UNIT III-TQM TOOLS AND TECHNIQUES -I

The seven 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.

SEVEN TOOLS OF QUALITY (Q-7 TOOLS) ?

Prof. Ishikawa proposed seven elemental tools based on statistical techniques.

The seven basic tools are used to facilitate successful accomplishment of quality improvement objectives.

Seven tools of quality are:

1. check sheets,
2. Histograms,
3. cause and effect diagrams,
4. pare to diagrams,
5. stratification analysis,
6. scatter diagrams, and
7. Control charts.

Check sheet:

A check sheet also known as tally sheet is a form for systematic data gathering to get a clear view of the facts.

Histograms:

A histogram is a bar chart showing a distribution of variable quantities or characteristics.

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 after the man who developed it in 1943

Pareto diagram:

A pareto diagram is a diagnostic tool commonly used for separating the vital few causes that account for a dominant share of quality loss.

Stratification analysis:

Stratification is a method of analysis of data by grouping it in different ways. Literally stratification means segregating a group of measurements, observations or any other data in to several subgroups on the basis of certain characteristics.

Scatter diagram:

The scatter diagram is a simple graphical device to depict the relationship between two variables. A scatter diagram is composed of a horizontal axis containing the measure values of one variable and a vertical axis, representing the measurements of the variable.

Control chart:

A control chart is a graph that displays data taken over time and the variations of this data. The control chart is based on a series of random samples taken at regular intervals.

MANAGEMENT TOOLS

Why?

It is a simple and effective tool. This approach focuses on the process (to reveal the causes), rather than the people.

Example: Why was there a delay in dispatch of good?

Cutting tool failed, resulting in delay in manufacture.
Why? The tools were reused?
Why? Ordered tool were not delivered?
Solution changes the dispatch schedule, if ever the tools were not delivered.

Forced Field Analysis

Readers' attention is invited to the discussion in Chapter 2 on this topic.

Nominal Group Technique

This technique provides for ideas input from every one in the team and for effective decision making.

A team wants to decide upon a current complaint to attend. Every one in the team writes the problem on a paper, what they think is most important. They are listed in a chart and then the team members are asked to rank, from most important to least important. The ranking are given a numerical value starting from, say, on a 10 to 1 scale. Points for each problem is totaled and the ones with highest number of points, is considered o be the most important.

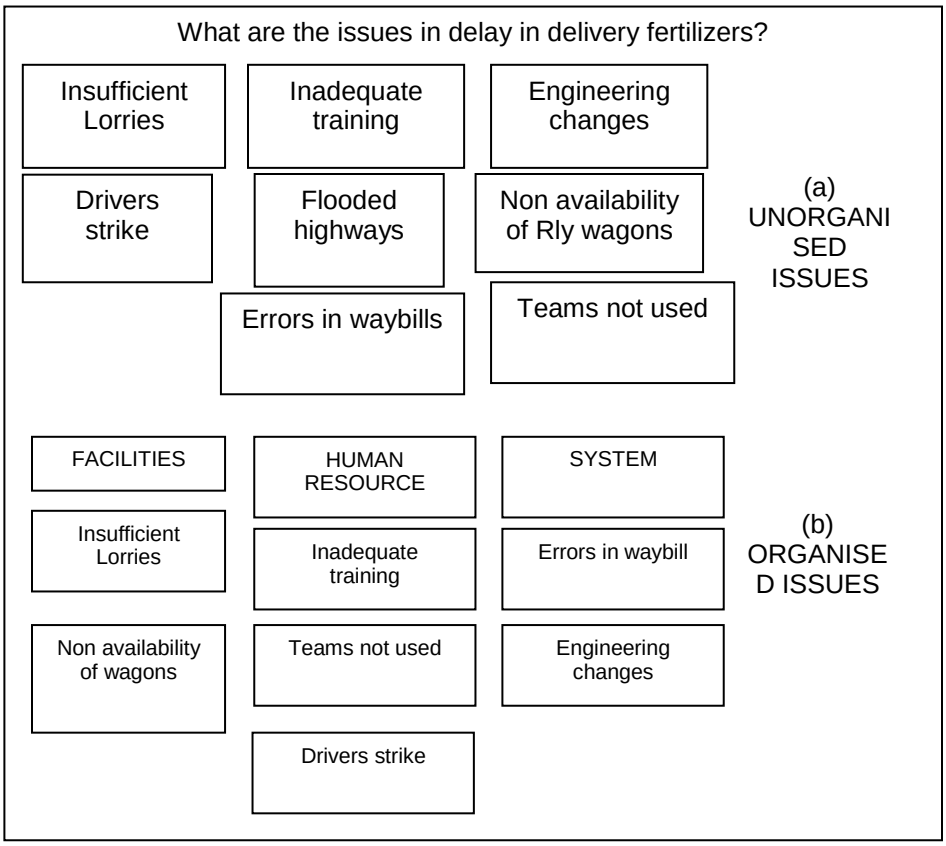
MANAGEMENT AND PLANNING TOOLS

Affinity Diagram

This diagram permits the team to creatively generate large number of ideas and then group them logically for understanding and possible solutions.

In this procedure, the issue is stated in full, then brainstormed using short sentences, posted them for the team to see. The ideas are sorted into logical groups and finally brief headings for each group are identified. The affinity diagram encourages team creativity, break down barriers, promote breakthroughs and motivate ownership of the process. Figure shows a typical example of this approach.

Affinity diagram



Inter-Relationship Diagram

This method is useful in clarifying the relationship in complex situations. The team will be able to classify the cause and effect relationship, so that the key elements can be used to solve the problems.

Steps:

The team agrees on the statement of the problem.

Different ideas or issues from other methods are initially listed and named with alphabets, A B etc.

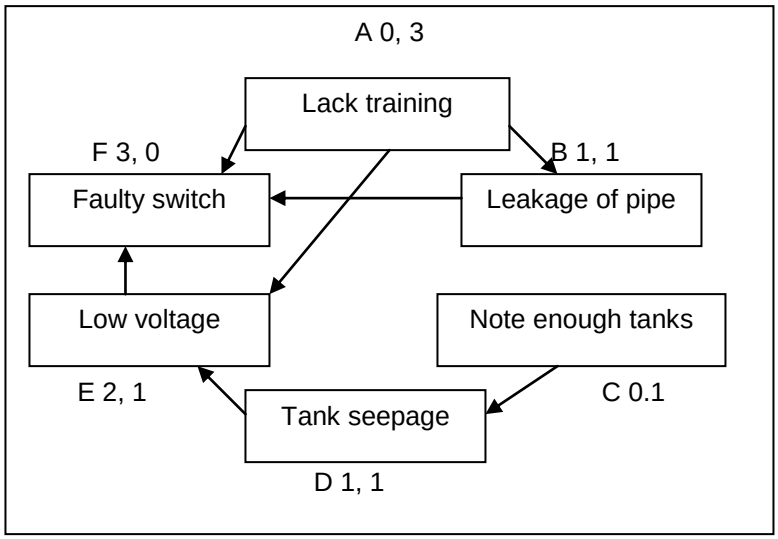
Begin with the issue A, and evaluate the cause and effect relationship with B. If A is stronger, draw the arrow A to B, by a thick line. Each issue is compared with A, one by one. Draw thick arrows wherever strong influence is identified. In this example, only issues B, E and F have relationship with A. The first trial is now over.

Second iteration is to compare B with issues C, D, E and F. The third step is to compare C with other issues. The fourth is compare issue D with E and F. The fifth step is to compare issue E with F.

The diagram may be reviewed and revised, if necessary.

The incoming and outgoing arrows are recorded as indicated, above the rectangle block. The completed diagram is shown in figure.

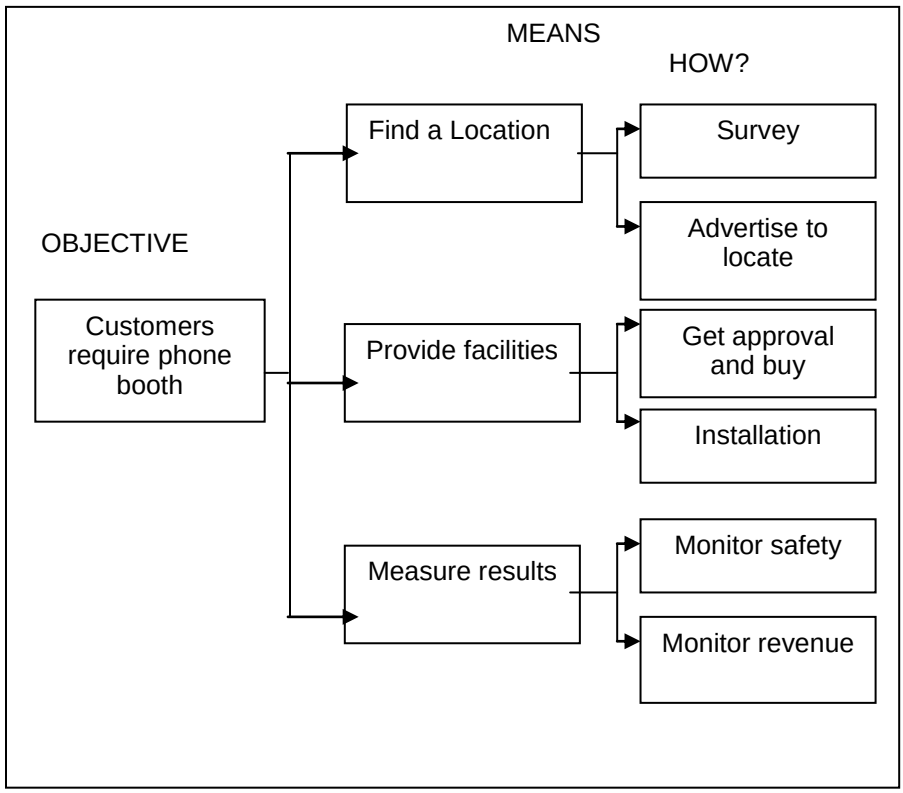
The issue with highest outgoing arrows (A), is the root cause and the issue with highest incoming arrows (F), is the critical issue. This method encourages the team work and effectiveness in identifying major problem and the root cause, to tackles further the problem.



Tree Diagram

In the first step, the objective is traced from the interrelationship diagram, brainstorming and team participation. Using further brainstorming, major means are identified.

In the next step, the next level details are generated for study and solution. The question, "What is need next?" is repeated to two three levels, to complete the diagram. The diagram may be reviewed to find, if any actions are ignored or the action will yield expected results. An example of this approach is shown in figure. The merit of this method is that it encourages the team work and thoroughness.



Matrix Diagram

The Matrix diagram helps to identify, analyse and rate the relationship among the variables. Data can be presented in tabular form, with numerical values or otherwise. Quality function Deployment, is a typical example of the matrix diagram. The standard formats that are used are: for 2 variables, L shaped; for 3 variables, T shaped, Y shaped and C shaped and for 4 variables, X shaped. L shaped matrix diagram for 2 variables are most frequently used.

Matrix diagram for uses of seven management tools

Tool	Use creativity	Analysis	Consen-sus	Action
Affinity diagram	⊙		O	Δ
Interrelationship diagram				
Tree diagram		O	⊙	
Prioritisation matrix		⊙		⊙
Matrix diagram			O	
Process decision		O	⊙	O
Program chart				
Activity network	⊙	⊙	⊙	O
Diagram			⊙	O

The seven management tools are presented in Table as matrix diagram. The steps involved in its construction are:
select the appropriate format

Determine the relationship symbols. Numerical values may be added when necessary
Complete the matrix, by analyzing each cell and insert appropriate symbol.

The matrix diagram approach encourages lateral thinking by the team, in terms of the relationships, their strengths and patterns.

Prioritization Matrix

In this method the issues, tasks, and characteristics are prioritized, based on weighted criteria, using a combination of tree and matrix diagram techniques. This is the most difficult, of the tools discussed.

Steps:

Construct an L shaped matrix combining the options, which are then lowest level of detail of the tree diagram with the criteria.

Determine the implementation criteria, using the nominal group technique or any other technique, with proper weight age criteria. Each team member submits the most important criteria on a piece of paper. They are listed on as flip chart and the team members submit the rank in another paper, ordering those listed criteria on the chart. Those criteria with greatest value are the most important. Three or four criteria are chosen.

Prioritize the criteria using the NGT. Each team member weighs the criteria so the total weight equals 100%. The results are shown in Table.

Table: Weightage for different criteria

Criteria	Member A	Member J	Member M	Total
Low cost	30	25	35	155
Easy to implement	40	30	30	210
Technology permits	15	20	25	100
Customer preference	20	25	20	110

Using NDT, the options are ranked, in terms of importance by each criterion; the results are averaged, and rounded to the nearest integer.

Compute the option importance score under each criterion, by multiplying the rank by the weight age of criteria. The details are shown in Table. The options with the highest total are those that should be implemented first.

Table: Improvement of a process by consensus criteria method

	CRITERIA								
Options	**Low cost**		**Easy to implement**		**Technology permits**		**Customer preference**		**Total**
1. Train supervisor	10x1.55	+	12x2.10	+	8x1.0	+	9x1.1		58.6
2. Purchase trucks	12x1.55	+	8x2.10	+	9x1.0	+	7x1.1		52.1
3. Have teams of 4 men	8x1.55	+	7x2.10	+	10x1.0	+	6x1.1		43.7
4. Training clerks	6x1.55	+	6x2.10	+	8x1.0	+	5x1.1		35.4

Process Decision Program chart

The Process decision program chart avoids unexpected developments and identifies possible counter measures. Figure shows an example of this technique.

Level 1 objective		**Plan Seminar**			
Activities	Call for paper & acceptance	Registration	Conduct Proceedings		Boarding & Lodging
Level 2 What if?	Power Supply fails	Minister arrives Late	Printed proceedings arrived late		Too long Session
	|	|	|	|	|
Level 3 counter Measures	Have a stand by generator	Gave the collector to Inaugurate	Start the session	Send it by Post	Produce the present action

Initially the team states the objective that is to plan a successful industrial seminar. Those activities are listed in the first level, which are, call for papers, screening and acceptance, registration, and conduct proceedings and arranging Boarding and lodging facilities. The activity of conducting the

proceedings is explained hereinafter. The team is brainstormed to determine what could go wrong with the seminar proceedings, and these are shown in Level 2 i.e., 'what if level'. Countermeasures are discussed and listed in the last level. Now the countermeasures are evaluated and the optimal ones are selected and marked O, and rejected ones are marked, X, as shown in the figure.

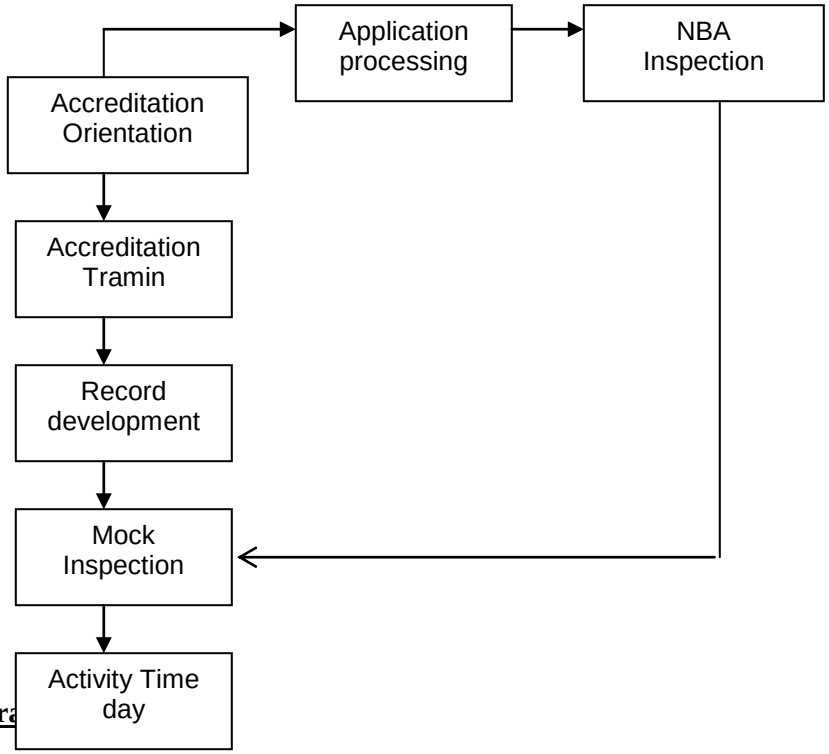
This method is preferred if the task is new or unique, complex, or potential failure has great risks. It provides a means to effectively minimize uncertainty in implementation stage.

Activity Network Diagram

PERT, CPM, and Arrow diagram are the typical variations of this diagram. They allow the team to schedule the project efficiently. The details such as the critical path, project completion time, simultaneous tasks, and precedence relationships are obtained from this diagram.

Steps:

- The team brainstorms or documents all the activities to complete the project.
- The first task is identified and fixed on the extreme left of the board.
- The tasks done simultaneously are placed in parallel.
- Steps (b) and (c) are repeated until all the tasks are located on the board in correct sequence, as shown in figure.
- Number all activities and draw the corresponding arrows. Activity times are recorded in the lower left box. It may be hours, days, weeks or months.
- Find the critical path, after completing the details of box in each activity.



Activity Network Diagra

The critical path is the path along which all the activities are completed in the minimum time. The advantages of this method are:

a. A realistic project execution time is determined.

b. Bottlenecks are identified and when necessary, corrective actions can be planned.

c. Focus is made on the activities lying in the critical path. Time-cost trade off can be worked out, to complete the project earlier, with optimum additional cost.

SIX SIGMA
WHAT IS SIX SIGMA?

- **Six sigma** stands for six standard deviation from mean (sigma is the Greek letter used to represent standard deviation in statistics).
- Six sigma, similar to Zero Defect (ZD), is a philosophical benchmark or standard of excellence proposed by Philip Crosby.
- Six sigma methodology provides the techniques and tools to improve the capability and reduce the defects in any process.
- It was started by Motorola in 1987, in its manufacturing division.
- Six sigma strives for perfection. **It allows for only 3.4 defects per million opportunities (or 99.999666 percent accuracy).** Here a defect can be anything from a faulty party to an incorrect customer bill.
- Six sigma improves the process performance, decrease variation and maintains **consistent quality** of the process output. This leads to defect reduction and improvements in profits, product quality and customer satisfaction.
- Six sigma incorporates the basic principles and techniques used in business, statistics and engineering.

The objective of six sigma principle is to achieve zero defects products/process. It allows 3.4 defects per million opportunities.

WHY DO WE NEED SIX SIGMA?

(Three sigma quality is not enough. Why?)

We know that, the three sigma quality, i.e., the natural variability $(\bar{x} \pm 3\sigma)$ is equal to tolerance (= upper specification limit – lower specification limit). It means, in normal distribution curve, only 0.27% of the output would be expected to fall outside the specifications limits.

The real meaning of 3σ concept: A medium aircraft consists of 10,000 different parts. At 3σ quality, 27 of those parts in an assembled aircraft would be defective. So three sigma quality level cannot be accepted as good enough quality level. So we have to increase the sigma level (i.e., reducing the number of defectives). In fact, even four sigma quality also not sufficient for the aircraft case. That's why six sigma quality level is preferred than 3σ and 4σ quality levels.

THE CONCEPT OF SIX SIGMA

Before studying the concept of six sigma, first let us re-introduce the concept of process capability ratio (C_p)

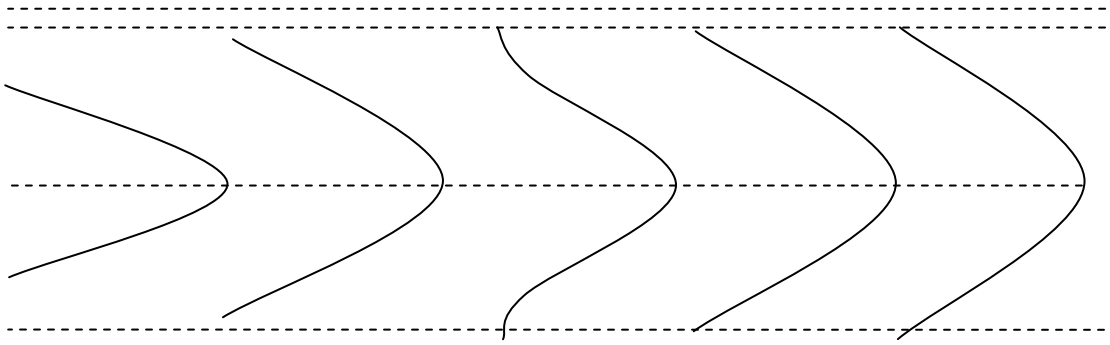
Process capability ratio,

$$C_p = \frac{\text{Design width}}{\text{Process width}} = \frac{USL - LSL}{UCL - LCL}$$

USL = Upper Specification Limit;
LSL = Lower Specification Limit,

(Assumption is that process is centered midway the specification limits, i.e., there is no shift in process mean)

Process capability ratio measures how well the product requirements match with the process capabilities. The higher the value of Cp' the better the match between product and process.



Different Cp values with different process spreads (σ's)

Process variability	C_p	Total amount outside limits	Typical actions to be taken
2σ	0.67	4.56% (45500 ppm)	Heavy process control, sorting rework, etc.
3σ	1.0	2700 ppm	Heavy process control, inspection
4σ	1.33	64 ppm	Reduced inspection, selected use of control charts

5σ	1.67	1 ppm	Spot checking, selected use of control charts
6σ	2	0.001 ppm	Reduced need for control, uniformity in process inputs

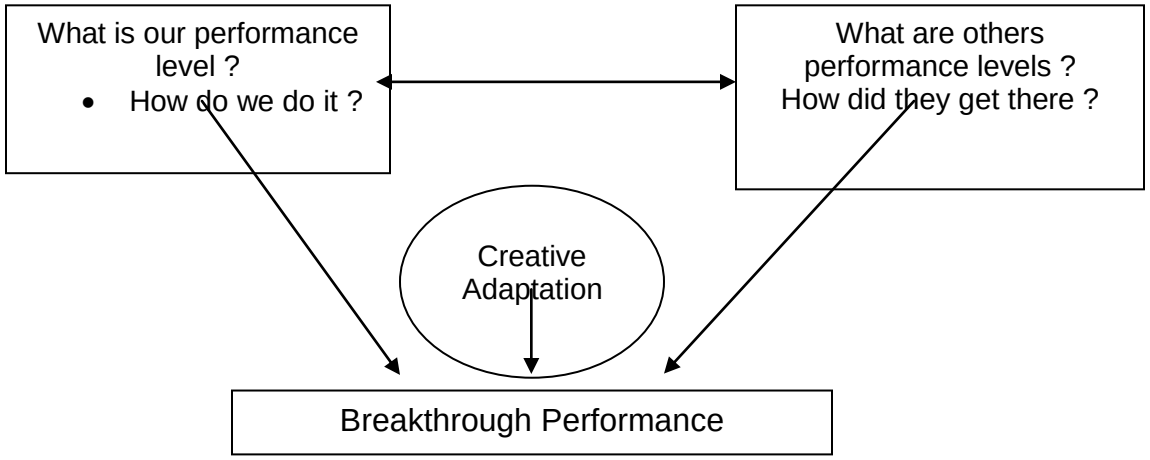
USL - Upper Specification Limit LSL – Lower Specification Limit

BENCHMARKING

Benchmarking is a systematic method by which organizations can measure themselves against the best industry practices.

- Benchmarking is a systematic search for the best practices, innovative ideas, and highly effective operating procedures.

BENCHMARKING CONCEPT



REASONS TO BENCHMARK :

- It is a tool to achieve business and competitive objectives
- It can inspire managers (and Organizations) to compete
- It is time and cost effective
- It constantly scans the external environment to improve the process
- Potential and useful technological breakthroughs can be located and adopted early

PROCESS OF BENCHMARKING

The following six steps contain the core techniques of Benchmarking

1. **Decide what to benchmark**
   - Benchmarking can be applied to any business or production process
   - The strategy is usually expressed in terms of mission and vision statements

- Best to begin with the mission and critical factors
- Choosing the scope of the Benchmarking study
- Pareto analysis – what process to investigate
- Cause and Effect diagram – for tracing outputs back

2. Understand current performance

- Understand and document the current process
- Those working in the process are the most capable of identifying and correcting problems
- While documenting, it is important to quantify
- Care should be taken during accounting information

3. Plan

- A benchmarking team should be chosen
- Organizations to serve as the benchmark need to be identified
- Time frame should be agreed upon for each of the benchmarking tasks

There are three types of benchmarking

a. Internal
b. Competitive
c. Process

4. Study Others

Benchmarking studies look for two types of information

- How best the processes are practiced
- Measurable results of these practices

Three techniques for conducting the research are

- Questionnaires
- Site visits
- Focus groups

5. Learn from the data

Answering a series of questions like

- Is there a gap between the organization's performance and the performance of the best-in-class organizations?
- What is the gap? How much is it?
- Why is there a gap? What does the best-in-class do differently that is better?
- If best-in-class practices were adopted, what would be the resulting improvement?

Benchmarking studies can reveal three different outcomes

- Negative gap
- Parity
- Positive gap

6. Using the findings

The objective is to close the gap. For this

- Findings must be communicated to the people within the organization
- Action plans must be developed to implement new processes

Groups that must agree on the change

- Process owners
- Upper management

Steps for the development and execution of action plans are

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

PITFALLS AND CRITICISMS OF BENCHMARKING :

- Idea of copying others
- It is not a cure or a business philosophy
- Some process have to be benchmarked repeatedly
- It is not a substitute for innovation

FMEA(FAILUR MODE EFFECTIVE ANALYSIS)

FMEA is an analytical technique that combines the technology and experience of people in identifying foreseeable failure modes of a product or process and planning for its elimination.
FMEA is a "before-the-event" action requiring a team effort to easily and inexpensively alleviate changes in design and production.
It is a group of activities comprising the following :

1. Recognize the potential failure of a product or process.
2. Identify actions that eliminate / reduce the potential failure.
3. Document the process.

Two important types of FMEA are

- Design FMEA
- Process FMEA

Types of FMEA

There are several types of FMEA : design FMEA, process FMEA, equipment FMEA, maintenance FMEA, concept FMEA, service FMEA, system FMEA, environmental FMEA, and others.

Failure Mode?

A **Failure Mode** is:

- The way in which the component, subassembly, product, input, or process could fail to perform its intended function
- Failure modes may be the result of upstream operations or may cause downstream operations to fail
- Things that could go wrong

Why

- Methodology that facilitates process improvement
- Identifies and eliminates concerns early in the development of a process or design

- Improve internal and external customer satisfaction
- Focuses on prevention
- FMEA may be a customer requirement
- FMEA may be required by an applicable Quality System Standard

INTENT OF FMEA :

- Continually measuring the reliability of a machine, product or process.
- To detect the potential product - related failure mode.
- FMEA evaluation to be conducted immediately following the design phase.

BENEFITS OF FMEA:

- Having a systematic review of components failure modes to ensure that any failure produces minimal damage.
- Determining the effects of any failure on other items.
- Providing input data for exchange studies.
- Determining how the high-failure rate components can be adapted to high-reliability components.
- Eliminating / minimizing the adverse effects that failures could generate.
- Helping uncover the misjudgements, errors etc.
- Reduce development time and cost of manufacturing.

Methodology used for FMEA.

FMEA Procedure

1. For each process input (start with high value inputs), determine the ways in which the input can go wrong (failure mode)

2. For each failure mode, determine effects
    - Select a severity level for each effect
3. Identify potential causes of each failure mode
    - Select an occurrence level for each cause
4. List current controls for each cause
    - Select a detection level for each cause
5. Calculate the Risk Priority Number (RPN)
6. Develop recommended actions, assign responsible persons, and take actions
    - Give priority to high RPNs
    - MUST look at severities rated a 10
7. Assign the predicted severity, occurrence, and detection levels and compare RPNs

FMEA Inputs and Outputs

- Severity ,Occurrence, and Detection

- Severity-Importance of the effect on customer requirements
- Occurrence-Frequency with which a given cause occurs and creates failure modes
- Detection-The ability of the current control scheme to detect or prevent a given cause

Rating Scales

- There are a wide variety of scoring "anchors", both quantitative or qualitative
- Two types of scales are 1-5 or 1-10
- The 1-5 scale makes it easier for the teams to decide on scores
- The 1-10 scale may allow for better precision in estimates and a wide variation in scores (most common)

Rating Scales

- **Severity** 1 = Not Severe, 10 = Very Severe
- **Occurrence** 1 = Not Likely, 10 = Very Likely
- **Detection** 1 = Easy to Detect, 10 = Not easy to Detect
- Risk Priority Number (RPN)
- RPN is the product of the severity, occurrence, and detection scores.

Summary

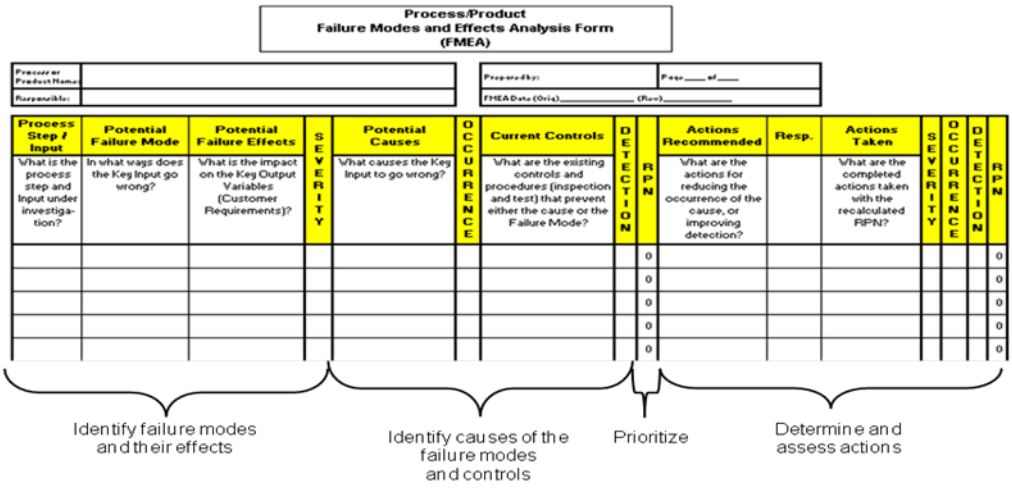
An FMEA:

- Identifies the ways in which a product or process can fail
- Estimates the risk associated with specific causes
- Prioritizes the actions that should be taken to reduce risk

Example Process FMEA document.

The basic philosophy behind process FMEA document is shown in the following document. Process FMEA is an analytical Technique utilized by a manufacturing Responsible Engineering Team as a means to assure that , to the extent possible, potential failure modes and associated causes /mechanisms have been considered and addressed

The FMEA Form



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Process or Product Name:	Using a Cell Phone	Prepared by: Ed the Expert	Page 1 of 1
Responsible:	Phyllis the Phone Owner	FMEA Date (Orig): February 22, 2006	(Rev): March 11, 2006

Process Step/Input	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Recommended	Resp.	Actions Taken	PSEV	POCC	PDET	PRPN
What is the process step/ Input under investigation?	In what ways does the key input go wrong?	What is the impact on the key output variables (customer requirements) or internal requirements?	How severe is the effect to the customer?	What causes the key input to go wrong?	How often does cause or failure mode occur?	What are the existing controls that prevent either the cause or the failure mode?	cause/failure before next step?		What are the actions for reducing the RPN. Should have actions only on high RPN's or easy fixes.	Who is responsible for the recommended action?	What actions have been taken and date completed?				
Make a call	Battery is dead	Can not make the call	7	Long calls on long drives	10	-Reminder beep -Battery symbol	7	490	Car phone charger	Phyllis		7	1	7	49
Make a call	Poor signal	Call interrupted with static	5	Out of phone range	3	-Antenna symbol -Stay in range	7	105	New phone service	Ed		5	1	7	35
Receive a call	Poor signal	Call interrupted with static	5	Out of phone range	3	-Antenna symbol -Stay in range	7	105	New phone service	Ed		5	1	7	35
Make a call	Battery is dead	Can not make the call	7	Bad battery will not hold charge	1	None	10	70				7	1	10	70
Receive a call	Battery is dead	Can not receive call	7	Bad battery will not hold charge	1	None	10	70				7	1	10	70
								0							0

FMEA TEAM :

Engineers from

- Assembly, Manufacturing, Materials, Quality, Service, Supplier, Customer

FMEA DOCUMENTATION :

The purpose of FMEA documentation is

- To allow all involved Engineers to have access to others thoughts

- To design and manufacture using these collective thoughts (promotes team approach)