comparing a large set of items, the complexity of the situation can make it difficult to determine how different factors relate to one another. In particular, it can be useful to find groups of items that behave in similar ways. For example, a washing powder may have different efficiencies at achieving 'softness' and 'stain removal' in garments made of acrylic, polyester, wool and various fiber mixtures. If similar affects are found in a group of fibers, then changing the powder ingredients may affect the whole group in a similar way.

The Matrix Data Analysis Chart (or *MDAC*) helps classify items by identifying two major characteristics common to all items and then plotting each item as a point on a standard x-y chart. This makes it easier to see how the individual items relate both to the characteristics and to one another, thus:



Measured Item	Character-istic A	Character-istic B
Item 1	10	8
Item 2	5	-4
Item 3	-8	-5
Item 4	-5	3
Item 5	7	-5
Item 6	8	9

<u>Contributions of the seven management tools</u>

Learn a new way of thinking
Acquire confidence in problem solving
Acquire the ability to view things as a whole
Distinguish well known things from those of not known
Gather and make use of information of various kinds.
Synthesize information that is easy to examine
Devise a solution to the problem
Make use of the company's potential know how.
Achieve effective results

SIX SIGMA

What is Six Sigma?

Six Sigma is a defined and disciplined business methodology to increase customer satisfaction and profitability by streamlining operations, improving quality and eliminating defects in every organization-wide process

Why "Sigma"? The word is a statistical term that measures how far a given process deviates from perfection. The central idea behind Six Sigma is that if you can measure how many "defects" you have in a process, you can systematically figure out how to eliminate them and get as close to "zero defects" as possible. To achieve Six Sigma Quality, a process must produce no more than 3.4 defects per million opportunities. An "opportunity" is defined as a chance for nonconformance, or not meeting the required specifications. This means we need to be nearly flawless in executing our key processes.

The fundamental objective of the Six Sigma methodology is the implementation of a measurement-based strategy that focuses on process improvement and variation reduction through the application of Six Sigma improvement projects. This is accomplished through the use of two Six Sigma sub-methodologies: DMAIC and DMADV.

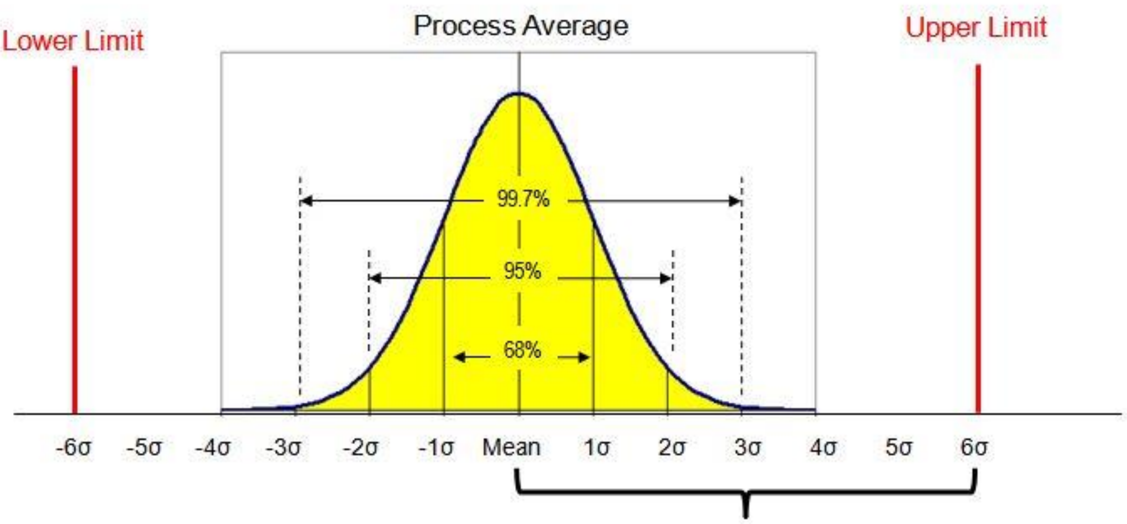
The Six Sigma DMAIC process (define, measure, analyze, improve, control) is an improvement system for existing processes falling below specification and looking for incremental improvement.

The Six Sigma DMADV process (define, measure, analyze, design, verify) is an improvement system used to develop new processes or products at Six Sigma quality levels. It can also be employed if a current process requires more than just incremental improvement.

General Electric, one of the most successful companies implementing Six Sigma, has estimated benefits on the order of $10 billion during the first five years of implementation.

GE first began Six Sigma in 1995 after Motorola and Allied Signal blazed the Six Sigma trail. Since then, thousands of companies around the world have discovered the far reaching benefits of Six Sigma.

Sigma represents the population standard deviation, which is a measure of the variation in a data set collected about the process. If a defect is defined by specification limits separating good from bad outcomes of a process, then a six sigma process has a process mean (average) that is six standard deviations from the nearest specification limit. This provides enough buffer between the process natural variation and the specification limits.



For example, if a product must have a thickness between 10.32 and 10.38 inches to meet customer requirements, then the process mean should be around 10.35, with a standard deviation less than 0.005 (10.38 would be 6 standard deviations away from 10.35).

Six Sigma can also be thought of as a measure of process performance, with Six Sigma being the goal, based on the defects per million. Once the current performance of the process is measured, the goal is to continually improve the sigma level striving towards 6 sigma. Even if the improvements do not reach 6 sigma, the improvements made from 3 sigma to 4 sigma to 5 sigma will still reduce costs and increase customer satisfaction.

Sigma Level	Defects per Million	Yield
6	3.4	99.99966%
5	230	99.977%
4	6,210	99.38%
3	66,800	93.32%
2	308,000	69.15%
1	690,000	30.85%

Define	Measure	Analyse	Improve	Control
Review Project Charter	Value Stream map for deeper understanding and focus	Identify potential root causes	Develop potential solutions	Implement mistake proofing
Validate Problem Statement and Goals	Identifying key input, process and output metrics	Confirm root cause to output relationship	Evaluate and select best solutions	Develop standard operating procedure (SOP) and training plan
Validate Voice of the customer	Develop data collection plan	Estimate impact of root causes on key output	Develop future value stream map	Develop process control
Validate voice of the process	Validate measurement system	Prioritize root causes	Develop and implement pilot solution	Implement solution and ongoing process measurements
Validate Financial benefits	Collect baseline data		Confirm attainment of project goals	Identify project replication opportunities
Validate hIgh level value stream Map			Develop full scale implementation plan	
Create communication plan	Determine process capability			
Select and launch team				
Develop Project Schedule				

DMAIC

This methodology is used when a process is already in place, but is not performing as well as it should be. The steps in DMAIC are as follows:

- **Define:** Identify the problem and the goals of the improvement project.
- **Measure**: Gather data on the process to understand how it is currently performing.
- **Analyze:** Analyze the data to identify the root cause of the problem.
- **Improve:** Develop and implement solutions to address the root cause and improve the process.
- **Control:** Put measures in place to ensure the process remains improved over time.

DMADV

DMADV stands for Define, Measure, Analyze, Design, and Verify. This methodology is used when a new process or product is being developed. The steps in DMADV are as follows:

- **Define**: Identify the goals and customer requirements for the new process or product.
- **Measure**: Gather data on customer needs and market trends.
- **Analyze:** Analyze the data to identify the key features and requirements for the new process or product.
- **Design**: Develop and design the new process or product to meet the identified requirements.
- **Verify**: Test and verify that the new process or product meets the customer requirements

DMAIC refers to a data-driven quality strategy for improving processes, and is an integral part of the company's Six Sigma Quality Initiative. DMAIC is an acronym for five interconnected phases: Define, Measure, Analyze, Improve, and Control

Each step in the cyclical DMAIC Process is required to ensure the best possible results. The process steps:

Define the Customer, their Critical to Quality (CTQ) issues, and the Core Business Process involved.

Define who customers are, what their requirements are for products and services, and what their expectations are
Define project boundaries the stop and start of the process
Define the process to be improved by mapping the process flow

Measure the performance of the Core Business Process involved.

Develop a data collection plan for the process
Collect data from many sources to determine types of defects and metrics
Compare to customer survey results to determine shortfall

Analyze the data collected and process map to determine root causes of defects and opportunities for improvement.

Identify gaps between current performance and goal performance
Prioritize opportunities to improve
Identify sources of variation

Improve the target process by designing creative solutions to fix and prevent problems.

Create innovate solutions using technology and discipline
Develop and deploy implementation plan

Control the improvements to keep the process on the new course.

Prevent reverting back to the "old way"
Require the development, documentation and implementation of an ongoing monitoring plan
Institutionalize the improvements through the modification of systems and structures (staffing, training, incentives)

Six sigma in IT industries

Difference between software product and Manufacturing product

Software Product	Manufacturing Product
It has logical components.	It has physical components.
It has no material existence and has no physical properties.	It has physical properties i.e. color, mass etc.
It do not have any link with the physical laws i.e. Newton's laws.	It obeys physical laws.

Non repetitiveness-Once software is developed, it can be reproduced into millions of identical copies. This is the reason why software developers focus on the development process unlike manufacturing process where the focus is on the reproduction of the identical copies

Input and output-Unlike manufacturing process the inputs and outputs are different in each software process. Each software process deals with different set of user requirements.

External Factors-The external factors in a manufacturing process are temperature, relative humidity, human interaction, machine performance. None of these factors affect software development processes. In software development processes the external factors are programming kills, level of expertise, knowledge, etc.

Actually Six Sigma is applicable to software companies. For example Motorola is using Six Sigma in his software department for many years and Tata consultancy Services has gain lots of profits after applying Six Sigma

Application of Six sigma in IT

- Improved testing of mainstream software products
- Improved ways of delivering customized software to clients
- Reduced the defect ratio with 60% in a software development process that used 70% of the total R&D budget
- Established and improved a software defect handling process (Service pack process), such that a major European Airline ranked it as best practice

BENCHMARKING

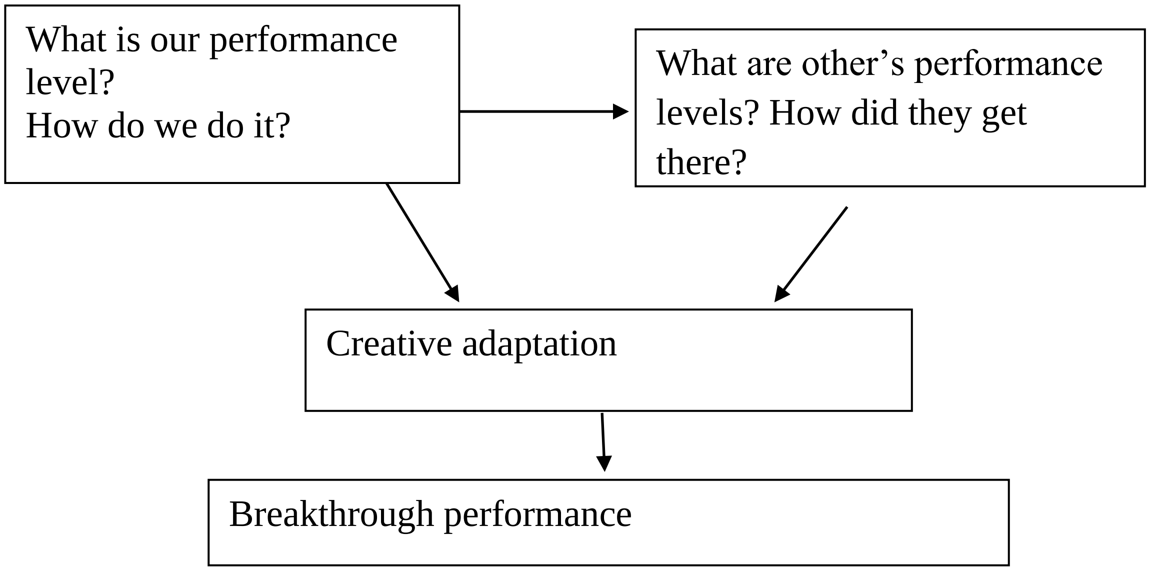
Introduction

- ❖ Benchmarking is a systematic method by which organization can measure themselves against the best industry practices.
- ❖ The essence of benchmarking is the process of borrowing ideas and adapting them to gain competitive advantage.
- ❖ It is a tool for continuous improvement.

Benchmarking defined

- ❖ Benchmarking is the systematic search for best practices, innovative ideas, and highly effective operating procedures.
- ❖ Bench marking consider the experience of others and uses it.
- ❖ It is commonsense proposition to learn from others what they do right and then imitate it to avoid reinventing.

Benchmarking concept



REASONS TO BENCH MARK

- ❖ Benchmarking is a tool to achieve business and competitive objectives.
- ❖ It is a powerful and extremely effective when used for right reasons and aligned with organizational strategy.
- ❖ Benchmarking is one tool to help organization to develop strength and reduce weaknesses.
- ❖ Benchmarking can notify the organizations if it has fallen behind the competition or failed to take advantage of important operating improvements developed elsewhere.

- In short benchmarking can inspire mangers to compete.
- Benchmarking is a time and cost efficient because the process involves imitation and adaptation rather then pure invention.
- Benchmarking partners providing a working model of an improved process, which reduces some of planning, testing and prototyping effort.
- The primary weakness of benchmarking is the fact that the best in class performance is a moving target.
- Bench marking enhances innovation by requiring organizations to constantly scan the external environment and to use the information obtained to improve the process.

BENCHMARKING PROCESS

Organizations that benchmark, adapt their process to best fit their own needs and culture.

1. **Decide what to benchmark.**
2. **Understand current performance**
3. **Plan**
4. **Study other**
5. **Learn from the data**
6. **Use the findings.**

1. Deciding what to benchmark.

Bench marking can be applied to any business process.
High impact areas to benchmark are.

1. Which processes are causing the most trouble?
2. Which processes contribute most to customer satisfaction and which are not performing up to expectations?
3. What are the competitive pressures impacting the organization most?
4. What processes have the most potential for differentiating our organization from the competition?

Broad and shallow

Narrow and deep

Broad and shallow study's asks **what is done** and span many functions and people and do not go into detail any one area.
Broad and shallow studies are useful in developing strategies, setting goals ands reorganizing functions to be more effective.

Narrow and deep study's asks **How it is done?**
This study is useful in how people perform jobs.
Pareto analysis can be helpful technique for deciding what process is to investigate

2. UNDERSTANDING CURRENT PERFORMANCE

To compare practices to outside benchmarks, it is first necessary to thoroughly understand and document the current process.

The benchmarking team should be comprised of those who own or work in the process to ensure suggested charges are actually implemented.

When documenting the process, it is important to quantity it. Units of measure must be determined.

3. PLANNING

Once internal processes are understood and documented, it is possible to make decisions about how to conduct the study.

- ❖ A benchmarking team should be chosen.
- ❖ The team should decide what type of benchmarking to perform what type of data to be collected and the method of collection.

Benchmarking process is a learning process.

There are three type of benchmarking.

1.Internal
2.Competitive
3.**Process**.

Internal benchmarking

In most large firms similar activities are performed in different operating divisions.

Advantages.

Data are easy to obtain because problem of confidentiality don't exist.

- ❖ Dialog with internal group generate immediate improvement ideas or define common problems that help to focus to help external inquiries.

Product Benchmarking

Product competitors are an obvious choice to benchmark. Any organization survival depends upon its performance to the competition. Customer's reports evaluate the features of various products. Buying competitors product and test is another common practice. The organization observes both its products and its competitor's products in use at the customer location and collect's comparative data.

Process Benchmarking

Process benchmarking is sometimes known as functional or generic benchmarking. The idea is that many processes are common across industry boundaries and innovations from other type of organizations can be applied across industries. (E. g) . Delivery systems, accounting procedure Etc.

Hierarchy of Sources.

World class
Any organization
Industry wide
Competitor
Internally

4. STUDYING OTHERS

Benchmarking studies look for two of information:

A description of how best in class processes are practiced and Measurable **result of these practices.**

Three techniques for conducting original research are

- **Questionnaires**
  Site visits
- **Focus groups**

Questionnaires are particularly useful to ensure respondent secrecy and confidentiality when data are desired from many external organizations and when using a third party to collect information.

Respondent's can be surveyed by mail, by telephone or in person.

Site visit provide the opportunity to see processes in action and for face-to-face contact with in class operators.

Site visits usually involve a tour of the operation of plant followed by discussion period.

Focus groups are simply panel of benchmarking partners brought together to discuss areas of mutual interest.

Most often the panels are comprised of people who have some previous joint benchmarking activity

5. LEARNING FROM THE DATA

Learning from the data collected in a benchmarking involves answering a series of questions.

1.Is there a gap between the organization performance and the performance in the best in class organizations

2. What is the gap? How much is it?

3. Why there is a gap ? What does the best in class do differently that is better?

4. If best in class practices where adapted what should be resulting improvement?

Bench marking studies can reveal three different outcomes.

External processes may be approximately equal.

Internal processes may be better than they found in the organizations.

Negative gaps call for a major improvement effort.

Parity determines further investigation to determine if improvement opportunity exists.

It may be that when the process is broken down to sub process some aspects are superior and represent significant improvement opportunities. Finally the finding of a positive gap should result in recognition for the internal processes.

6. USING THE FINDINGS

When the bench marking study reveals a negative gap in performance, the objective is to change the process to close the gap.

To effect change, the finding must be communicated to the people within the organization who can enable improvement
The finding must translate to goals and objectives and action plans must be developed to implement process.

The generic steps for the development and execution of action plan are:

1. **Specify tasks.**
2. **Sequence tasks**
3. **Determine resource needs.**
4. **Establish tasks schedule.**
5. **Assign responsibility for each task.**
6. **Describe expected results.**
7. **Specify methods for monitoring results.**

The next step is to repeat the benchmarking process.

It is not to be done to create one permanent improvement and there by miss the opportunity for future improvements.

In order to avoid satisfaction benchmarking should be used be used continuously to pursue emerging ideas.

Failure modes and effects analysis (FMEA)

- Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service.
- “Failure modes” means the ways, or modes, in which something might fail. Failures are any errors or defects, especially ones that affect the customer, and can be potential or actual.
- “Effects analysis” refers to studying the consequences of those failures.
- Failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected. The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones.

When to Use FMEA

- When a process, product or service is being designed or redesigned, after quality function deployment.
- When an existing process, product or service is being applied in a new way.
- Before developing control plans for a new or modified process.
- When improvement goals are planned for an existing process, product or service.
- When analyzing failures of an existing process, product or service.
- Periodically throughout the life of the process, product or service

There are two broad categories of FMEA, Design FMEA (DFMEA) and Process FMEA (PFMEA).

Design FMEA

Design FMEA (DFMEA) explores the possibility of product malfunctions, reduced product life, and safety and regulatory concerns derived from:

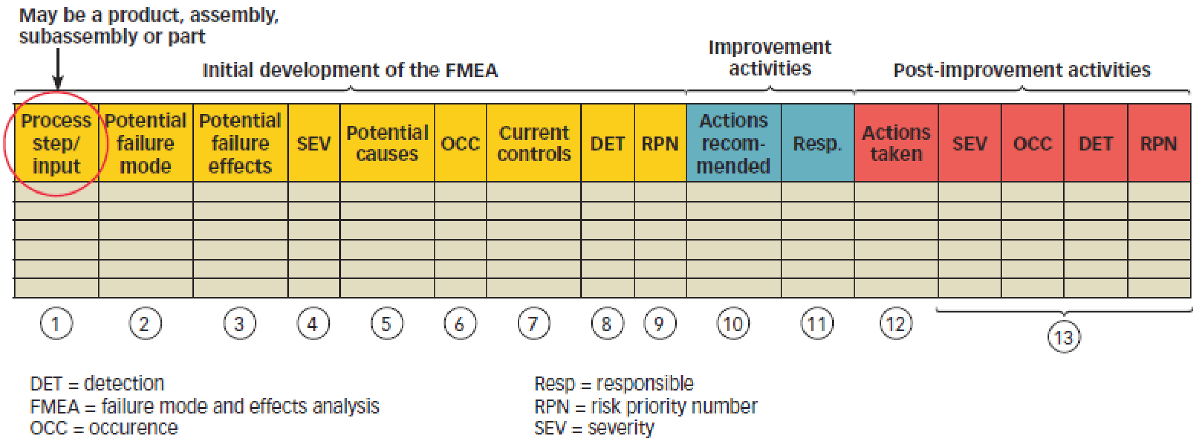
- Material Properties
- Geometry
- Tolerances
- Interfaces with other components and/or systems
- Engineering Noise: environments, user profile, degradation, systems interactions

Process FMEA

Process FMEA (PFMEA) discovers failure that impacts product quality, reduced reliability of the process, customer dissatisfaction, and safety or environmental hazards derived from:

- Human Factors
- Methods followed while processing
- Materials used
- Machines utilized
- Measurement systems impact on acceptance
- Environment Factors on process performance

FMEA document general format / TABLE 1



1. **Process step**—Identify the process step and input under investigation. Each step is identified sequentially. If the PFMEA is fed from a cause and effect matrix, only high-value steps might be listed.
2. **Potential failure mode**—Identify all the ways a failure can occur at this process step.
3. **Potential failure effects**—Identify all the effects each failure mode has, including the effects on the customer. Use a new line for each failure effect. Table 2 demonstrates the many-to-many relationships that exist across the document columns for any given step.
4. **Severity**—Quantify the severity of the impact of the failure effect. The scale for severity ranges from "no effect" on the low end to "safety hazard"—up to and including "loss of life without warning" on the high end. Also, the effect can be expressed in monetary damages, as well as destruction and delays. All scales must be described in the context of the FMEA situation.
5. **Potential causes**—Identify all root causes leading to the failure. If root causes are unknown at the time the FMEA is conducted, it may be necessary to divert from the FMEA temporarily and conduct a root cause analysis using the variety of quality tools available.

6. **Occurrence**—Quantify the frequency of occurrence of the failure mode. The scale for occurrence ranges from "highly unlikely" on the low end to "highly likely" on the high end. Some users, teams and organizations will go to great lengths to provide absolute definitions for the frequency of occurrence. For example, the Automotive Industry Action Group stated that an occurrence entry value of one designates a possible failure rate < 0.01 per thousand vehicles/items, and an entry value of 10 designates a possible failure rate > 100 per thousand vehicles/items. The occurrence scale generally will translate to a rate or even a probability
7. **Current controls**—Identify all the existing controls and procedures, including inspections and tests, which prevent the cause of the failure mode. Include a standard operating procedure number, if available.
8. **Detection**—Quantify the ability to detect the failure at a specific process step (that is, not at a previous or subsequent step, but at the step under consideration). The scale for detection ranges from "almost certain" on the low end to "not possible" on the high end. See Table
9. **Risk priority number (RPN)**—Determine the multiplicative effect (that is, RPN = severity value x occurrence value x detection value) of values assigned to columns four, six and eight, respectively. Although teams generally work the highest RPN values first, they may set additional prioritization criteria, such as working any line item on the FMEA where the severity value is at the highest level, the detection value is at its highest or any value is at its highest.
10. **Actions recommended**—Recommend actions for reducing the severity of the impact, frequency of occurrence or the ability to improve detection.
11. **Responsible**—Identify who is responsible for the actions recommended. If more than one individual is identified, a lead should be specified as responsible.
12. **Actions taken**—List the actions taken and completed, and include the completion date.
13. **Severity, occurrence, detection and RPN-** Identify new severity, occurrence and detection values, and compute the new RPN value. These have the same meaning as items four, six, eight and nine, respectively. However, these values reflect the actions taken in item 12. Ideally, one or more of these values will be reduced by the actions taken, resulting in a lower RPN value. If the value is not reduced, the actions taken were ineffective.