UNIT IV - TOOLS AND TECHNIQUES FOR QUALITY MANAGEMENT

Quality functions development (QFD)-Benefits, Voice of customer, information organization, House of quality(HOQ), QFD process, Failure mode effect analysis(FMEA)-requirements of reliability, failure rate, FMEA stages, design, process and documentation, seven tools(old new),bench marking and POKA YOKE.

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INTRODUCTION TO QFD

A planning tool used to fulfill customer expectations. A tool used to translate customer requirements to engineering specifications. Is a link between customers-design engineers-competitors-manufacturing.

Quality function deployment (QFD) is the latest approach to product design.

QFD is a systematic and organized approach of taking customer needs and demands into consideration while designing new products and services (or while improving the existing products and services).

The Japanese developed an approach called "quality function deployment" (QFD) to meet customer's requirements throughout the design process and also in the design of production systems. Quality function deployment is a method by which cross-sectional teams translate customer requirements into appropriate design requirements at each stage of the product development process

QFD is an excellent way for firms to capture the "Voice of the customer". It ensures that the customer is the focus of all design activities.

QFD is a customer-driven planning process to guide the design, manufacturing and marketing of goods. It tries to eliminate the gap between what customers want in a new product and what the product must deliver.

QFD translates this voice of the customer into technical and functional requirements at every stage of design and manufacture.

Thus in QFD, the requirements of the customers are „deployed" to the desired function, which in turn, is used to yield the engineering characteristics of the product

Prerequisites to QFD are 'Market Research' and 'VOC gathering'.

As QFD is the process of building capability to meet or exceed customer demands, understanding the market, knowing the various customer segments. what each customer segment wants, how important these benefits are, and how well different providers of products address these benefits are some of the key precursors to a successful QFD. These are prerequisites because it is impossible to consistently provide products / services which will attract customers unless you have a very good understanding of what they want.

DEFINITION OF QFD

A structured process for planning the design of a new product or service or for redesigning an existing one. It emphasizes thoroughly understanding what the customer wants or needs. Then those customer wants are translated into characteristics of the product or service. Finally, those characteristics are translated into details about the processes within the organization that will generate the product or service.

QFD is define as "A system for translating customer requirements into appropriate company requirements at each stage from research and product development to engineering and manufacturing to marketing/sales and distribution."

Quality function deployment refers to both determining what will satisfy the customer and secondary, translating those customer desires into the target design. QFD is used early in the production process to determine what will satisfy the customer and also where to deploy quality efforts.

How QFD was developed

QFD was developed in Japan in the late **1960s by Professors Yoji Akao** and **Shigeru Mizuno.**

The Professors aimed at developing a quality assurance method that would design customer satisfaction into a product before it was manufactured. Prior quality control methods like Ishikawa were primarily aimed at fixing a problem during or after manufacturing.

Key Reasons

1. Customers are our number one concern. Satisfied customers keep us in business. Therefore, we must have an excellent understanding of their needs.

2. Proactive product development is better than reactive product development. QFD can help a company move toward a more proactive approach.

3. Quality is a responsibility of everyone in the organization. QFD is a team methodology which encourages a broader employee involvement and focus.

4. The QFD methodology helps an organization determine the most effective applications for many engineering and analytical tools such as: Design of Experiments, Failure Analysis and Statistical Process Control.

Features of QFD

The key features of QFD are as follows:

1. **Focuses on meeting market needs by using actual customer statements ("Voice of the customer")**

   - Expectations

   - Requirements

2. **It requires Customer and top Management commitment .**

   Its effective application of multidisciplinary teamwork

   - Cross functional

   - Makes use of effective communication

3. **The use of a comprehensive matrix called (the "House of Quality") for**
   - Documenting information

4. **It captures the customer's voice:**

   The customer's voice is captured in order to define product or service specifications.

5. **It ensures strong cross-functional teamwork:**

   Teamwork is ensured between the various functions involved with the design, such as marketing, R&D, and manufacturing. Numerous studies have shown that such teamwork is essential for a company's success.

6. **It links the main phases of product development:**

A more thorough use of QFD ensures the generation of four matrices that link the four main phases of product development

(i) Product planning, after customer needs are understood

(ii) Part deployment

(iii) Process planning

(iv) Production planning

3. Objectives of QFD

- To identify the true voice of the customer and to use this knowledge to develop products which satisfy customers

- To help in the organization and analysis of all pertinent information associated with the project.

QFD team

QFD team of six to eight persons has to be constituted for every project. The team should have a senior employee as facilitator.

The team members should be able to spend the required time for successful completion of the project. They should meet for about two hours in each sitting. The QFD task is carried out for design of new product as well as improvement of an existing product. By and large, the Japanese use QFD for improving existing products whereas the Americans use it for design of new products

4.2.4. Benefits of QFD

More time spent on early stages = less time spent on later stages (re-designing).

a. Improves customer satisfaction
   - Defines requirements into basic needs
   - Fewer customer complaints

b. Reduces implementation time
   - Reduction in design changes
   - Expensive corrections and redesigns are eliminated

c. Promotes teamwork
   - Inputs are required from all facets of an organization

d. Provides documentation
   - Database serves as a valuable source for future designs

e. Increases in market share
f. QFD is a communication and planning tool that:
g. Promotes better understanding of customer demands
h. Improves customer satisfaction
i. Promotes team work
j. Facilitates better understanding of design interactions
k. Involves manufacturing in the design process
l. Breaks down barriers between functions and departments

m. Concentrates on design effort
n. Minimises the number of later engineering changes
o. Introduces new design to the market faster
p. Provides better documentation of the design and development process
q. Reduces the overall costs of design and manufacture

r. QFD process provides a structure to help managers to identify both expected quality and exciting quality and to focus process design and implementation specifically to meet these needs. Expected quality refers to statement of product traits that customers expect to find in a product. These traits usually represent order qualifiers or order losers. Customers may not appropriate them explicitly, but failure to meet these specifications cause customer dissatisfaction. In contrast, exciting quality refers to traits that customers do not expect. They do not notice lack of such traits, but special characteristics can excite them and induce them to choose one product over another. In general, excited quality enhances the value of a product, while expected quality maintains value.

s. QFD benefits companies through improved communication and teamwork between all constituencies in the production process, such as between marketing and design, between design and manufacturing and between purchasing and suppliers. Product objectives are better understood and interpreted during the production process

t. Use of QFD determines the cause of customer dissatisfaction, making it a useful tool for competitive analysis of a product quality by the top management.

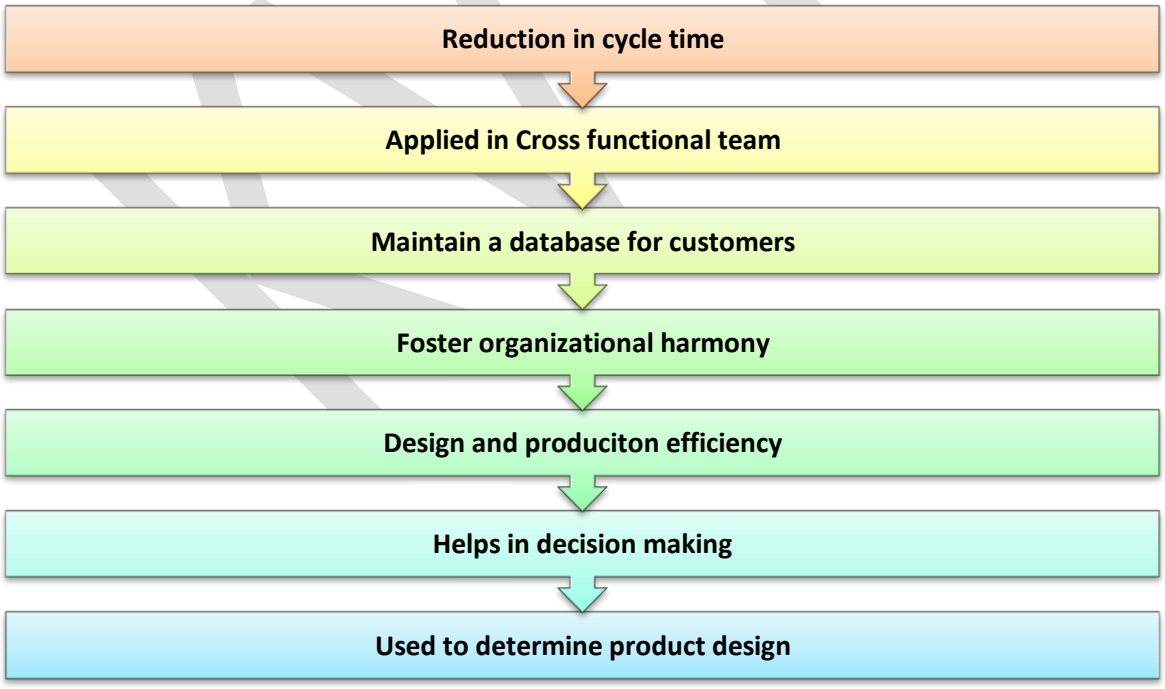
u. It improves quality and productivity, reduces the lead time for product development, lower product costs and reduces changes after the design stage.

v. It allows companies to simulate the effects of new design ideas and concepts

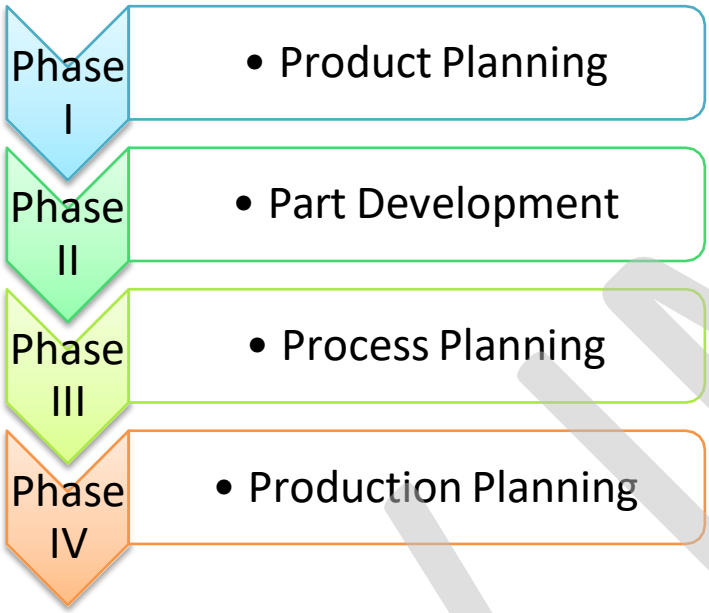
w. QFD process helps to integrate a firms TQM effort by unifying four major functional strategies: i) Marketing ii) Sales iii) Product design iv) operations management process

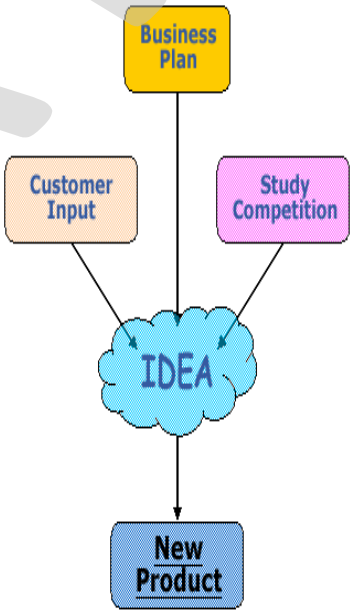
QFD has many demonstrable benefits especially for firms interested in achieving competitiveness, increasing market share, improving productivity and improving the bottom line.

Those companies that have adopted QFD have reported significant **cost reductions**.



QFD Process





Phase I – Production Planning

- Translate customer requirement into product technical requirements to meet their needs.
- Links user requirements to product attributes.

Phase II- Part Development

- Translate technical requirements to key part characteristics or systems.
- Subsystems broken down into critical part characteristics

Phase III- Process Planning

- Identify key process operations necessary to achieve key part characteristics.
- Relates single subsystems with production processes (critical step)

Phase IV- Production Planning (Process Control)

- Establish process control plans, maintenance plans, training plans to control operations.
- Define quality control steps to follow.

Limitations of QFD

- As with other Japanese management techniques, some problems can occur when one applies QFD within the western business environment and culture.
- Customer perceptions are found by market survey, if the survey is performed in a poor way, then the whole analysis may result in doing harm to find.
- The needs and wants of customers can change quickly nowadays. Comprehensive system and methodical thinking can make adapting to changed market needs more complex
- Subjectivity in the strength of relationships between the factors and the results
- There is always the need to input a large amount of data before estimating
- Requires substantial upfront investment
- Requires specialized training
- Misinterpretation
    - Mistaking product characteristics for customer requirements

- Often the answers given by customers are difficult to classify as needs

- Time and resource
  - Often seen as additional workload
  - Costly, the planning stage may take longer

- Constraints
  -Investment in training & market research and use of key functional representatives
  -Makes high demands on already stretched personnel resources

- Clash of culture
  -Based upon Japanese management practices
  -Symptoms of conflicts may include poor internal communications between functions
  -Lack of management commitment to the process.

Voice of customer

Voice of customer represents the requirements of the customer. Many a time the voice does not reach the appropriate persons in the supplier organization. Even if it reaches no action is taken. The employees in the supplier organizations modify the voice of customers to be in tune with their thoughts about the product or their own impressions on the product. if the customer voice is same as the receiving employee's ideas, then the employees feel happy and takes action to fulfill the customers requirements. If not the voice may be suppressed.

QFD is a technique to record every requirement expressed by the customer and take a conscious decision about the voice of the customers.

WHATs in QFD are the list of what the customer wants in the product or service, Many times, customers instead of bringing out their requirements, may tend to suggest a possible solution. It is more so in the area of software development. They would say that they want the implementation of the software in say oracle platform. This is not a requirement, but a solution. We have to take care to see that the requirements of the customer are captured and not their solution to the implementation.

Requirements elicitation

The starting point of QFD is to find the customer requirements of a product or service from a number of formal and informal channels. There are a number of sources of information for finding out customer requirements.

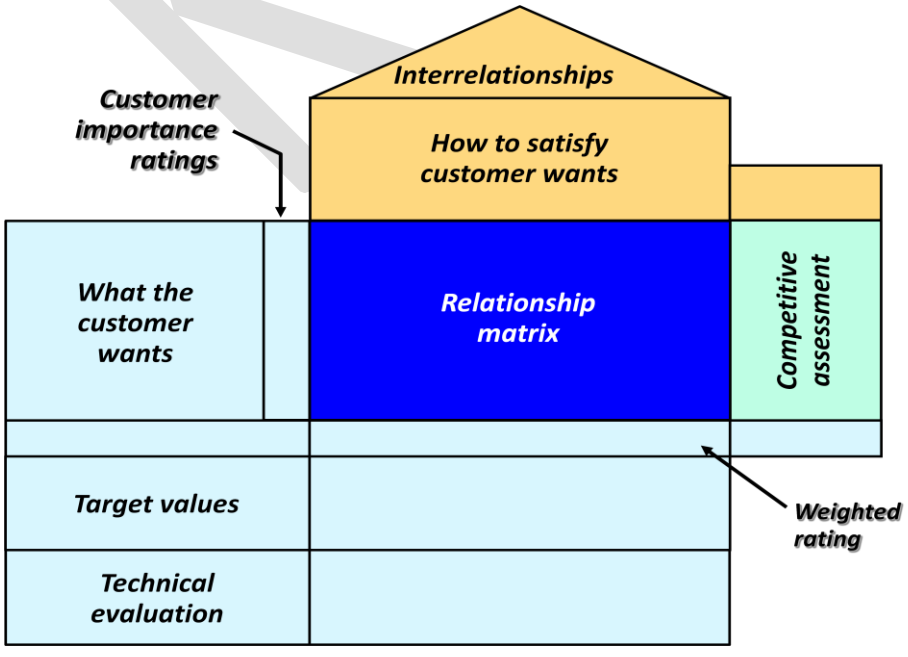
- Market survey from customers
- Information from sale team
- Information from service team

- Customer complaints
- Customer feedback
- Testing of product in lab
- Comparative analysis of competitive products
- Advertisement in news paper and journals of competitor.
- Customer direct feed back
- Product related exhibitions
- Uninformed visit to a customer visit
- Beta testing reports

HOUSE OF QUALITY

The primary planning tool used in QFD is the House Of Quality (HOQ). The house of quality converts the voice of the customer into product design characteristics. QFD uses a series of matrix diagram, also called „quality tables" that resemble connected houses.

Six sections of a basic house of quality matrix



The six sections of a basic house of quality matrix are:

1. **List Customer requirements(WHATs):**-a structured list of customer requirements

2. **List of Technical requirements (HOWs)**:-a structured set of relevant and measurable product or service characteristics.

3. **Develop Inter relationship matrix**:-illustrates the QFD team's perception of inter relationships between customer requirements and technical requirements. The degree of relationship is marked using symbols.

4. **Technical correlation(roof) matrix**:-used to identify where technical requirements support or impede each other in the product or service design

5. **Prioritize Customer Requirements (Planning matrix)**:-illustrate relative importance of customer requirements, perceptions, on company and competitor performance in meeting customer requirements. It also contains prioritizing customer requirements.

6. **Prioritized technical Descriptions.**

FAILURE MODE AND EFFECT ANALYSIS

- FMEA is an engineering technique used to define, identify and eliminate known and / or potential failures, problems, errors which occur in the system, design, process and service „before they reach the customer".

- Failure modes and effects analysis (FMEA) is a step-by-step approach to identify all possible failures in a design, a manufacturing or assembly process, or a finished product or a final service. "Failure modes" means the ways or modes, in which something may fail. "Failures" are errors or defects which affect the customer and can be potential or actual failures. "Effect analysis" refers to the study of the consequences or effects of those failures.

- Failure modes and effects analysis (FMEA) is also called as "Potential failure modes and effects analysis", or "failure mode, effects and critically analysis" (FMECA)

- FMEA is one of the tools of total quality management which helps in finding out the possible failure modes of a design, product, process or service and setting up ways of preventing their recurrences.

- It is a methodology to assess and reduce risk in systems, products or services. It aims to define, identify, prioritise and eliminate known or potential failures at an early stage as possible.

- FMEA is a preventive approach for systematically mapping the causes, effects and possible actions regarding the observed problems or failures

- FMEA is pro-active tool which is used to foresee the probable failures which can occur at a later stage. It involves critical analysis of each and every process with the aim of identifying problems which may emerge in the future.

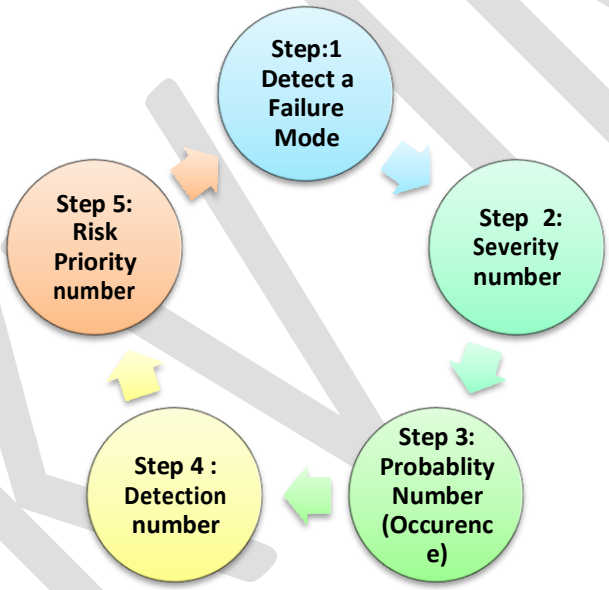
- The failures are prioritised according to how serious their consequences are, how frequently they occur and how easily they can be detected. FMEA helps to take actions to eliminate or reduce failures, starting with the highest priority ones. It also documents current knowledge and actions about the risks of failures, for use in continuous improvement.

- FMEA is used during design stage to prevent failures, before and during on going operation of the process for controlling the process. Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service

There are three factors for the identification of specific failures

- **Occurrence:** How often the failure occurs
- **Severity**: How serious the failure is
- **Detection:** How easy or difficult is to detect the failure.

Failure Mode Effect Analysis (FMEA)



The different steps of FMEA

1) **Select the team**
2) **Functional block diagram and / or process flowchart**
3) **Prioritize**
4) **Data collection**
5) **Analysis**
6) **Results**

7) **Confirm/evaluate/measure**

8) **Do it all over**

again Select the

team:-

Team members who are all willing to contribute are selected from various departments and put together to work on FMEA. After the team is selected, the opportunities of improvement are prioritized and the right direction to proceed is further identified.

Functional block diagram and / or process flowchart:-

Functional block diagram gives various details and helps in understanding of the system and design. Process flow chart focuses mainly on process and service. The function of both these tools is to make each team member to understand the system, design, process and service and the problems connected with them.

Prioritize:-

After understanding the problem, the team tries to find out the important segment and decide where to begin. The top management after analyzing customer complaints assists this process.

Data collection:-

Failure modes of FMEA are identified by collecting data about failures occurred so far in the company.

Analysis:-

The effect of a failure, its severity, detection and occurrence are identified by analyzing the information which is derived from the data.

Results:-

Results obtained from data analysis is used to quantify severity, detection and occurrence and from this RPN (Risk priority Number) is evaluated.

Confirm/Evaluate/Measure:-

This is used to evaluate the results of actions, which are suggested to improve the present condition. This is done by measuring the present condition with the past and the results may be that

the situation is better, same or worse

Do it all over again:-

- Since continuous improvement is the best method of eliminating errors, the above stated steps have to be repeated again and again.

- The ultimate aim of FMEA is to prevent each and every failure that may occur. Continuous improvement, involvement and perseverance are the important factors that help

- FMEA is not done by an individual but by a group of people. The result is the identification of failure modes. Such exercises bring out synergetic effect in the outcome. Points missed out by a few people will always be supplemented by others, making the analysis. As everyone involved in the process is taken into confidence and made to take part in the analysis, their interest and commitment are guaranteed. When one's ideas form a part of the decision they will voluntarily involve and strive for success. The probability of the occurrence of the failure is another factor to be considered by the team.

- After identifying the possible failures and their occurrence the extent of damage that the failure can cause to the system has to be estimated. This is done in the severity analysis. The group members with their background knowledge and with the help of the past data come to a consensus on the severity of each and every failure mode

identified. The more severe problems can be identified to be tackled first for the maximum benefit. However number is obtained. This has proved to be a workable and more beneficial strategy.

Requirements of reliability and FMEA

Reliability is the absence of failures in products and systems. Engineering is defined as the management function that prevents the creation of failures by people (such as systems, engineers, design engineers, production personnel, users and maintenance personnel). The ideal state of „absence of failures" is achieved in practice by preventing failures from occurring. This is only possible if there is a thorough understanding of all of the potential failure modes and then taking appropriate steps to prevent them from occuring. Understanding potential failure modes is achieved by analyzing and testing during both the design and the production phases of a project. To carry this methodology to its proper conclusion, the requirement of the reliability is needed because of the following reasons:

1. Not all problems are important

This is very fundamental to the entire concept of FMEA, because unless internalized; we are going to "chase fires" in the organization. We must recognize that some problems are more important

than others for whatever the reason. The fact is that some problems have indeed higher priority than others. FMEA helps identify this priority.

2. Knowing the customer

The definition of "customer" normally is thought of as the "end user". However a customer may also be defined as a subsequent as well as a service operation. When using the term customer from an FMEA perspective, the definition plays very major role in addressing problems.

3. Knowing the function

It is imperative to know the function, purpose, or objective of what you are trying to accomplish, otherwise you are going to waste time and effort in redefining your problem based on situations. If you have to, take extra time to make sure you understand the function or purpose of what you are trying to accomplish.

4. being prevention-oriented

Unless you recognize that continual improvement is in your best interest, the FMEA is going to be a "static" document to satisfy your customer or market requirements. The push for this continual improvement makes the FMEA a "dynamic" document changing as the design and / or process changes with the intent always to make a better design and / or process

4.4.3. Stages in FMEA process

1) Describe the product / process
2) Create a block diagram
3) Complete the header on the FMEA form worksheet
4) List items / functions
5) Identify failure modes
6) Document the failure mode
7) Describe the effects of failure modes
8) Identify the causes for failure
9) Enter the probability factor
10) Identify current controls
11) Determine the likelihood of detection
12) Review risk priority number (RPN)
13) Determine recommended action
14) Assign responsibility
15) Indicate actions taken
16) Update the FMEA

Describe the product / process:-

An understanding of the product or process under consideration is important to have clearly expressed. This understanding simplifies the process of analysis by helping the engineer identify those products / process uses that fall within the intended function and which ones fall outside.

Create a block diagram:

A block diagram of the product / process should be developed.

Complete the header on the FMEA form worksheet:

Product / system, subsystem / assembly, components, design lead, prepared by, date, revision, and revision date. Modify these headings as needed.

List items / functions:

Use the figure prepared above to begin listing items or functions.

Identify failure modes:

A failure mode is defined as the manner in which a component, system, process etc., could potentially fail to meet the design.

Document the failure mode:

A failure mode in one component can serve as the cause of a failure mode in another component. Each failure should be listed in technical terms. Failure modes should be listed for functions of each
component or process step. At this point, the failure mode should be identified whether or not the failure is likely to occur.

Describe the effects of failure modes:

For each failure mode identified, the engineer should determine what the ultimate effect will be. A failure effect is defined as the result of a failure mode on the function of the product / process as perceived by the customer. The customer might see or experience, if the identified failure mode occur. Establish a numerical ranking for the severity of the effect. A common industry standard scale uses 1 to represent no effect and 10 to indicate very severe with failure affecting system operation. The intent of the ranking is to help the analyst determine whether a failure would be a minor nuisance or a catastrophic occurrence to the customer. This enables the engineer to prioritize the failures and address the real big issues first.

Identify the causes for failure:

A failure cause is defined as a design weakness that may result in a failure. The potential cause for each failure mode should be identified and documented.

Enter the probability factor:

A numerical weight should be assigned to each cause that indicates how likely that cause is (probability of the cause occurring). A common industry standard scale uses 1 to represent not likely and 10 to indicate inevitable

Identify current controls:

Current controls are the mechanisms that prevent the cause of the failure mode from occurring or which detect the failure before it reaches the customer. The engineer should now identify testing, analysis, monitoring, and other techniques that can or have been used on the same or similar products / processes to detect failures. Each of these controls should be assessed to determine how well it is expected to identify or detect failure modes. After a new product or process has been in use, previously undetected or unidentified failure modes may appear. The FMEA should then be updated and plans made to address those failures to eliminate them from the product / process

Determine the likelihood of detection:

Detection is an assessment of the likelihood that the current controls (design and process) will detect the cause of the failure mode or the failure mode itself, thus preventing it from reaching the customer.

Review Risk priority number:

The risk priority number is a mathematical product of the numerical severity, probability and detection ratings:

RPN= (Severity)x(probability)x(detection)

The RPN is used to prioritize items that require additional quality planning or action

Determine recommended action:

Determine recommended actions to address potential failures that have a high RPN. These actions could include specific inspection, testing or quality procedures; selection of different components or materials; limiting environmental stresses; redesign of the item to avoid failure mode; monitoring mechanisms; performing preventive maintenance.

Assign responsibility:

Assign responsibility and a target completion date for these actions. This makes the responsibility clear-cut and facilitates tracking.

Indicate actions taken:

After these actions have been taken, re-assess the severity, probability and detection and review the revised RPN‟s

Update the FMEA:

Update the FMEA as the design or process changes, the assessment changes or new information becomes known.

4.4.4 Benefits of FMEA

FMEA is designed to assist in improving the quality and reliability of design and process. If properly used, the FMEA provides several benefits. These benefits include:

1) Increase in customer satisfaction:

Documents risk and actions taken to reduce risk

2) Elimination of potential:

Early identification and elimination of potential

I. Improve product / process reliability and quality product / process failure modes,
II. Prioritize product / process deficiencies

3) Logical approach:

Ensures a logical approach to assessing

- Emphasizes problem prevention design and processes,
- Provide focus for improved testing and development

4) Capture engineering / organization knowledge:

Minimizes late changes and associated cost

Limitations of FMEA

1. Tedious for complex systems
2. Human errors not included
3. Environmental factors

SEVEN NEW MANAGEMENT TOOLS

1) Affinity diagram

2) Inter-relationship diagram

3) Tree diagram

4) Matrix diagram

5) Matrix data analysis diagram

6) Process decision programme chart

7) Arrow diagram

Affinity diagram:-

Affinity diagram sometimes referred to as a KJ diagram, after the initials of the person who created this technique, Jiro Kawakita is a special kind of tool.

Affinity diagram is used to gather large amounts of ideas, opinions or issues and group those items that group together. So, it is a group-decision making technique designed to sort a large number of ideas, process variables, concepts and opinions into naturally related groups.

Purpose:

The purpose of an affinity diagram is to provide a visual representation of grouping of a large

number of ideas or factors or requirements into logical sets of related items to help one organise action- plans in a systematic manner.

Due to visual representation, one can easily understand the problem and its various solutions and impact, which, in turn, help implement the solutions with a clear understanding

Application:

It is a creative as well as logical process that enables the team-members to participate in an issue's solution rather than simply restating the problem. It is best done with six to twelve members. Due to its simplicity, it can be combined with other tools and put into a wide variety of applications.

Construction of affinity programme:-

- Identify the problem and phrase it without biases
- Brainstorm ideas and opinions, individually and record on the cards
- Sort cards into groups and discard those with no affinity
- Label the groups and organize the cards under them to form chart
- Analyze the results and plan action-points

Inter – relationship diagram:

Interrelationship diagram is a tool for finding causes to a problem. It not only clarifies the relationship between cause and effect but also between the various causes. Interrelationship diagraph is a graphical representation of all the factors in a complicated problem.

Purpose:

The purpose of the interrelationship diagraph is to generate a visual representation of the relations between an effect and its causes as well as the interrelationship between the different causes of the problem. In a fairly tangled situation, it is a powerful means of forcing a group to map out the interactions between factors and, usually, helps bring out the most important issues into focus.

Application:

The most common use is in problem-solving to identify multiple interrelated causes. The output of the tool is a list of root causes for the problem with some indication of their relative importance. The output has to be considered as only an indication of the relative importance of the causes. So, this tool can be used under the following circumstances:

- Identifying key or driver issues from a list of important issues
- Identifying the most important problems for solving when the number of problems exceeds the

  resources available to solve all of them
- Identifying the root cause of existing problems
- Identifying key factors needed to make a decision when there is insufficient information available to make a data-driven decision.

Tree diagram

Tree diagram is a tool used to generate the ideas for developing a list of alternative solutions to a problem. A team, when faced with a problem, first uses a cause-and-effect diagram or interrelationship
diagraph to determine the causes. After identifying the major causes for the problem, it collects data to confirm the causes that contribute most towards the problem. .

Purpose:

The purpose of the tree diagram is to explore the ways and means to achieve an objective, develop a list of alternate means to reach the desired situation in a sequential order and to present them in visual understandable form. In this way, tree diagram helps to generate a logical set of proposals at a number of levels, which turn a general problem into a set of possible actions.

Application:

Tree diagram is very useful when there are a number of options in response to a particular problem and one need to see what they all imply and involve. It helps one to develop a systematic, step- by-step, strategy to achieve an objective.

Construction of tree diagram:-

- State the problem to be studied

- Brainstorm all possible causes or Methods of addressing the problem
- Identify and list the primary, secondary and tertiary means from brainstorm
- Arrange and rearrange the elements in proper order in boxes

Matrix diagram

A matrix diagram is a tool that is used to systematically organise information that must be compared on a variety of characteristics in order to make a comparison, selection or choice. It is a tool which depicts the relations between two sets of factors in the form of a table or a matrix. Matrix diagram is, sometimes, referred to as a „quality table, and is the starting point in building a „house of quality".

Purpose:

The purpose of a matrix diagram is to explore the existence and the extent of relations between individual items in two sets of factors or features or characteristics and express them in a symbolic form that is easy to understand.

Application:

Matrix diagram, being a simple table showing relations between individual items in two sets of factors, can be put in wide variety of uses. The symbolic representation of the relationship makes the diagram much easier to understand as compared to a table with a lot of figures. Matrix diagram can be used to solve problems by arranging data in such a way that the relations between relevant factors are brought into sharp focus.

Matrix data analysis

Matrix data analysis is the only tool among the „new seven" which uses numerical data and produces numerical results. It is, somewhat, similar to a matrix diagram with a difference that numerical data is used instead of symbols indicating the existence and strength of relationship. With numerical data replacing the symbols, matrix data analysis is now really a table and some people prefer to call the tool as matrix data analysis method.

Purpose:

The purpose of matrix data analysis diagram is to present numerical data about two sets of factors in a matrix form and analyze it to get numerical output. The factors, most often, are products and product characteristics. The purpose then is to analyse the data on several characteristics for a number of products and use the information to arrive at optimum values for the characteristics for a new product or to decide the strong points of a product and use the information, say, for designing copy for the production of the product.

Application:

The most common application of a matrix data analysis diagram is to decide the desired product characteristics of a new product, based on the analysis of product characteristics of similar

products in the market and the intended positioning of the new product.

Construction of matrix data analysis:-

- Decide the two factors whose relations are to be analyzed
- Check the number of individual items in the two factors
- Prepare a matrix to accommodate all items of the two factors
- Enter numerical data in the matrix
- Analyze the final results

Process decision programme chart (PDPC)

Process decision programme chart is to map out conceivable and likely events and contingencies that can occur in any implementation plan along with appropriate and reasonable counter- measures. It is a planning tool. It forces proactive thinking on what can go wrong with one's plan and what would one do to overcome the effect of such adverse occurrences.

The tools help to anticipate undesirable occurrences and enable one to prepare with plants to neutralise their effect. It encourages negative thinking with a view to plan for achieving one's goals in spite of obstacles in one's path. Instead of thinking positively like, „do not worry; everything will be fine" and being surprised and shocked when something goes wrong, the tool encourages thinking of the worst than can happen and prepares one for it.

Purpose:

The purpose of process decision programme chart (PDPC) is to prepare for abnormal occurrences with low probability which may, otherwise, be overlooked and to present the occurrences as well as the necessary counter-measures to guard against such occurrences in the form of visual chart.

How do we construct it?

- First, prepare a „normal" flow chart of the process with all expected events as steps in the chart
- Identify the various possibilities of the process not going as per the plan due to any abnormal occurrences
- Write these occurrences on the flow chart through branching at appropriate locations
- Now identify the ways and means to counter the effect due to abnormal occurrences
- Writes these counter-measures in rectangles connecting the corresponding abnormal occurrence on one side and the process objective on the other.

Arrow diagram

An arrow diagram is a simplified kind of critical path analysis, especially developed for scheduling activities-particularly assembly operations. It is another term for a PERT or CPM chart. It is a graphic description of the sequential steps that must be completed before a project can be completed. It is essentially a planning tool that determines the critical path of a project or a process. Arrow diagram is a flow chart of the process or the project with few differences. In an arrow diagram, „event nodes" are stages which denote the completion of a step or a number of steps. The line connecting the event-nodes represents the step in the process. The time at each individual step is used to calculate the time by which it must be accomplished, at latest, to complete the process in time. It can also be used for assembly- operations.

Purpose:

The main purpose of the arrow diagram is to show the paths to complete a project, find the shortest time possible for the project and graphically display simultaneous activities. By the use of it, becomes easy to follow map of every activity in the cycle and schedule activities to meet the target cycle times.

Applications:

Arrow diagram is used under the following conditions:

1. Understanding and managing a complex project or task which is of major importance to the organisation and the consequences of late completion are severe

2. Understanding and managing a project in which multiple activities must take place and be managed, simultaneously, in a networked manner.

3. Scheduling, execution, expediting and explaining the project status to others.

Construction of arrow diagram:

- Identify and list each activity to be done in the project
- Determine the sequence of activities
- Construct a network reflecting the precedence relationships
- Write the activity time under arrow leading from it

SEVEN OLD STATISTICAL TOOLS

1. Histograms

2. Scatter diagrams and stratification
3. Pareto analysis
4. Check-sheets
5. Cause and effect diagram
6. Flow chart
7. Control

Charts 1.**Histograms**

- A bar chart is a graphical representation of discrete groups or categories of data, shown in such a way that clear comparisons can be easily made
- A bar chart is frequently used to emphasize the variation and unevenness in data. Using this information, further investigation could follow to determine why the Variation was occurring. The items are usually ranked from high to low, with the lengths of the bars indicating the value or frequency that a bar represents.

When do we use it?

A histogram is used to show clearly where the most frequently occurring values are located and the data is distributed.

- It is a tool for determining the maximum process results
- It enables the analyst to quickly visualize the features of a complete set of data

How do we construct it?

A histogram may be constructed using the following steps:

- After the data collection, count the number of data values collected
- Determine the range of the data
- Range = highest value – lowest value
- Divide the data values in groups or classes and count the number of values in each class
- Draw a frequency table for all values
- Construct a histogram based on the frequency table. For that, mark the class limits on the horizontal axis and the frequency on the vertical axis.
- Finally write the title and number of values on the

diagram.

2.**Scatter diagrams**

The scatter diagram was developed so that intuitive and qualitative conclusions could be drawn about the paired data or variables. The concept of correlation was employed to decide whether a significant relationship existed between the paired data. Furthermore, regression analysis was used to identify the exact nature of the relationship. Scatter diagrams are used to study possible relationship between two variables. Although these diagrams cannot prove that one variable causes the other, they do indicate the existence of a relationship as well as the strength of that relationship. A scatter diagram is composed of a horizontal axis containing the measured values of one variable and a vertical axis, representing the measurements of the other variable.

Purpose:

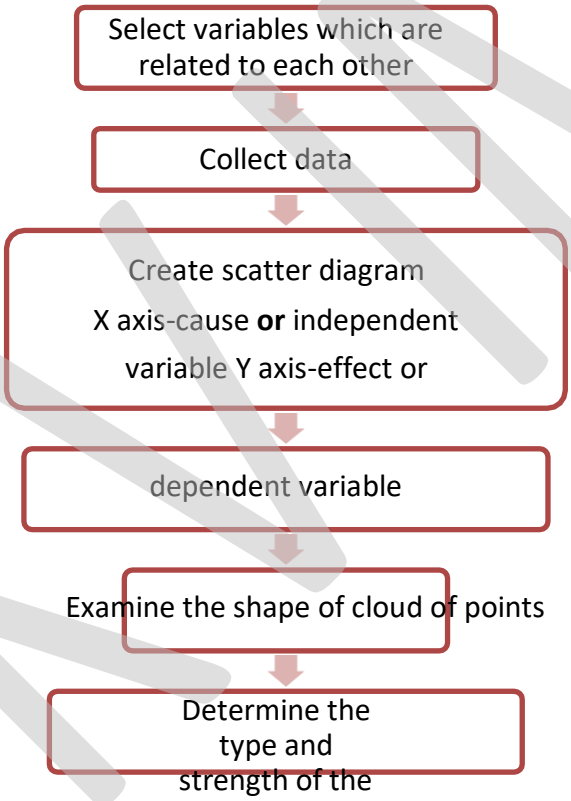
- The purpose of the scatter diagram is thus, to display what happens to one variable when

another variable is changed. The diagram is used to test a theory that the two variables are related. The type of relationship that exists is indicated by the slope of the diagram. In this way, scatter diagram is used to understand, why particular variations occur and how they can be controlled.

When do we use it?

- The purpose of the scatter diagram is, therefore, to display what happens to one variable when another variable is changed.
- This diagram is used to understand, why particular variations occur and how they can be controlled.

Steps to construct Scatter diagram



Determine the type and strength of the Mutual relationships

3.Pareto analysis

Pareto analysis is a prioritisation technique that identifies the most significant items among many. This technique implies that about 80% of the problems or effects are produced by 20% of the causes. Pareto analysis is a method of classifying items, events or activities according to their relative importance. It is frequently used in inventory management where it is used to classify stock items into groups based on the total annual expenditure for or total stockholding cost of, each item. Organisations can concentrate more detailed attention on the high value/important items. Pareto analysis is used to

arrive at this prioritisation.

Purpose:

Pare to analysis is a strong visual representation of how to prioritise problems and where to concentrate resources and attention for the best results. It can be used as a risk assessment technique. Pareto analysis yields broad, quantitative results that are graphically depicted on simple bar charts and, depending on the information analysed, it generally requires some form of data tracking.

Applications:

Pareto analysis can be used in a wide range of situations where there are a number of variables contributing to a problem and one need to know which are the most important.

- It is most often used to rank activity or system accidents/failures
- It can be used to rank the causes that contribute to defects
- It is also used to evaluate the risk improvement that results from activity or system modifications with „before" and „after" data

How can we construct it?

- Obtain data, using a check sheet
- Arrange the data in descending order starting from the largest category to smallest
- Draw a bar chart with two vertical axes. Along the vertical axis, mark the measured values for each cause, starting from zero till the total number of causes. The different kinds of causes along the horizontal axis, from left to right in descending order of frequency or costs
- Draw a bar above each item whose height represents the number for that cause

- 4. **Check-sheets**

A check sheet also known as tally sheet, is a form for systematic data gathering and registering to get a clear view the facts. It is used to keep track of how often something occurs.

Types of check sheets:

Process distribution check sheet: This check sheet is used to collect on process variability

Defective item check sheet: This check sheet is intended to specify the variety of defects occurring, together with their frequency of occurrence

Defect location check sheet: This check sheet is intended to identify where defects occur on the product

Defect factor check sheet: This check sheet is used to monitor the input parameters in a process that might affect the incidence of defects.

5.Cause and effect diagram

- The cause and effect diagram is a graphical-tabular chart to list and analyze the potential causes of a given problem.

- The cause and effect diagram is also called the fishbone diagram because of its appearance and the Ishikawa diagram

When do we use it?

The CE diagram is used:

a. To analyze cause and effect relationships
b. To facilitate the search for solutions of related problems
c. To standardize existing and proposed operations
d. To educate and train personnel in decision-making and corrective action activities

How do we construct it?

The cause and effect diagram may be constructed using the following steps:

- Define the effect (the problem) clearly and concisely
- Mark the short description of the effect in a box. Then draw a line from this box towards left.
- List down all the possible minor and major causes
- Mark the major causes on the branches and minor causes on the sub-branches on the CE diagrams
- Look for possible solutions for these causes
- Introduce the changes

6.**Flowchart**

Flowcharts are pictorial representations of a process. By breaking the process down into its constituent steps, flowcharts can be useful in identifying where errors are likely to be found in the system

7.Control charts

- A control chart is a graph that displays data taken over time and the variations of this data.
  - A histogram gives a static picture of process variability, whereas a control chart illustrates the dynamic performance of the process.
- The control chart is based on a series of random samples taken at regular intervals
- The chart consists of three horizontal lines that remain constant over time: a centre, a lower control limit (LCL), and on upper control limit (UCL). The centre is usually set at the normal design value
- If a sample drawn from the process lies inside these (UCL and LCL) limits, it means the process is in control. On the other hand, if sample lies outside these limits, then the process is said to be out of control. So appropriate corrective action is necessary to eliminate the condition.Types of control charts
- **Control charts for variables:** for measurable data such as time, length, temperature, weight, pressure etc
- **Control charts for characteristics:** for quantifiable data such as number of defects, typing errors in a report etc.

When do we use it?

The purpose of a control chart is to identify when the process has gone out of statistical control, thus signaling the need for some corrective action to be taken.

BENCHMARKING

Benchmarking is the process of determining who is the **very best,** who sets the standard, and what that standard is. Benchmarking can provide them with data to show what can be achieved and how can be achieved. Thus benchmarking is a systematic method by which organizations can measure themselves against the best industry practices.

- In more conventional terms, benchmarking can be defined as measuring an organization's performance against that of best-in-class companies, determining how the best-in-class achieve those performance levels.

- The essence of benchmarking is the process of borrowing ideas and adapting them to gain competitive advantage. Therefore it is a tool for continuous improvement.

Definition of Benchmarking

American productivity and quality centre has defined the benchmarking as "the process of identifying, understanding, and adapting outstanding practices and process from organizations anywhere in the world to an organization to improve its performance"

Reasons (objectives of benchmarking)

- Benchmarking aims at a goal setting process to facilitate comparison with the best
- It aims at motivating and stimulating company employees towards the goal of continuous quality improvement
- It aims at external orientation of the company
- It aims at identifying a technological breakthrough
- It aims at searching for industry best practices

Types of benchmarking

1. Classification based on the object to be benchmarked:

a) Product benchmarking

- This refers to comparison of different features and attributes of competing products and services
- It is done through either engineering analysis or through analyses of perception of customers
- It is also called as „customer satisfaction benchmarking" or „customer valueprofiling"
- It can help in identifying activities where improvement is possible

b) Performance benchmarking:

- This refers to comparison of performance indicators related to a business as a whole or to the group of critical activities or processes
- It measures all the different kinds of system performance variables such as efficiency,

effectiveness, productivity, quality, flexibility, profitability etc.

- It is a very important tool to identify different functional areas where scope for improvement is high

- It also provides external feedback to the concerned persons involved in the process or in any of the constituent activities.

C) Process benchmarking:

This refers to comparison of process and it identifies a more effective and efficient process to be implemented

d) Strategic benchmarking:

- This refers to examining competitive position in the market place
- It helps the company to study the business strategy for becoming more competitive

2. Classification based on the organisations against whom one is benchmarking

a) Internal benchmarking:

It refers to comparison of performance between departments, plants, subsidiaries, etc., within the organization.

b) Industry benchmarking:

It refers to comparison of performance by the organization producing the same class of products and services

c) Competitive benchmarking:

It refers to comparison of performance against direct competitors

d) Relationship benchmarking:

It refers to comparison of performance with the benchmarking company which already has relationship like customer-supplier relations, joint venture arrangement, etc.

Benchmarking process

Steps in benchmarking process

Phase I: Planning

Step1: What can be benchmarked? (i.e; deciding what to benchmark)

Benchmarking can be applied to any business or production process. During this step, determine which functions, tasks, processes, or activities within the own organization will be subjected to benchmarking. Appoint a benchmarking team will pilot the activity within the organisation. In this stage, formulate the project goals; determine the data to be collected; and prepare a tentative list of questions.

Step2: To whom or what shall we compare? (i.e., identifying benchmark partners)

Identify the world-class or leading edge companies that have a similar product or process. Important criteria for the selection of benchmark partners are: The partners should be outstanding (best- in-class) regarding the benchmark subject; competitiveness of activities; and availability of reliable information about the partners.

Step-3: Determine data collection method and collect data

Gather both qualitative and quantitative data about the process performances of partners based on interviews, surveys, and consultation of contacts and technical magazines

Phase II: Analysis

The analysis phase involves a careful understanding of current process practices as well as those of benchmarking partners. This phase consists of the following two steps:

Step4: Determine the current performance gap

Determine the gap between the performance level of the organization and that of its benchmark partner. After the data is gathered, measured, and analyzed, compare these to the data of the own organization. Based on this, determine the current performance gap between the own organization and that of the benchmark partner.

Step5: Project future performance levels

The gap is a projection of performance. Therefore the performance will change as industry practices change. So keeping the future in mind, project the performance levels.

Phase III: Integration

Integration is the process of using benchmark findings to get operational targets for change. It involves careful planning to incorporate new practices in the operation and ensures that benchmarking findings are incorporated in all formal planning process. This phase consists of the following two steps:

Step6: Communicate benchmark findings and gain acceptance

Demonstrate the benchmark findings to the management for their acceptance. Communicate the benchmark findings to all organizational levels to obtain support, commitment and ownership

Step7: Establish functional goals

On the basis of communicated data and acceptance of analysis, establish the functional goals and achieve them through the benchmarking process

Phase IV: Action

The action phase encompasses the following three steps:

Step8: Develop action plans

Transform the functional goals into concrete action plans. The action plans should answer the following questions: when should, which action, with which, goal to be implemented?; How can changes successfully implemented?; Who does that?; In which way?; Who is responsible for the

implementation of the different actions?

Step9: Implement specific actions and monitor the progress

This step relates to the execution of improvement actions and introduction of changes. Constantly monitor the implementation of actions of successful execution

Step10: Recalibrate benchmarks

The updating may require the recalibration of the competitive benchmarking data. Since benchmarking is a continuous quality improvement tool, recalibrate the benchmarks again and again.

Phase: Maturity

Maturity phase would be reached when best industry practices are incorporated in all business processes. This maturity phase is reached through the following two steps:

Step11: Attain the leadership position

Step12: Integrate practices into the

process

Benefits of benchmarking

The benefits of competitive benchmarking include:

- Creating a culture that values continuous improvement to achieve excellence
- Sharing the best practices between benchmarking partners
- Prioritizing the areas that need improvement
- Enhancing creativity by devaluating the not-invented-here syndrome
- Increasing sensitivity to changes in the external environment
- Shifting the corporate mind-set from relative complacency to a strong sense of urgency for ongoing improvement
- Focussing resources through performance target set with employee unit

POKA-YOKE

Poke yoke is a Japanese term which means “fail-safing” or “mistake-proofing”. Poka-yokes are mechanisms used to mistake-proof an entire process. Ideally, poka-yokes ensure that proper conditions exist before actually executing a process step, preventing defects from occurring in the first place. Where this is not possible, poka-yoke means perform a detective function, eliminating defects in the process as early as possible.

Why is it important?

Poka-yoke helps people and processes work right the first time. Poke-yoke refers to techniques that make it impossible to make mistakes. These techniques can drive defects out of

products and processes and substantially improve quality and reliability. It can be thought of as an extension of FMEA. The use of simple poka-yoke ideas and methods in product and process design can eliminate both human and technical errors

When to use it?

Poka-yoke can be used wherever something can go wrong or an error can be made. It is a technique, a tool that can be applied to any type of process be it in manufacturing or the service industry. Errors are many types:

- Processing error: Process operation missed or not performed per the standard operating procedure
- Setup error: Using the wrong tooling or setting machine adjustments incorrectly.
- Missing part: Not all parts included in the assembly, welding, or other processes.
- Improper part / item: Wrong part used in the process
- Operations error: Carrying out an operation incorrectly having the incorrect version of the specification.
- Measurement error: Errors in machine adjustment, test measurement or dimensions of a part coming in from a supplier.

Poka yoke framework

1. Prevention-Based poke-yokes

Prevention-based mechanisms sense an abnormality that is about to happen, and then signal the occurrence or halt processing, depending on the severity, frequency or downstream consequences.

There are two approaches for prevention-based poka-yokes

(i) **Control method:** This method senses a problem and stops a line or process, so that corrective action can take place immediately, thus avoiding serial defect generation. **Examples:** an example of this, is an assembly operation wherein, if one of the components is found to be missing before the actual assembly step takes place, then the process shuts down automatically. Another example is an incomplete sales order, which cannot be released for production until a true manufacturable configuration is defined.

(ii) **Warning method:** This method signals the occurrence of a deviation or trend of deviations through an escalating series of buzzers, lights or other warning devices. However, unlike the control method, the warning method does not shut down the process on every occurrence. This method is used when a bandwidth of acceptance exists, for a process. **Example:** An example of this is pressurising a vessel or a filling operation, in which the results need not be, exactly the same. Although the process continues to run, the poka-yoke signals the operator to remove a defect from the line, or make necessary adjustments to keep the process within control.

2. Detection-based poka-yokes

In many situations, it is not possible or economically feasible to prevent defects, particularly where the capital cost of the poka-yoke mechanism, far exceeds the cost of prevention. For these situations, defects are detected early in the process, preventing them from flowing to downstream processes and multiplying the cost of non-conformance

The three categories of detection-based poke-yokes are as follows:

(i) **Contact method:** This method detects any deviation in shape, dimensional characteristics or other specific defects, through mechanisms that are kept in direct contact with the part.

(ii) **Fixed value method:** This method is used in operations, in which a set of steps is sequentially performed. The fixed value method employs automatic counters or optical devices and controls the number of moves, rate and length of movement as well as other critical operating parameters.

(iii) Sometimes this is referred to as odd part out method, in which parts left over after assembly signal a defect. Fixed value also indicates critical condition detection (pressure, temperature, current, etc) through electronic monitoring devices.

(iv) (iii) **Motion step method:** This method ensures that a process or operator does not mistakenly perform a step that is not part of the normal process

How to use it?

Step by step process in applying poka-yoke are given below:

Step 1: Identify the operation or process, based on a pareto

Step 2: Analyze the 5-whys and understand the ways a process can fail

Step 3: Decide the right poka-yoke approach, such as using (i) a shut out type (Preventing an error being made), or (ii) an attention type (highlight that an error has been made) poka-yoke

Step 5: Take a more comprehensive approach instead of merely thinking of poka-yoke as limit switches, or automatic shutoffs. A poka-yoke can be electrical, mechanical, procedural, visual, human or any other form that prevents incorrect execution of a process step.

Step 6: Determine whether a (i) contact-use of shape, size or other physical attributes for detection; (ii) constant number-error triggered if a certain number of actions are not made; (iii) sequence method-use of a checklist to ensure completing all process steps; is appropriate.

Step 7: Trial the method and see if it works.

Step 8: Train the operator, review performance and measure success

Benefits of poka-yoke

Some of the important benefits experienced by poka yoke are as follows:

- Improved productivity
- Reduced inspection time
- Poka yoke is the fastest way to zero defects
- It acts as a key enabler for efficient manufacturing
- It virtually eliminates scrap, rework and repair
- The cost of quality control using mistake-proofing is substantially less expensive than traditional alternatives
- Minimized inventory
- Increased customer satisfaction and customer loyalty.