19ME72
Quality Engineering & Management

Chapter – 2
Quality Engineering & TPM
(QE & TPM)

Course Coordinator

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Course content

19ME72 - QUALITY ENGINEERING AND MANAGEMENT

ASSESSMENT: THEORY

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COURSE OBJECTIVE

To know about basicaspects and tools related to quality engineering and management.

COURSE OUTCOMES

At the end of the course, the students will be able to

CO1: *Outline the quality engineering system with various types of evaluation of loss function.*

CO2: *Analyze the characteristics and schedules in preventive maintenance along with various quality tools.*

CO3: *Design on-line quality control system for various production environments by considering feedback and various process control parameters.*

CO4:*Define quality management axioms and implement Deming philosophy along with action plans.*

CO5:*Demonstrate and implement various quality management tools.*

Course content

Quality Engineering and Loss Function . **(9)**

Quality value and engineering- overall quality system-quality engineering in product design - quality engineering in design of production processes - quality engineering in production - quality engineering in service.Derivation – loss function for products/system- justification of improvements- loss function and inspection- quality evaluations and tolerances-N type, S type, L type

Quality Engineering and TPM **(9)**

Preventive Maintenance (PM) schedules- PM schedules for functional characteristics- PM schedules for large scale systems. Quality tools–fault tree analysis, event tree analysis, failure mode and effect analysis.ISO quality systems.

On-Line Quality Control **(9)**

On-line feedback quality control variable characteristics-control with measurement interval- one unit, multiple units-control systems for lot and batch production. On-line process parameter control variable characteristics- process parameter tolerances- feedback control systems- measurement error and process control parameters.

Course content

Quality Management **(9)**

Definitions of the terms – quality planning, quality control, quality assurance, quality management, total quality management as per ISO 8402 – overview on TQM – the TQM axioms – Commitment – scientific knowledge – involvement Consequences of total quality. Six sigma, C_p, C_{pk}, P_{pk} Deming's fourteen points on quality management – five DDs – implementing the Deming philosophy - action plan – the Deming cycle – Case study.

Techniques in Quality Management **(9)**

Kaizen and innovation – the kaizen management practices – Total Quality Control (TQC) — small group activities – quality circles – Comparison of Kaizen and Deming's approach with illustration. Affinity diagram – brain storming – cause and effect analysis –check list– flow charts – Pareto analysis – quality costing – Quality Function Deployment (QFD) – Training of quality – self managing teams.

TOTAL : 45

Course content

TEXT BOOKS

1. De Feo J A and Barnard WW, "Six Sigma: Breakthrough and Beyond", Tata McGraw-Hill, New Delhi,2005.

2. Pyzdek T and Berger R W, "Quality Engineering Handbook", Tata-McGraw Hill, New Delhi, 1996.

3. LogotheticsN ., —Managing for total quality – From Deming to Taguchi and SPC — , Prentice hall Ltd, New Delhi, 1997.

4. Juran J.M &Gryna F.M., —quality Planning and Analysis – From Product development through usel,TataMcGrawHill Publishing Limited, new Delhi, 3rd Edition , 1995

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1. KaniskaBedi, "Quality Management", Oxford University Press, Chennai, 2007.

2. Brue G, "Six Sigma for Managers", Tata-McGraw Hill, New Delhi, Second reprint, 2002.

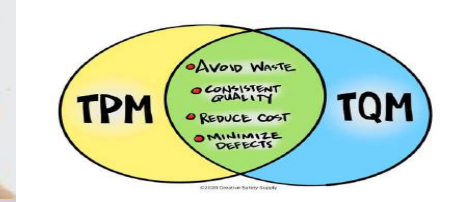
3. Taguchi G, Elsayed E A and Hsiang, T.C.,"Quality Engineering in Production Systems", Mc-Graw-HillBook company, Singapore, 1989.

4. Deming W E, —Out of the Crisis," MIT Press, Cambridge, MA, 1982.

5. Juran J M and Juran on —Leadership for Quality" An Executive Handbook, The Free Press, New York,1989.

6. Salor J.H., —TQM-FleldManual,‖ McGraw Hill, New York, 1992.

7. Crosby P.B., — Quality is Free,‖ McGraw Hill, New York, 1979



Quality Engineering and TPM (9)

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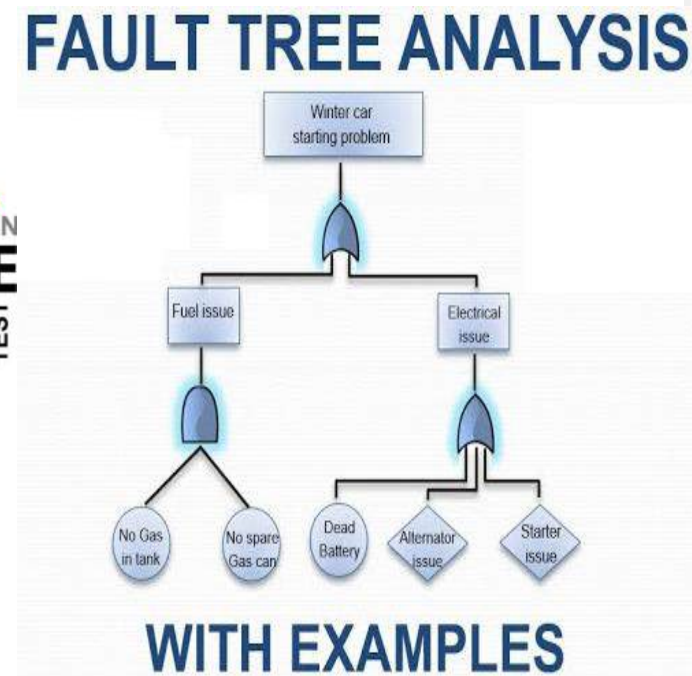
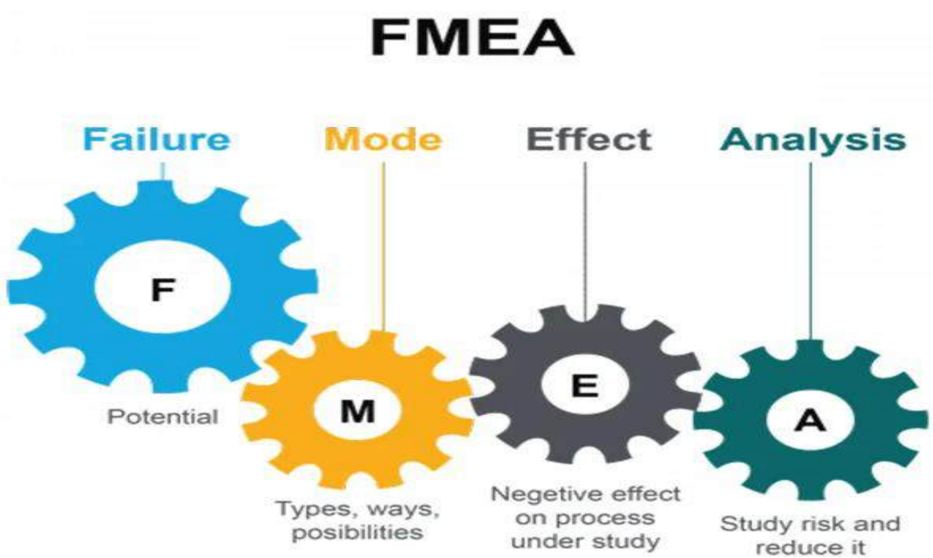





Quality Engineering
Process Thinking
Customer Satisfaction
Total Employee Commitment
Team Work and Quality Chain
Strategic and systematic approach
Integrated-System
Decisions based on Fact
Continuous improvement
Effective Communications
Training

QE & TPM – Various tools in QE

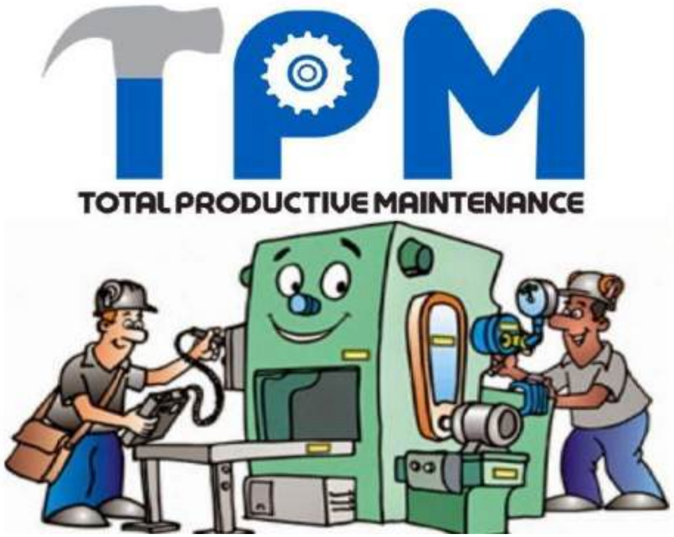
- Pareto Diagram
- Fishbone/Ishikawa Diagram
- Check Sheet
- Process Flow Diagram
- Scatter Diagram
- Histogram
- Control Chart
- Acceptance Sampling
- Random Sampling
- Reliability
- Quality Function Deployment
- ISO Series
- Benchmarking
- Total Productive Maintenance
- Management and Planning Tools
- Lean/Kaizen
- Quality Issues
- Six Sigma
- Design of Experiments (DOE)
- Process Analysis Tools
- FMEA / Fault tree / Event tree analysis

QE & Total Productive Maintenance (TPM)

- TPM is keeping the plant and equipment at its highest level through cooperation of all areas of the organization.
- The first part of TPM involves breaking down the barriers between maintenance & production personnel so they are working together.
- A common objective of TPM is peak performance or total productivity.

What is TPM

- It is a method for continuously improving the effectiveness of production equipment or manufacturing processes through the involvement of all people in the organization



QE & TPM

TPM – A company wide, team-based effort to improve output quality through equipment care and to improve overall equipment effectiveness

Total

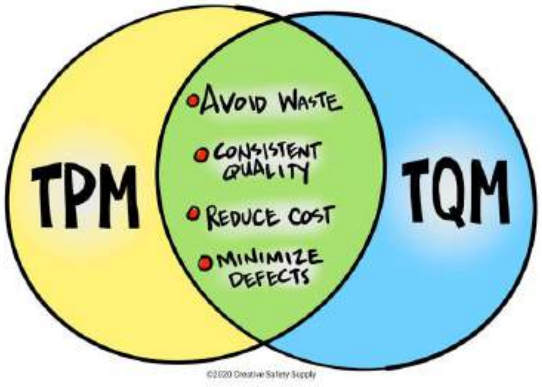
- All employees are involved
- Aims to eliminate all accidents, defects, and breakdowns

Productive

- Actions performed during production
- Troubles for production are minimized

Maintenance

- Keep in good condition
- Improve Overall Equipment Effectiveness (OEE)



Meaning of TPM

T-TOTAL

- Total efficiency
- Total life cycle of production system
- Total manpower coverage

P-PRODUCTIVE

- Productivity maximization by:
  - Zero accident
  - Zero defect
  - Zero break dowm

M-MAINTENANCE

- Maintenance covers life cycle of production system:
  - Individual processes
  - Plants
  - Prod. Mgt. System

QE & TPM

- Origins TPM is an original Japanese administrative approach.
- TPM is a innovative Japanese concept, and the origin of TPM can be traced back to 1951, when preventive maintenance was introduced in Japan.
- Concept of preventive maintenance was taken from the United States.
- Nippondenso was the 1st company to introduce plant wide preventive maintenance in 1960.
- The need to go further than preventive maintenance was quickly recognized by those companies who were committed to TQM.

QE & TPM

- TPM was originated with the systematic improvement of these principles by the president of Japanese Institute of Plant Maintenance (JIPM) Seichi Nakajima in 1971.
- As a result TPM originated in order to cover the shortcomings of TQM in the maintenance area.

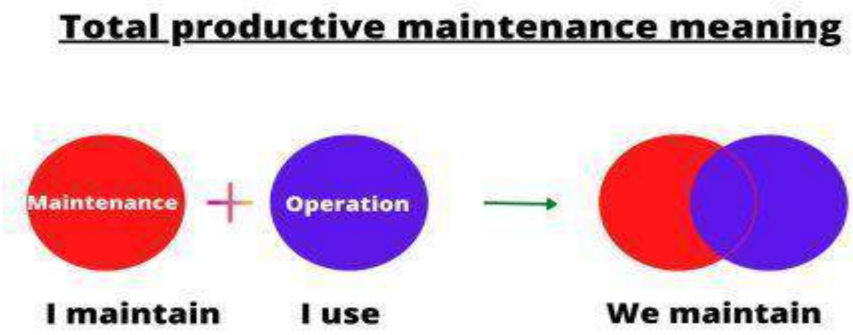
QE & TPM

- The goal of TPM is to maintain equipment so it will be able to achieve 100% on-demand availability for immediate use by the next process or customer.
  - Equipment breakdowns, unplanned downtime
  - Scrap/rework
  - Reduced productivity
  - Equipment start-up losses
  - Set-up time

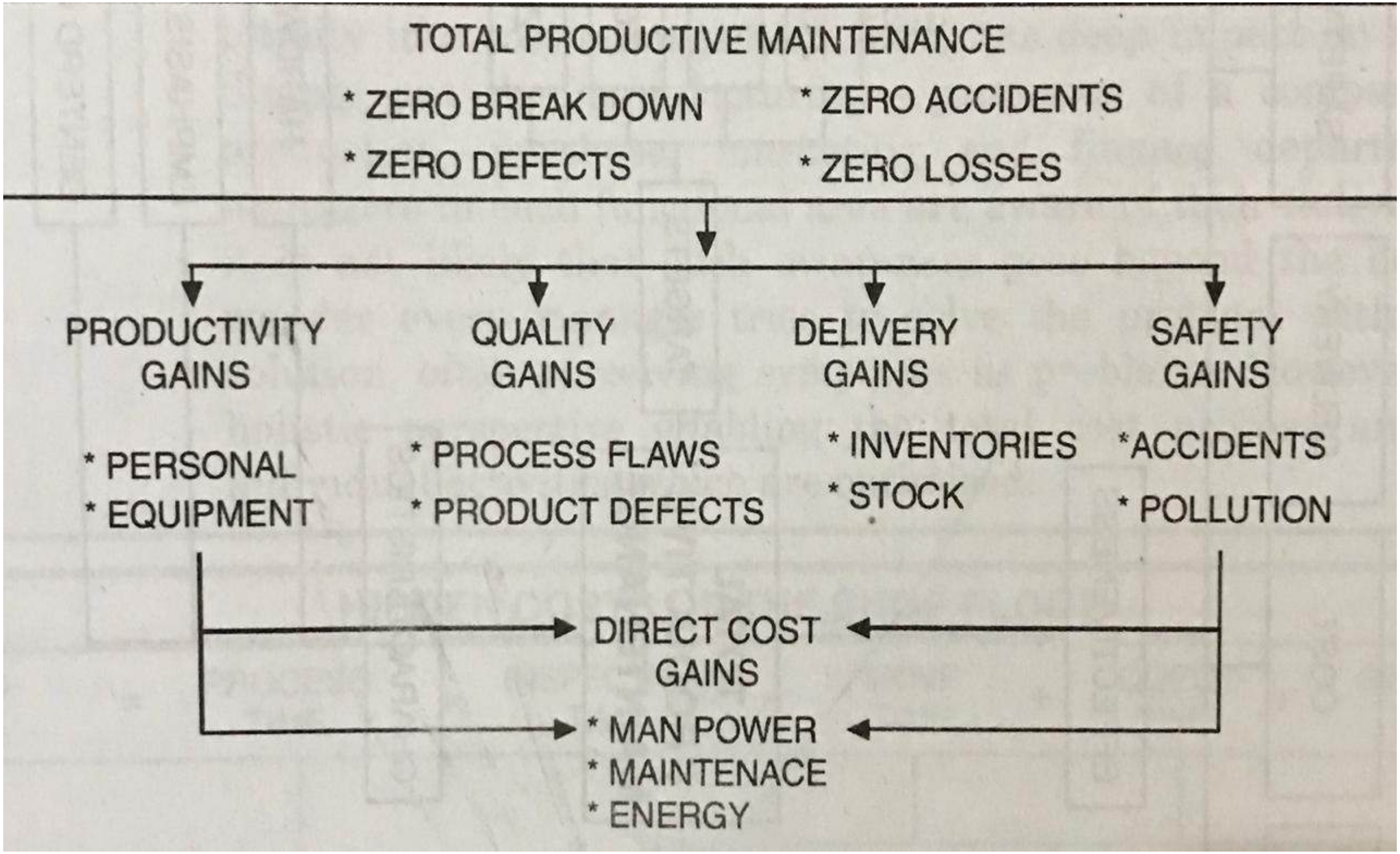
QE & TPM

TPM's other goals are :

- Having a clean, tidy and safe work place
- Keeping machines and tools in good condition
- Having a say in what goes on in your cell/area
- Getting things done Making life easier - being in control
- Working in a 'smart' way
- Owning and having a pride in your machines/cell/area
- Teamwork – production and maintenance
- About making machines as 'effective' as possible



QE & TPM


TOTAL PRODUCTIVE MAINTENANCE
* ZERO BREAK DOWN
* ZERO ACCIDENTS
* ZERO DEFECTS
* ZERO LOSSES
PRODUCTIVITY GAINS
QUALITY GAINS
DELIVERY GAINS
SAFETY GAINS
* PERSONAL
* EQUIPMENT
* PROCESS FLAWS
* PRODUCT DEFECTS
* INVENTORIES
* STOCK
*ACCIDENTS
* POLLUTION
DIRECT COST GAINS
* MAN POWER
* MAINTENACE
* ENERGY

Reactive vs. Proactive

- Reactive
  - Putting out fires
  - Getting it out the door
  - Customer “needed it yesterday”
  - Building it “just in case”
- Total Productive Maintenance is Proactive
  - Preventative maintenance – maintain to prevent breakdowns
  - Predictive maintenance – schedule maintenance based on Mean Time To Failure (MTTF)

5 TPM Principles

1. Improve Overall Equipment Effectiveness (OEE)
2. Improve operators in daily maintenance
3. Improve maintenance efficiency and effectiveness
4. Train all personnel
5. Establish early equipment management and maintenance prevention programs

TPM Prerequisites

1. Must be measuring OEE
2. 5S workplace organization

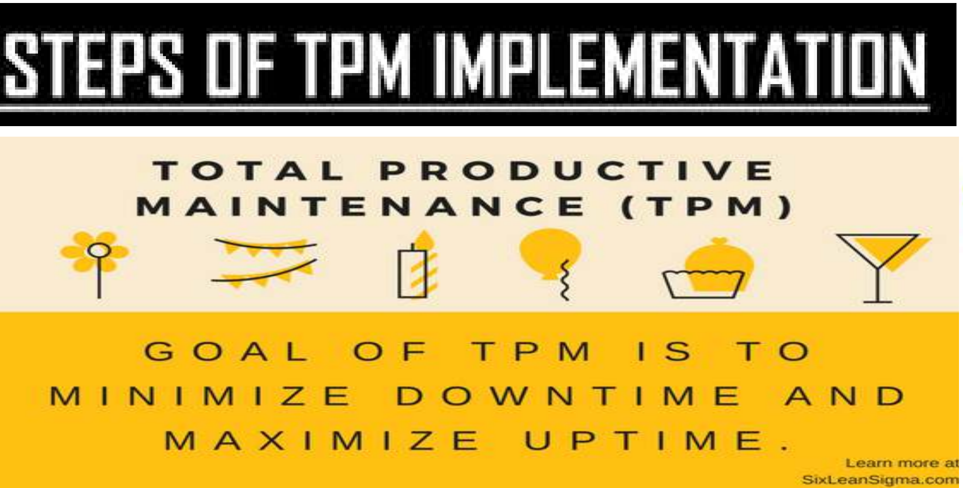
QE & TPM – Steps in Implementing TPM

<u>Steps in Implementing TPM</u>

Step A - Preparatory Stage

Step B – Introduction Stage

Step C – Implementation Stage



QE & TPM – Steps in Implementing TPM

TPM - Step A - Preparatory Stage

Step 1:

- Announcement by management to all about TPM introduction in the organization.
- Proper understanding, commitment and active involvement of the top management in needed for this step.
- Senior management should have awareness programs, after which announcement is made to all.
- Publish it in the house magazine and put it in the notice board.
- Send a letter to all concerned individuals if required.

STEPS OF TPM IMPLEMENTATION

TPM - Step A - Preparatory Stage

Step 2:

- Initial education and propaganda for TPM.
- Training is to be done based on the need.
- Some need intensive training and some just an awareness.
- Take people who matters to places where TPM already successfully implemented

Step 3:

- Setting up TPM and departmental committees.
- TPM includes improvement, autonomous maintenance, quality maintenance etc., as part of it.
- When committees are set up it should take care of all those needs.

STEPS OF TPM IMPLEMENTATION

TPM - Step A - Preparatory Stage

Step 4:

- Establishing the TPM working system and target.
- Now each area is benchmarked and fix up a target for achievement.

Step 5:

- A master plan for institutionalizing.
- Next step is implementation leading to institutionalizing wherein TPM becomes an organizational culture.

QE & TPM – Steps in Implementing TPM

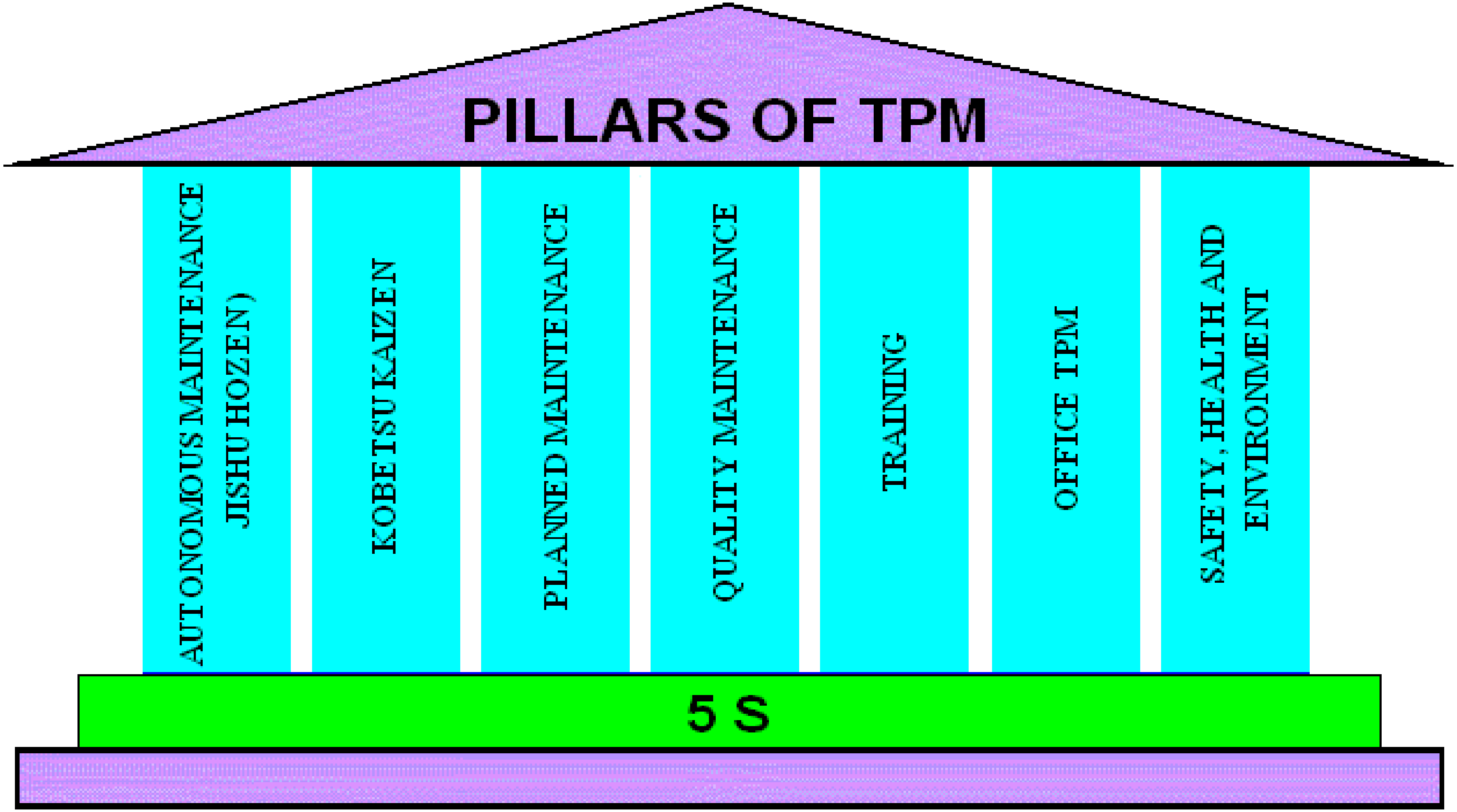
TPM - Step B – Introduction Stage

- This is a ceremony and we should invite all.
- Suppliers as they should know that we want quality supply from them.
- Related companies and affiliated companies who can be our customers, sisters concerns etc.
- Some may learn from us and some can help us.
- Customers will get the communication from us that we care for quality output.

QE & TPM – Steps in Implementing TPM

TPM - Step C – Implementation Stage

8 pillars of TPM activity are carried out.



TPM - Step C – Implementation Stage
Pillar 1 – 5S

- TPM starts with 5S.
- Sorting, Systematize, Shining, Standardize, Self - Discipline.
- Problems cannot be seen when workplace is unorganized.
- Cleans and organizes the workplace.
- Makes problems visible.

QE & TPM – Steps in Implementing TPM

TPM - Step C – Implementation Stage **Pillar 1 – 5S**

QE & TPM – Steps in Implementing TPM

TPM - Step C – Implementation Stage Pillar 1 – 5S

5S Forms Storage Area - Before

5S Forms Storage Area - After

Office 5S

BEFORE

AFTER

BEFORE

AFTER

Before 5S

After 5S

TPM - Step C – Implementation Stage

Pillar 2: Autonomous Maintenance

- Geared towards developing operators for small maintenance tasks.
- Frees up more skilled workers to focus on more valuable activity and technical repairs.
- Maintenance of equipment by operators to prevent deterioration.

Pillar 3: Kaizen (Kai=change Zen=good)

- Principle: very large number of small improvements are more effective in an organizational environment than a few improvements of large value.
- Systematically reduces losses and inefficiencies in the workplace.
- Can also be applied in production and administrative areas.
- Requires no or little investment.

TPM - Step C – Implementation Stage

Pillar 4: Planned Maintenance

- Aimed to have trouble free machines and equipment's.
- Produces defect free products for total customer satisfaction.
- Achieves and maintains availability and reliability of machines.
- Reduces inventory.

Pillar 5: Quality Maintenance

- Highest quality through defect-free manufacturing.
- Focus is on quality control – eliminate current quality concerns, then move to potential quality concerns.
- Maintains perfect equipment to have perfect quality of products.

TPM - Step C – Implementation Stage

Pillar 6: Training

- Aimed to have multi-skilled employees who perform all functions effectively and independently.
- Know-How: Can be learned through experience and how to overcome a problem.
- For Know-Why: Education given to operators to know the root cause of the problem / Increases productivity.

Pillar 7: Office TPM

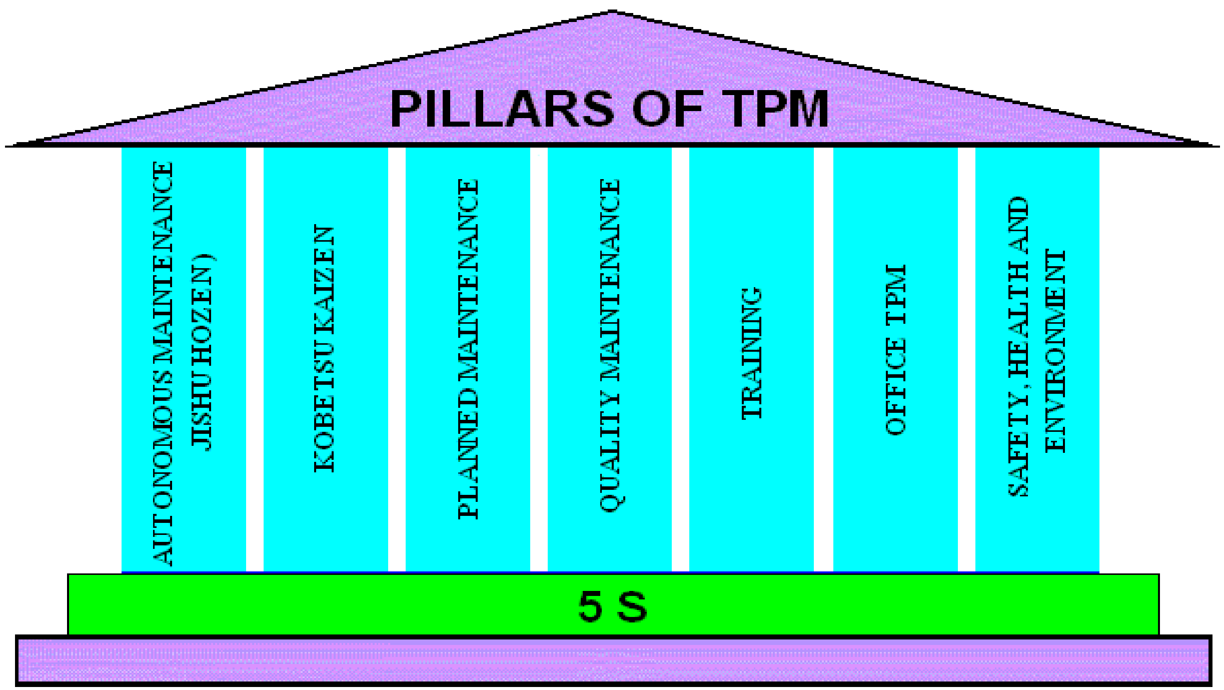
- Includes analyzing processes and procedures towards increased office automation.
- Must be followed to improve productivity and efficiency in the administrative functions.
- Identifies and eliminates losses.
- Involves all parties towards TPM which improves processes.

QE & TPM – Steps in Implementing TPM

TPM - Step C – Implementation Stage

Pillar 8: Safety, Health & Environment

- Target – zero accident, zero health damage, zero fires.
- Focus is to create a safe workplace and protect the environment
- Usually a committee is created for this which includes officers as well as workers.



Maintenance Strategies

- Breakdown
- Preventative
- Predictive
- Corrective or Improvement

Preventative Maintenance/Maintenance Prevention

- Reason for Preventative Maintenance
  - Improve OEE by reducing downtime
  - Extend Equipment life – protect investment
  - Increased reliability reduces inventory for JIT
  - Reduced energy/consumable cost
  - Reduced spare parts inventory
- Maintenance Prevention
  - Design to prevent need for maintenance
  - 95% of equipment's Life Cycle cost is determined in the design phase
  - Requires teamwork of design engineers, maintenance technicians and operators.

Improvement Measurements

- Equipment breakdowns
- Scrap/rework
- Reduced productivity
- Equipment start-up losses

QE & TPM – Pilot Study

ITEM	DESCRIPTION
Photograph	Take photographs that capture the initial state of the equipment and post them on the project board.
Clear Area	Clear the area of debris, unused tools and components, and any other items that are not needed.
Organize	Organize remaining tools and components onto shadow boards (boards containing outlines as visual cues).
Clean Up	Thoroughly clean the equipment and surrounding area (including residue from any leaks or spills).
Photograph	Take photographs that capture the improved state of the equipment and post them on the project board.
Checklist	Create a simple 5S checklist for the area (creating Standardized Work for the 5S process).
Audit	Schedule a periodic audit (first daily, then weekly) to verify that the 5S checklist is being followed. During the audit, update the checklist as needed to keep it current and relevant. Keep audits positive and motivational (treat them as a training exercise).

Overall Equipment Effectiveness

OEE is the product of the three measurements below.

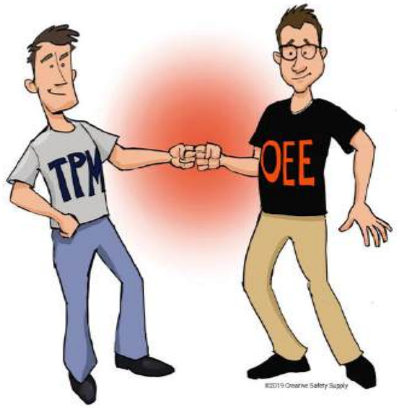
- Equipment Availability
  - Measures how often eqpt is not producing
- Equipment Efficiency Performance
  - Measures actual machine cycle time
- Equipment Quality Performance
  - Compares the # of good pieces produced/total number produced

Equipment Availability (EA)

$$EA = \frac{\text{Scheduled Production Time - Unplanned Downtime}}{\text{Scheduled Production Time}}$$

Since, Uptime = Scheduled Production Time – Unplanned Downtime

$$\text{Then, } EA = \frac{\text{Uptime}}{\text{Scheduled Production Time}}$$



Equipment Efficiency Performance (EEP)

$$EEP = \frac{(\text{Standard Cycle Time}) \times (\#\text{ of pcs Produced})}{\text{Uptime}}$$

Equipment Quality Performance (EQP)

$$EQP = \frac{\text{Total \# Produced} - \text{Total \# Defective}}{\text{Total \# Produced}}$$

Since, # of good pieces = Total # Produced – Total # Defective

$$\text{Then, } EQP = \frac{\text{\# of Good Pieces}}{\text{Total \# Produced}}$$

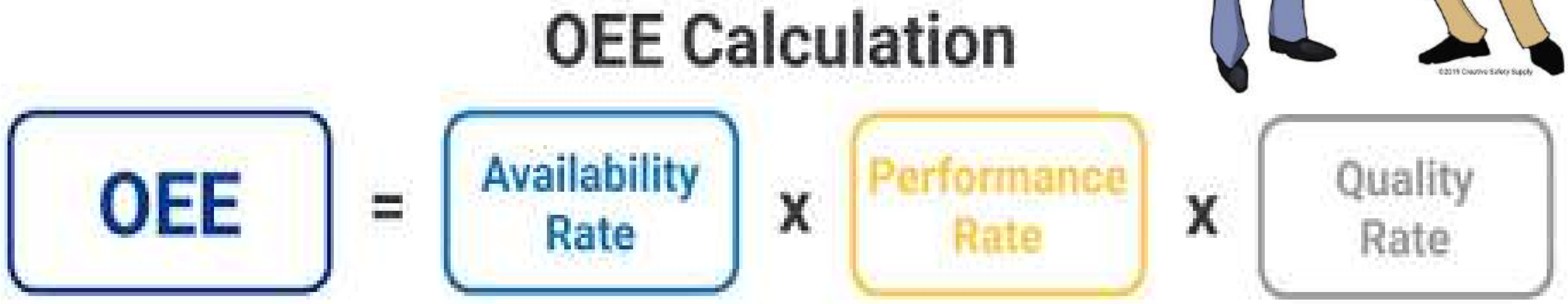
Overall Equipment Effectiveness (OEE)

OEE = (EA) X (EEP) X (EQP)

Current World Class benchmarks for these are:

EA = 90%, EEP = 95%, EQP = 99%

OEE = 85%



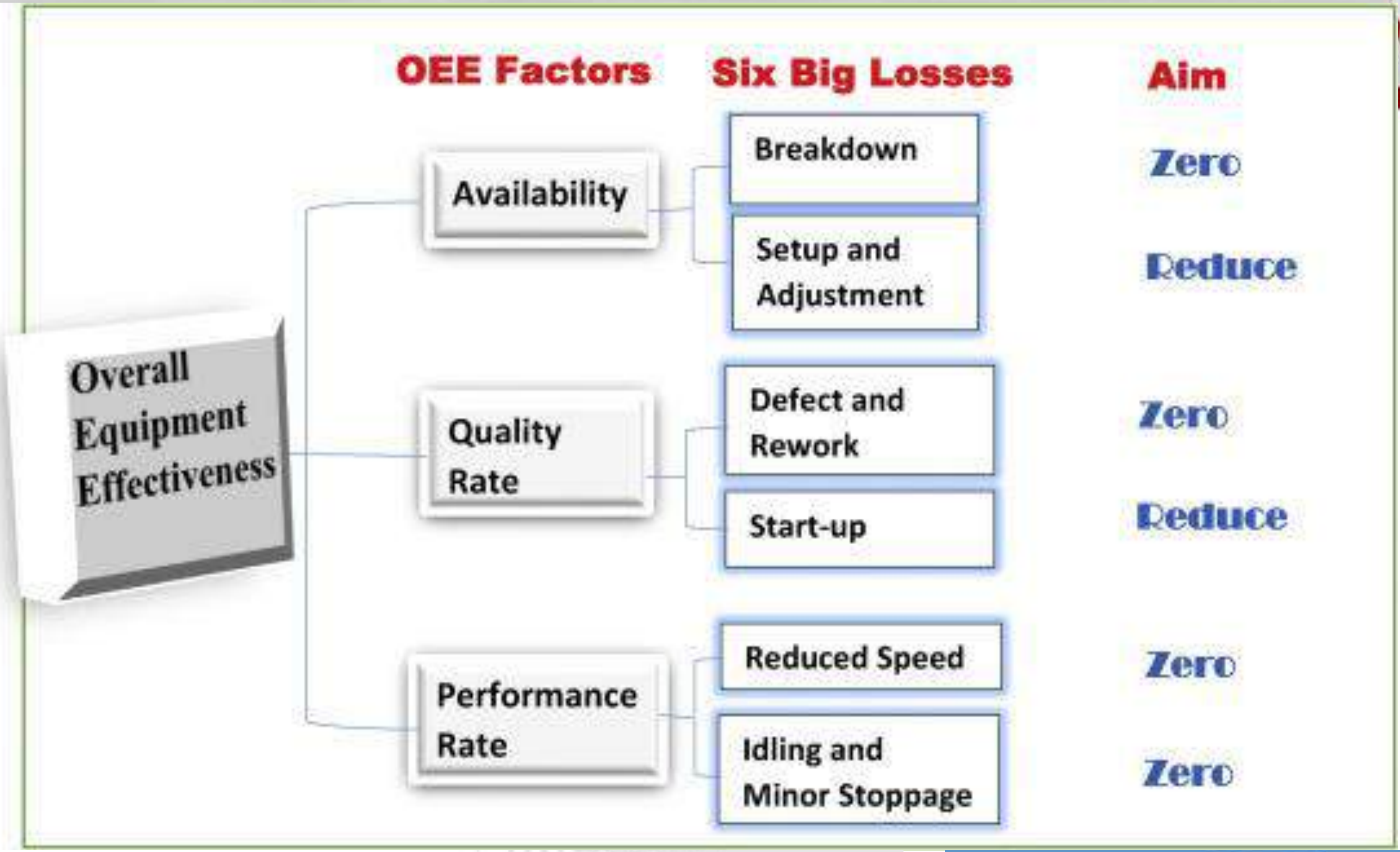
Availability | **Performance Rate** | **Quality Rate**

Availability
- Breakdown losses
- Tea and lunch breaks
- Set-up & Changeover
- Clean down
- Waiting for maintenance
- No operator
- Waiting for paperwork
- Shift Handovers
- Waiting for 1st off inspection

Performance Rate
- Reduced speed
- Production Jams
- Material feed and speed

Quality Rate
- Quality rejects
- Scrap from setup

QE & TPM


OEE Factors
Six Big Losses
Aim
Overall Equipment Effectiveness
Availability
Breakdown
Zero
Setup and Adjustment
Reduce
Quality Rate
Defect and Rework
Zero
Start-up
Reduce
Performance Rate
Reduced Speed
Zero
Idling and Minor Stoppage
Zero


AVAILABILITY
×
PERFORMANCE
×
QUALITY
= OEE


Overall Equipment Effectiveness
Eliminate Losses, Improve OEE

QE & TPM

Downtime Losses

1. Planned
   - a. Start-ups
   - b. Shift changes
   - c. Coffee and launch breaks
   - d. Planned maintenance shutdowns
2. Un planned Downtime
   - a. Equipment breakdown
   - b. Changeovers
   - c. Lack of material

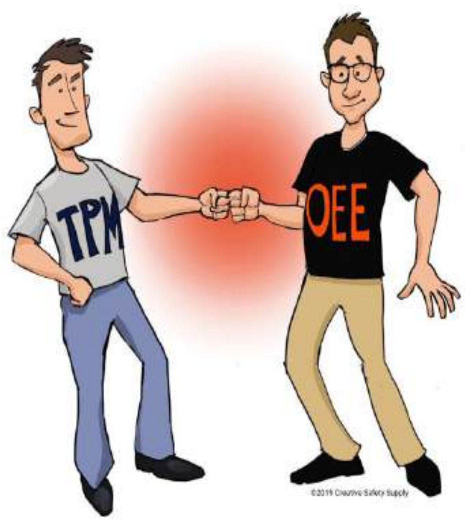
Reduced Speed Losses

3. Idling and minor stoppages
4. Slow-downs

Poor Quality Losses

5. Process nonconformities
6. Scrap

SIX BIG LOSSES



Incorporates 3 basic indicators of equipment performance and reliability:

- Availability (tool change, tool service) (A)
- Performance efficiency (in terms of capacity) (E)
- Rate of quality output (R).
- Thus, OEE is measured as the product of the decimal equivalent of the three previous metrics using the equation

OEE= A X E X R

- Availability is proportion of time machine which is actually available out of time it should be available.
- Downtime losses are measured by equipment availability using the equation

$$A = (T/P) \times 100$$

Where A = Availability

T = Operating time (P-D)

P = Planned operating time

D = Downtime

QE & TPM

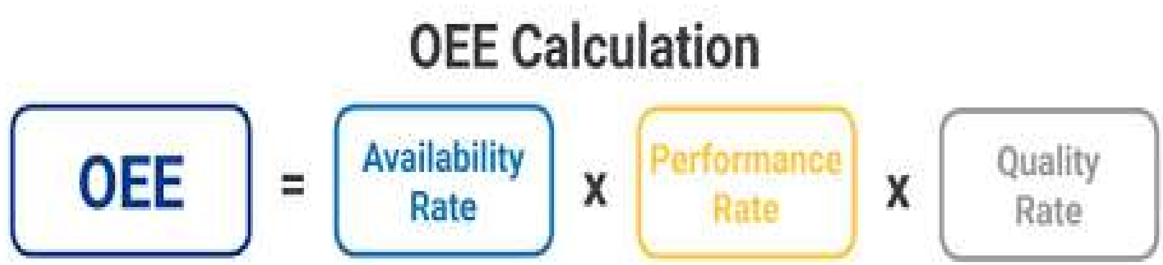
- The second category of OEE is performance.
- Reduced speed losses are measured by tracking performance efficiency using the equation

$$E = ((C \times N) / T) \times 100$$

Where E = Performance efficiency

C = Theoretical cycle time

N = Processed amount (Quantity)



QE & TPM

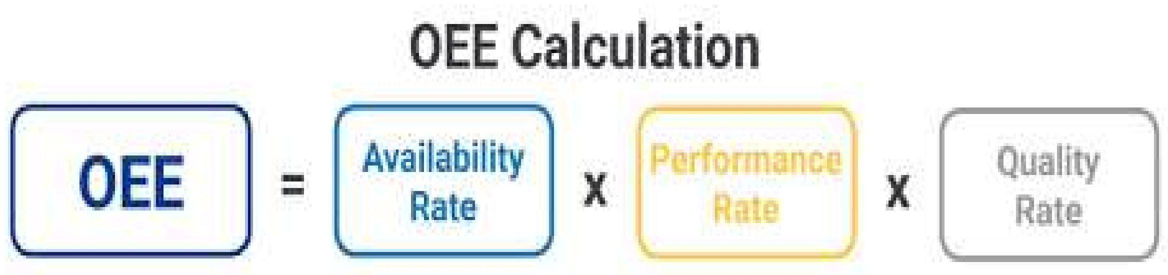
- It is third category of OEE.
- It is percentage of good parts out of total produced.
- Poor quality losses are measured by tracking the rate of quality products produced using the equation

$$R = ((N - Q) / N) \times 100$$

Where R = rate of quality products

N = processed amount (quantity)

Q = nonconformities



QE & TPM – Example Problem

- Last week's production numbers on machining center JL58 were as follows:
- Scheduled operation = 10 hours/day; 5 days/week
- Manufacturing downtime due to meetings, material outages, training, breaks, and so forth = 410 minutes/week
- Maintenance downtime scheduled and equipment breakdown = 227 minutes/week
- Theoretical (standard) cycle time = 0.5 minutes/unit
- Production for the week = 4450 units
- Defective parts made = 15 units

QE & TPM

- P = 10 hours/day X 5 days/week X 60 minutes/hour = 3000 minutes/week
- D = 410 minutes/week + 227 minutes/week = 637 minutes/week
- T = (P-D) = 3000 – 637 = 2363 minutes
- A = (T / P) X 100 = (2363 / 3000) X 100 = 78.8%
- E = ((C X N) / T) X 100 = ((0.5 X 4450) / 2363) X 100 = 94.2%
- R = ((N - Q) / N) X 100 = ((4450 - 15) / 4450) X 100 = 99.7%
- **OEE = A X E X R = 0.788 X 0.942 X 0.997 = 0.740 or 74.0%**

A Total Productive Maintenance (TPM) Approach to Improve Production Efficiency and Development of Loss Structure in a Pharmaceutical Industry

Article *in* Global Journal of Management and Business Research · April 2010

***Abstract*-Total Productive Maintenance (TPM) is a manufacturing program whose sole purpose is to maximize the effectiveness of equipment throughout its entire life by the participation and motivation of the entire workforce. The three main objectives of TPM are zero defects, zero breakdowns and zero accidents. These goals can be achieved through implementation of activities planned to increase equipment efficiency, the creation of a program of autonomous maintenance, the establishing of a planned maintenance system, the organization of training courses for workers and design of plant management system. This paper addresses the issue of implementing the total productive maintenance (TPM) philosophy in a pharmaceutical industry. In the first phase, the possible losses and the factors contributing to those losses have been identified. The critical factors which affect the overall equipment efficiency (OEE) of the pharmaceutical industry are loading time, down time, standard cycle time, actual cycle time, unit produced and defect unit. Overall equipment efficiency (OEE) is an indication of eight major equipment related losses which are equipment failure, set-up and adjustment, cutting blade change, start-up, minor stoppage and idling, speed, defect and rework and equipment shutdown. In the second phase of TPM implementation, a planned maintenance program has been suggested to make the production process quite smooth and proficient with increased efficiency.**

Keywords-TPM; Production Efficiency; Loss Structure; Overall Equipment Efficiency

International Journal of Engineering Trends and Technology (IJETT) - Volume4Issue5- May 2013

Study of Total Productive Maintenance & Its Implementing Approach in Spinning Industries

Abstract:-This paper presents the study and overview for the implementing approach of Total Productive Maintenance in Indian spinning industries. The study is carried out in medium scale cotton spinning industry using the observations coupled with documents collection. The TPM implementation methodology is suggested for improvement in the availability, performance efficiency and the quality rate, results in improvement of the overall equipment effectiveness of the equipment. The aim of this paper is to suggest and study the implementation of the TPM program in the spinning industry. Using a See through, JH-Check sheet, PM-Check sheet, One Point Lessons, empirical and comprehensive approach toward the methodology results proper implementation of TPM. After implementation of TPM on model machine, both direct and indirect benefits are shown to be obtained for equipment and employees respectively.

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Implementation of total productive maintenance: A case study

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Abstract

The semiconductor industry has gone through significant changes in the last decade. Competition has increased dramatically. Customers focus on product quality, product delivery time and cost of product. Because of these, a company should introduce a quality system to improve and increase both quality and productivity continuously. Total productive maintenance (TPM) is a methodology that aims to increase the availability of existing equipment hence reducing the need for further capital investment. Investment in human resources can further result in better hardware utilisation, higher product quality and reduced labour costs. The aim of the paper is to study the effectiveness and implementation of the TPM programme for an electronics manufacturing company. Through a case study of implementing TPM in an electronics manufacturing company, the practical aspects within and beyond basic TPM theory, difficulties in the adoption of TPM and the problems encountered during the implementation are discussed and analysed. Moreover, the critical success factors for achieving TPM are also included based on the practical results gained from the study. After the implementation of TPM model machine, both tangible and intangible benefits are shown to be obtained for equipment and employees respectively. The productivity of the model machine increased by 83%.

A study of total productive maintenance implementatio

F. Ireland, B.G. Dale

Journal of Quality in Maintenance Engineering
ISSN: 1355-2511
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Abstract

This paper focuses on a study of total productive maintenance (TPM) in three companies. The companies implemented TPM because of the business difficulties they faced. In all three companies senior management had supported TPM and set up suitable organisational structures to facilitate its implementation. The companies had followed Nakajima's seven steps of autonomous maintenance, although different TPM pillars had been adopted, with the common ones being improvements, education and training, safety, and quality maintenance. The main differences in TPM implementation related to the use of ABC machine classification

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IMPLEMENTATION OF TPM WITH CASE STUDY

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ABSTRACT

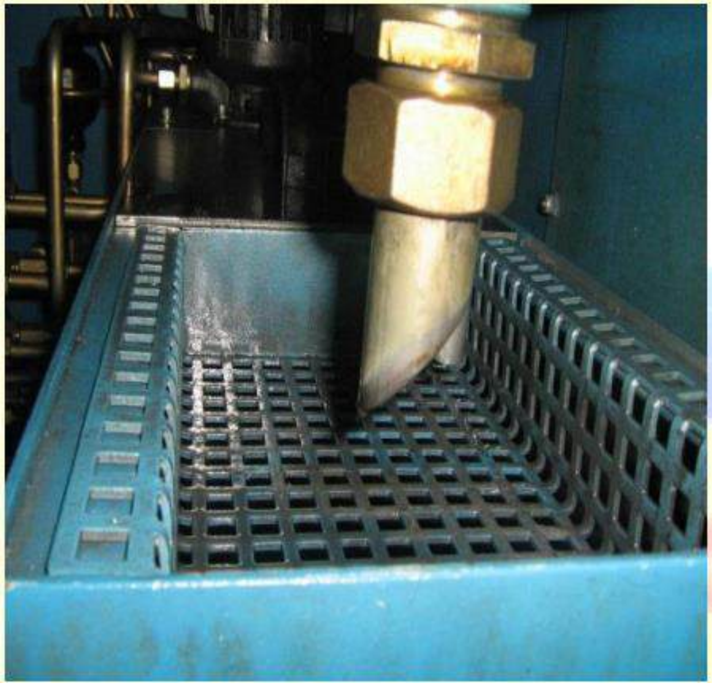
The purpose of this paper is to evaluate the contributions of Total Productive Maintenance (TPM) initiatives in reducing equipment breakdowns, increase equipment reliability and improve productivity. This will result in increased equipment utilization and life, reduced work stoppages and machine slowdowns, closer adherence to production and delivery schedules as well as increased employee morale. The Total Productive Maintenance (TPM) concept addresses these goals. The aim of TPM is to keep the plant and equipment at its highest productive level through the cooperation of all areas of the organization. TPM is a partnership between maintenance and production organization to improve product quality, reduce waste, reduce manufacturing cost and increase equipment availability.

Key words:-Total productive maintenance, Preventive maintenance, Overall equipment efficiency, Total quality management

Case Study

PROBLEM STATEMENT 1

The problem of frequent filter clogging was found due to unwanted particles in the cutting oil which results in the early damage of filter which results in reduction of filter life.

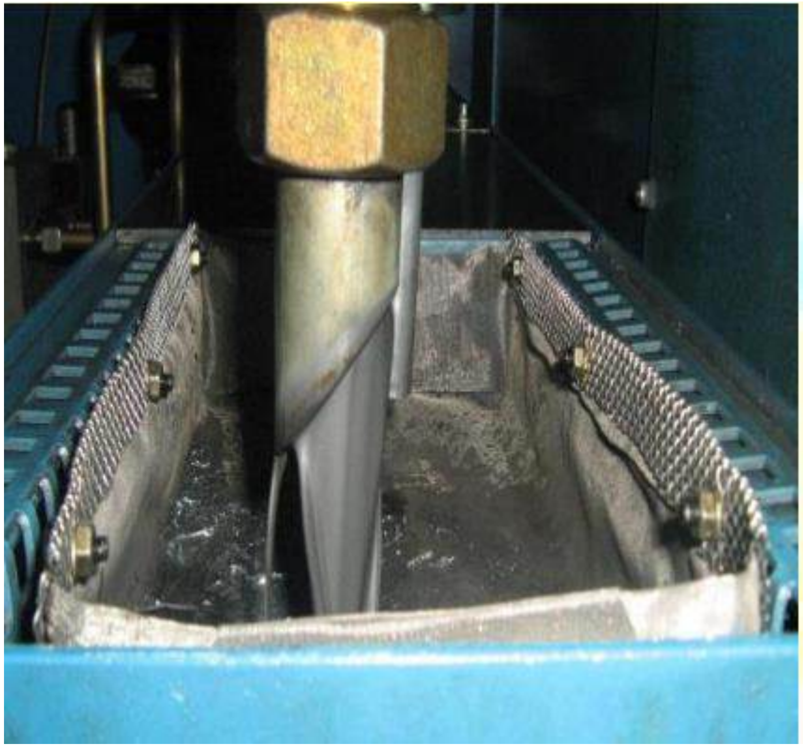


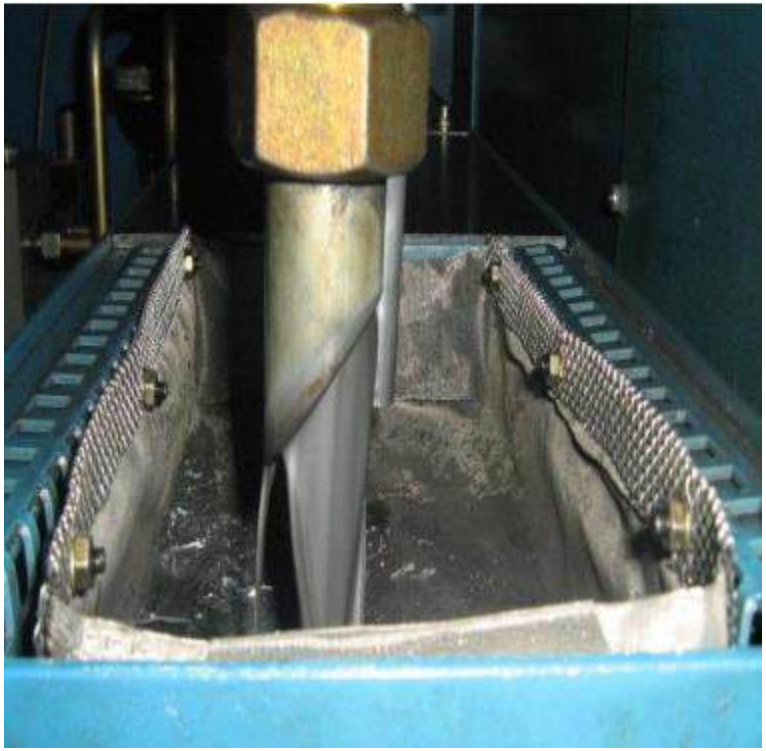
Before Implementation Of TPM

Case Study

COUNTER MEASURE

Fine wire mesh filtration system provided to avoid frequent filter clogging & also to safeguard the cutting oil pump.





After Implementation of TPM

Summary

- TPM can significantly improve a plant's quality, productivity, and product delivery
- TPM can generate culture changes in a plant.
- The only long term competitive advantage any company can have is its people.

Conclusion

TPM implementation depends on condition of equipment, work culture, equipment management, and maintenance effectiveness.

- TPM Benefits
  - Reduced equipment downtime
  - Increased equipment productivity
  - Increased plant capacity
  - Lower maintenance and production costs
  - Approaching zero equipment caused defects
  - Enhanced job satisfaction
  - Increased Return-on-investment

- Preventive maintenance is the act of performing **regularly scheduled maintenance** activities to help **prevent unexpected failures** in the future.
- Put simply, it's about **fixing things before they break**.

Preventive maintenance	Breakdown maintenance
Improve equipment life	Decrease Overall equipment life
Routine inspection	Emergency repair
Prevent major operating problem	Execute when equipment fails
No loss of production time	Loss of time and material
Good for safety	Chances of accidents
Planned	Unplanned

How to Create a Preventive Maintenance Schedule

Step 1: Prioritize assets by maintenance needs

Step 2: Collect historical data about each asset

Step 3: Make projections about assets maintenance needs

Step 4: Put together the initial preventive maintenance plan

Step 5: Verify progress and adjust as needed

Step 6: Expand your preventive maintenance program

Sample Vehicle Preventive Maintenance Schedule

- Every year
  - Flush radiator
  - Replace coolant
  - Service air conditioner
- Every two years
  - Replace all hoses
- Every four years
  - Replace battery

Sample Vehicle Preventive Maintenance Schedule (Mileage Specific)

- Every 3,000 – 5000 miles
  - Change oil, oil filter, fuel filter (diesel)
  - Lubricate chassis
  - Rotate tires
- Every 10,000 miles
  - Inspect drive belts, adjust tension, change air filter (dusty area)
- Every 15,000 miles
  - Change air filter and PCV valve
- Every 20,000 miles
  - Change front and rear brake pads

Sample Vehicle Preventive Maintenance Schedule (Mileage Specific)

- Every 25,000 miles
  - Engine tune-up
- Every 30,000 miles
  - Change fuel filter, spark plugs
  - Service transmission, replace filter and fluid
  - Pack wheel bearings
- Every 60,000 miles
  - Replace EGR value and clean EGR passage
  - Ignition cables, distributor cap, and rotor
  - Vacuum-operated emissions system components
- Every 80,000 miles
  - Replace oxygen sensor, if so equipped

QE & TPM – Preventive Maintenance (PM)

- **Checklists** can be a great tool to standardize routine tasks that have to be run regularly.
- In the same fashion, a Preventive Maintenance **PM-Checklist** can be used to streamline a variety of preventive maintenance tasks.

Why we need preventive maintenance checklists

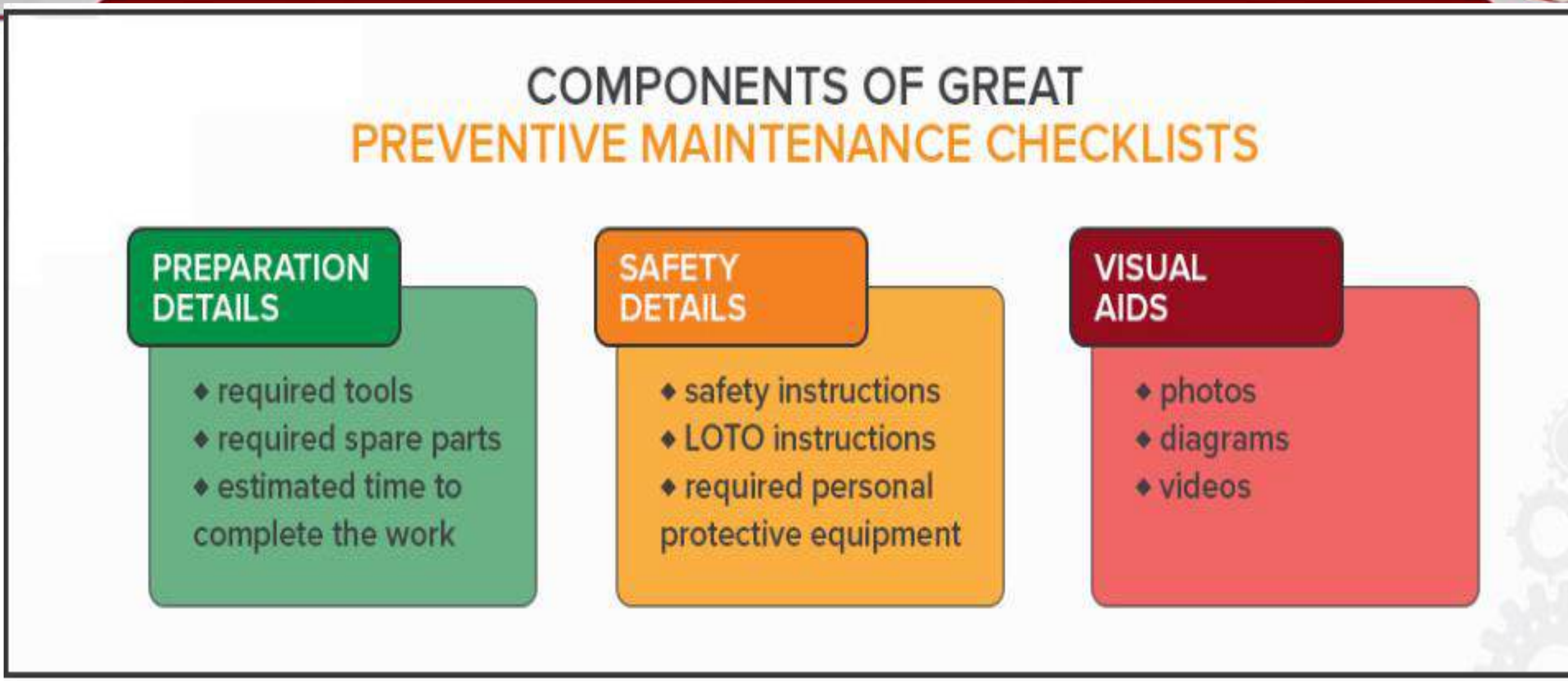
1) Workflow standardization and increased productivity
2) Improved safety
3) Faster troubleshooting
4) Better maintenance planning

How to prepare a preventive maintenance checklist ?

Three things you should do before creating PM checklists

- Create a list of assets that need PMs
- Gather original equipment manufacturer (OEM) manuals.
- Review asset history.

QE & TPM – Preventive Maintenance (PM)



QE & TPM – Preventive Maintenance (PM)

- **Clear & Concise** - Avoid writing long paragraphs / Use diagram or a picture / Every step should have a purpose / Be precise
- **Sequential** - Followed in the exact order
- **Update** - Not set & forget(Optimized and Customized regularly)

Bonus Tip

- When you have your preventive maintenance checklist ready, run it by an experienced maintenance technician to ensure you didn't miss/skip a step or two.
- Alternatively, you can ask a senior technician to create it in the first place.

Example - HVAC PM-Checklist for AC

- ❑ Check and adjust the thermostat.
- ❑ Check the condenser coil to determine if it needs cleaning.
- ❑ Check all wiring connections & electrical connections.
- ❑ Check blower belt wear, tension, and adjust.
- ❑ Check voltage & amperage draw on all motors with a meter.
- ❑ Check the compressor contactor.
- ❑ Visually inspect compressor and check amp draw.
- ❑ Check start capacitor and potential relay.
- ❑ Check the pressure switch cut-out setting.
- ❑ Replace air filter or clean reusable type filter.

PM CHECKLISTS

PREVENTIVE MAINTENANCE CHECKLIST

(This list contains many examples of items that can be used for preventive maintenance issues by school districts. It is not a complete list. Each district should adjust the checklist to meet their local needs, requirements and abilities. Space has been provided under each category for additional items)

______________________	______________________________	____________
School/Facility	***Name(s) of Inspectors***	***Date***

ITEM	Completed	Needs Further Attention
LIGHTING (EXTERIOR & INTERIOR)		
Building Exterior		
Pedestrian Walkways		
Parking Areas		
Athletic and Sports Fields		
Building Interior		
Emergency		
All lights working		
Glassware conditions		
Fixture support conditions		
Wire conditions		
Ballast conditions		
Timers/sensors		
Junction box and cover conditions		
Switch conditions		
Outlet and cord conditions		
Protective caging conditions		

QE & TPM – Preventive Maintenance (PM)

PM CHECKLISTS

ITEM	Completed	Needs Further Attention
CLASSROOMS		
Fire safety		
Furniture: desks/chairs/tables/shelves		
Marker board		
Electronic board		
Audio-visual equipment		
Computers/work stations/wiring		
Partitions		
Flooring for tripping hazards		
Plumbing (if applicable)		
PA speaker system operation		
Emergency/panic call button (if applicable)		
Wall map(s)		
Exit access		

PM CHECKLISTS

AUDITORIUMS		
Fire safety		
Seating		
Passageway clearance and markings		
Exit lighting		
Aisle/walkway lighting		
Markers for edges of stage areas		
Risers		
Stage		
Curtains		
Changing rooms		
Area lighting		
Stage lighting		
Staging equipment		
Sound system		
Lobby/entrance area		
Concession area		

PM CHECKLISTS

Sample TPM Standard Work

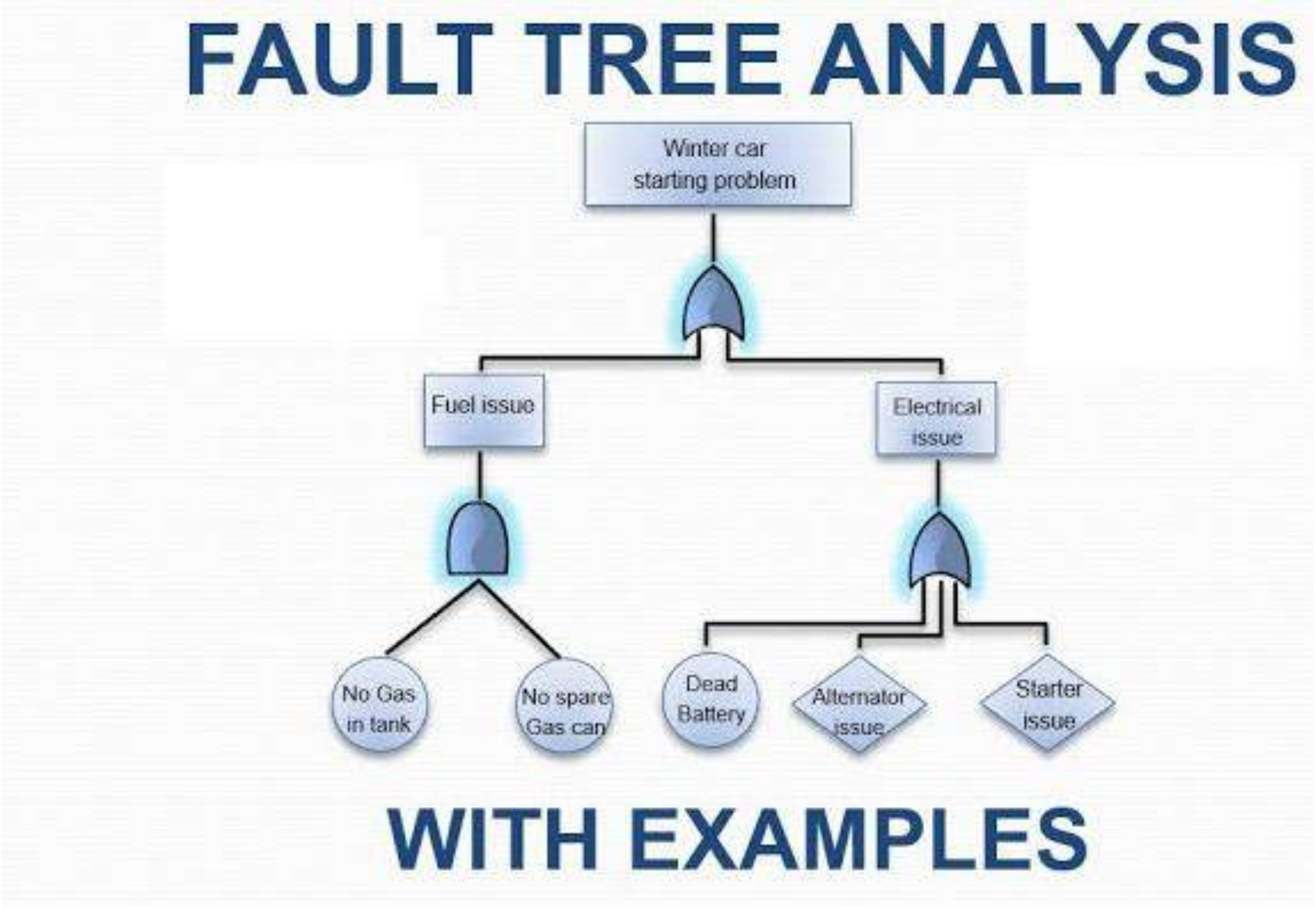
Daily Operator PM

- ☐ 1. Check coolant level through clear Plexiglas
- ☐ 2. Check heat exchanger fans (strings should be moving)
- ☐ 3. Check servo drive fans (string should be moving)
- ☐ 4. Check heat exchanger air filter (change when dark)
- ☐ 5. Check servo drive air filter (change when dark)
- ☐ 6. Check way lube reservoir (add when low)
- ☐ 7. Check main motor air filter (change when dark)
- ☐ 8. Check main motor cooling fan (string should move)
- ☐ 9. Check mist collector motor and air filter (change when dark)
- ☐ 10. Check bar feeder hydraulic motor air filter
- ☐ 11. Check bar feeder hydraulic oil level (add when low)

QE & TPM – Various tools in QE

- Pareto Diagram
- Fishbone/Ishikawa Diagram
- Check Sheet
- Process Flow Diagram
- Scatter Diagram
- Histogram
- Control Chart
- Acceptance Sampling
- Random Sampling
- Reliability
- FMEA / Fault tree / Event tree analysis
- Quality Function Deployment
- ISO Series
- Benchmarking
- Total Productive Maintenance
- Management and Planning Tools
- Lean/Kaizen
- Quality Issues
- Six Sigma
- Design of Experiments (DOE)
- Process Analysis Tools

QE Tools - Fault Tree Analysis (FTA)



QE Tools - Fault Tree Analysis (FTA)

Introduction

- Fault tree analysis (FTA) is a graphical-mathematical tool to explore the causes of system level failures.
- It uses deductive logic and proceeds top-down to identify the component level failures (basic events) that cause the system level failure (top event) to occur.
- The top event is linked to the basic events through several intermediate events using logic gates and event symbols.

QE Tools - Fault Tree Analysis (FTA)

History

- FTA was developed in 1961-62 by H Watson and A Mearns (Bell Telephone Laboratory) for the US Air Force for use with the Minuteman Launch Control System.
- Later adopted by boeing (1964), nuclear (1971), chemical (1981) and software (1981) industries.
- It is extensively used in reliability and safety studies.

QE Tools - Fault Tree Analysis (FTA)

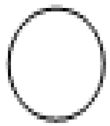
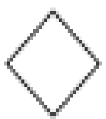
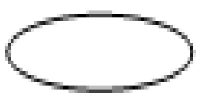
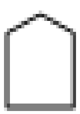
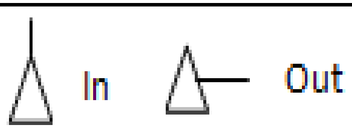
Fault Tree Symbols

FTA uses two types of symbols:

- *Event symbols* to describe the events that lead to the *system level failure event*, and
- *Gate symbols* that connect *event symbols as per their causal relations*.

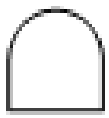
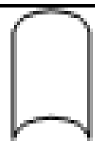
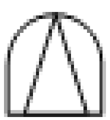
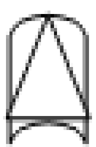
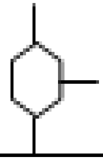
QE Tools - Fault Tree Analysis

FTA Symbols – Event symbols

S.No	Event Symbol	Description
1		Primary or basic failure event. It is a random event and sufficient data is available
2		State of system, subsystem or component event
3		Secondary failure or under developed event, can be explored further
4		Conditional event and is associated with the occurrence of some other event
5		House event representing either occurrence or non-occurrence of an event
6		Transfer in and transfer out symbols used to replicate a branch or sub-tree of the FTA

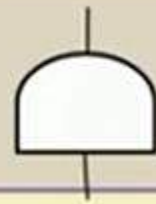
QE Tools - Fault Tree Analysis

FTA Symbols – Gate symbols

S.No	Gate Symbol	Description
1	 AND Gate	The output event occurs when all the input events occur
2	 OR Gate	The output event occurs when at least one of the input events occur
3	Priority AND Gate 	The output event occurs when all the input events occur in the order from left to right
4	 Exclusive OR gate	The output event occurs if either of the two input events occur but not both
5	 Inhibit gate	The output event occurs when the input event occurs and the attached condition is satisfied

QE Tools - Fault Tree Analysis (FTA)

FTA Symbols – Gate symbols

Sl. No	Gate symbol	Description
1	AND gate 	The output event occurs when all the input events occur
2	OR gate 	The output event occurs when at least one of the input events occur
3	Priority AND gate 	The output event occurs when all the input events occur in the order from left to right.

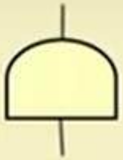
QE Tools - Fault Tree Analysis (FTA)

FTA Symbols – Gate symbols

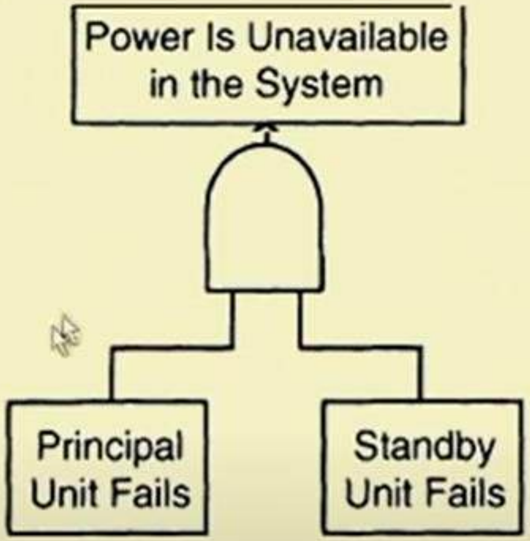
Sl. No	Event Symbol	Description
4	Exclusive OR gate 	The output event occurs if either of the two input events occur but not both.
5	Inhibit gate 	The output event occurs when the input event occurs and the attached condition is satisfied.
6	m/n gate 	The output event occurs when m-out-of-n input events occur.

QE Tools - Fault Tree Analysis (FTA)

Gate symbols with application

- AND gate 

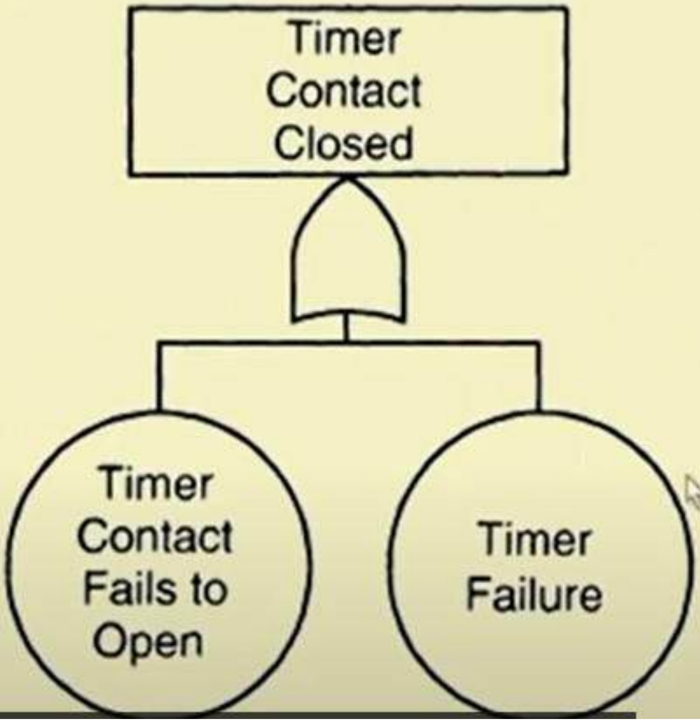
The output event occurs when all the input events occur



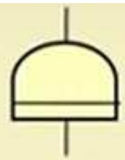
QE Tools - Fault Tree Analysis (FTA)

- OR gate

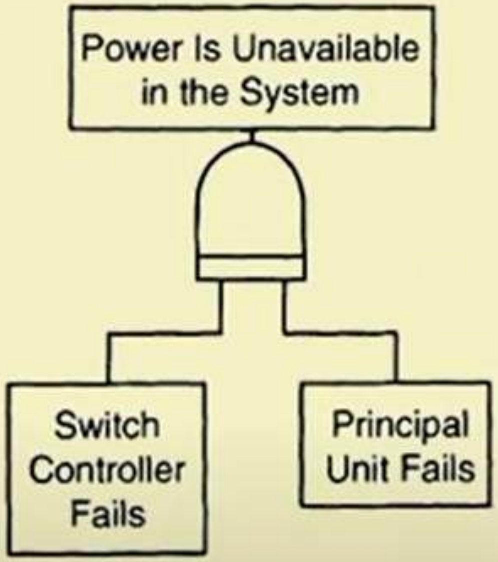
The output event occurs when at least one of the input events occur



QE Tools - Fault Tree Analysis (FTA)

- Priority AND gate 

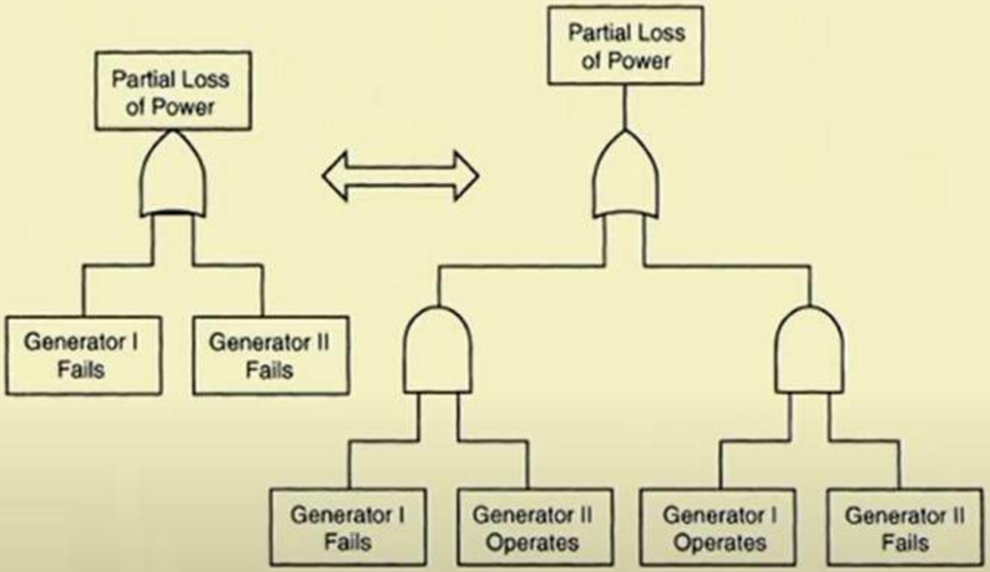
The output event occurs when all the input events occur in the order from left to right.



QE Tools - Fault Tree Analysis (FTA)

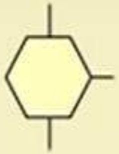
- Exclusive OR gate 

The output event occurs if either of the two input events occur but not both.

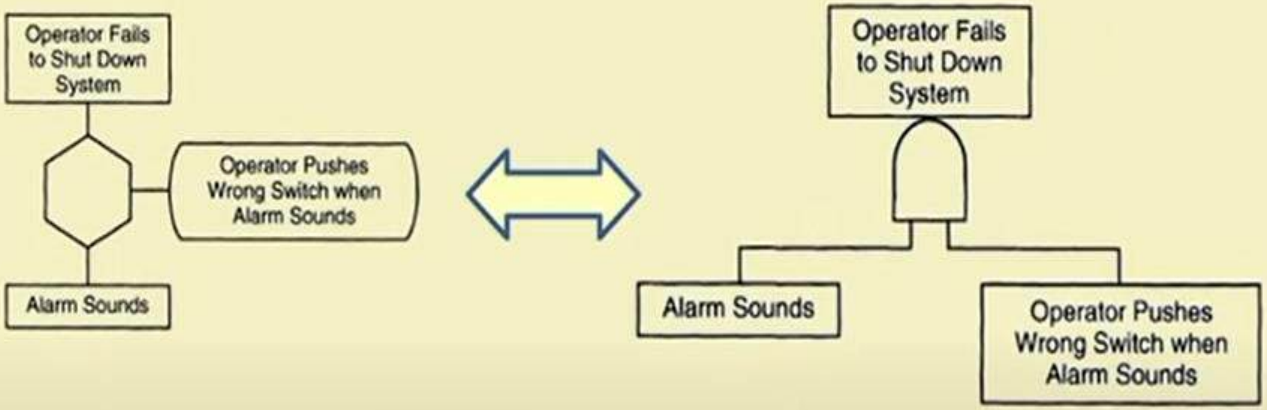


QE Tools - Fault Tree Analysis (FTA)

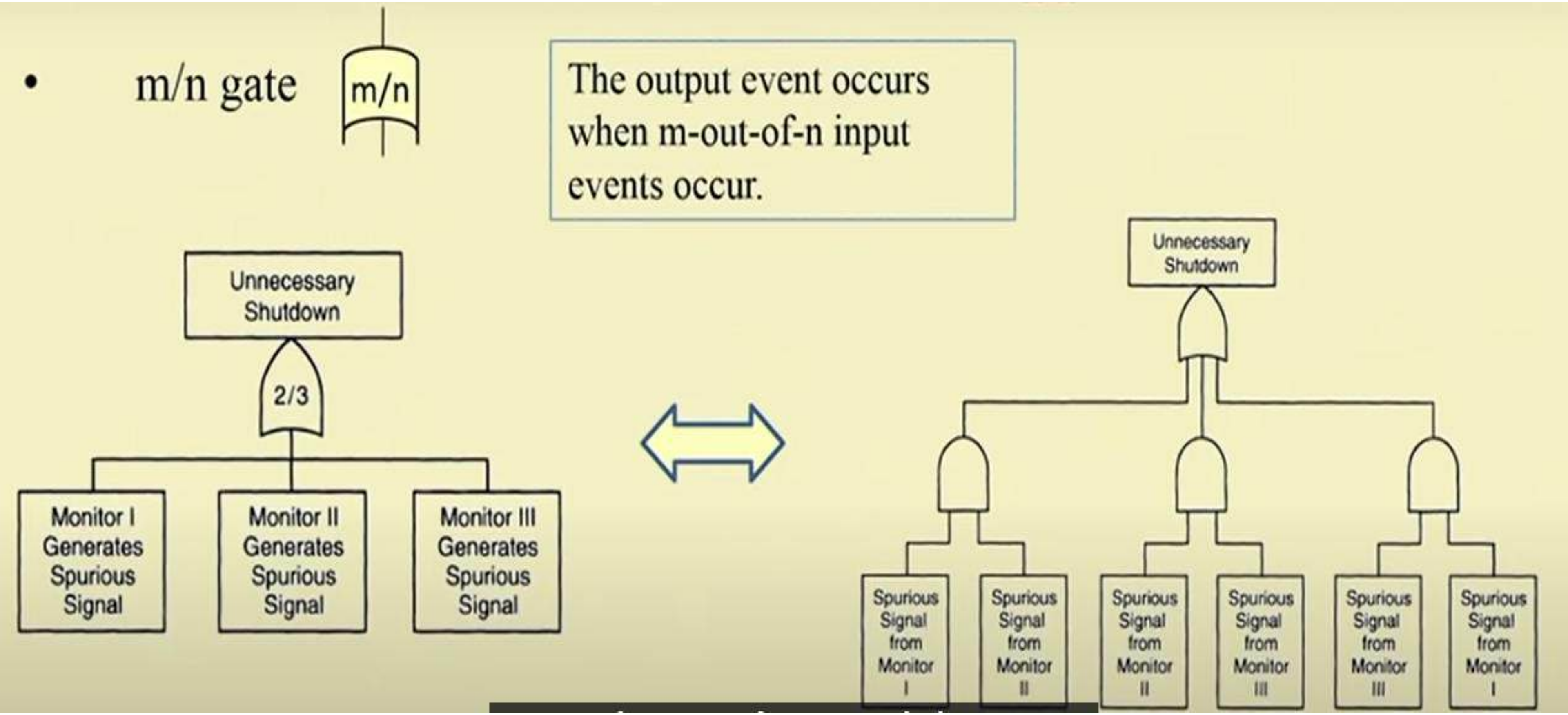
- Inhibit gate



The output event occurs when the input event occurs and the attached condition is satisfied.



QE Tools - Fault Tree Analysis (FTA)



Fault Tree Construction

Ericson (2005) provided three principal concepts for constructing fault tree:

i. The I-N-S concept

ii. The SS-SC concept

iii. The P-S-C concept

QE Tools - Fault Tree Analysis (FTA)

I-N-S Concept

The I-N-S concept involves identifying the immediate (I), necessary (N) and sufficient (S) causes of an event to occur and links these causes to the event with appropriate gate symbols.

SS-SC Concept

- The SS-SC concept classifies a failure either the state-of-the-system (SS) or state-of-the-component (SC).
- If the failure is a SS, it is further developed using the I-N-S concept to find relevant causes and gate symbols to represent the SS failure.
- For SC failure, the event is linked with an OR gate to the P-S-C inputs.

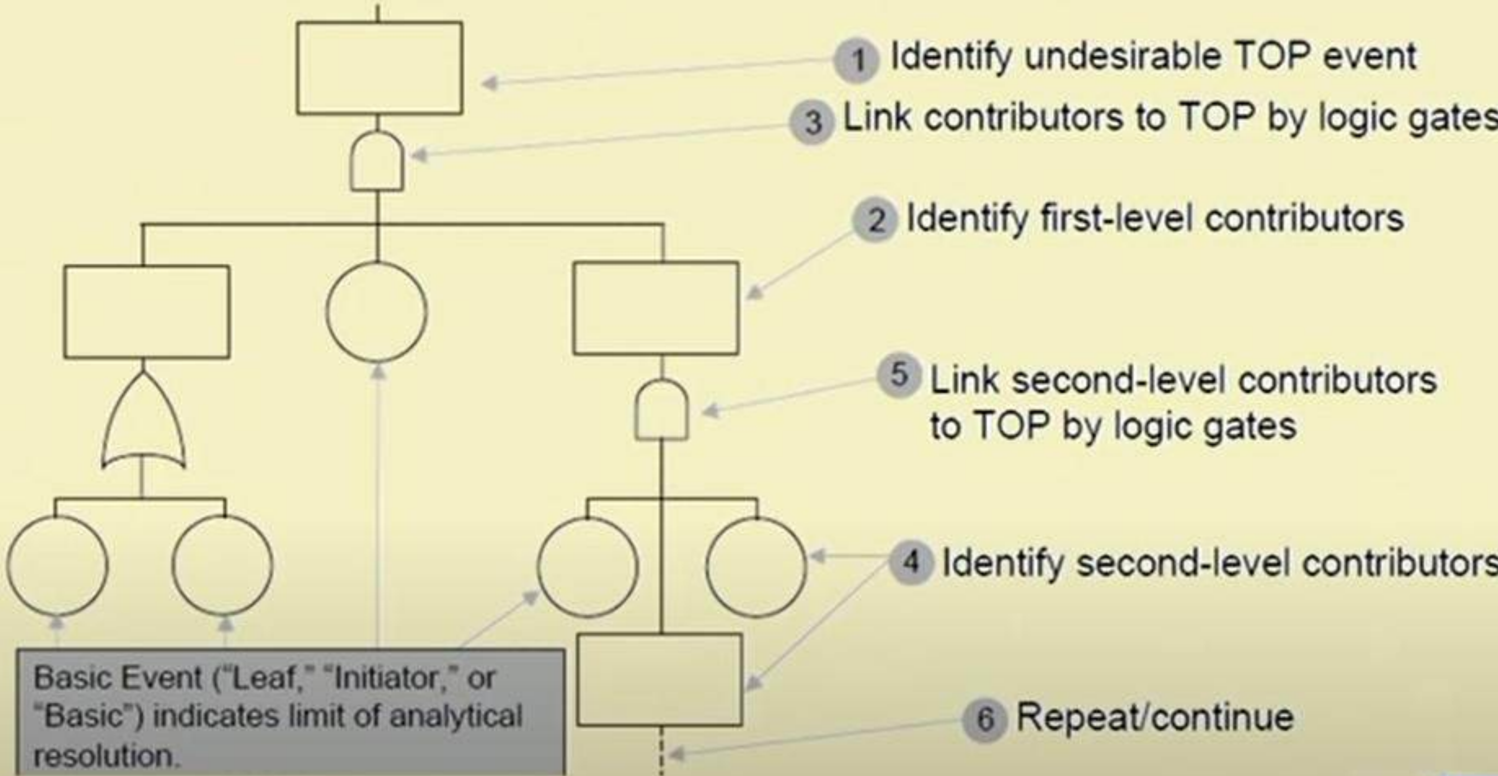
QE Tools - Fault Tree Analysis (FTA)

P-S-C Concept

- The P-S-C concept classifies a component failure as primary (P), secondary (S) or command (C) failure.
- The root of primary failures (P) lie within the design envelop and are caused by natural aging, wear and tear of the component.
- Secondary failures (S) are due to excessive stresses applied to a component, human error, environmental degradation and problems with neighboring components.
- Command failures (C) are inadvertent control signals and noise generated due to malfunctioning of human, environment and neighboring equipment.

QE Tools - Fault Tree Analysis (FTA)

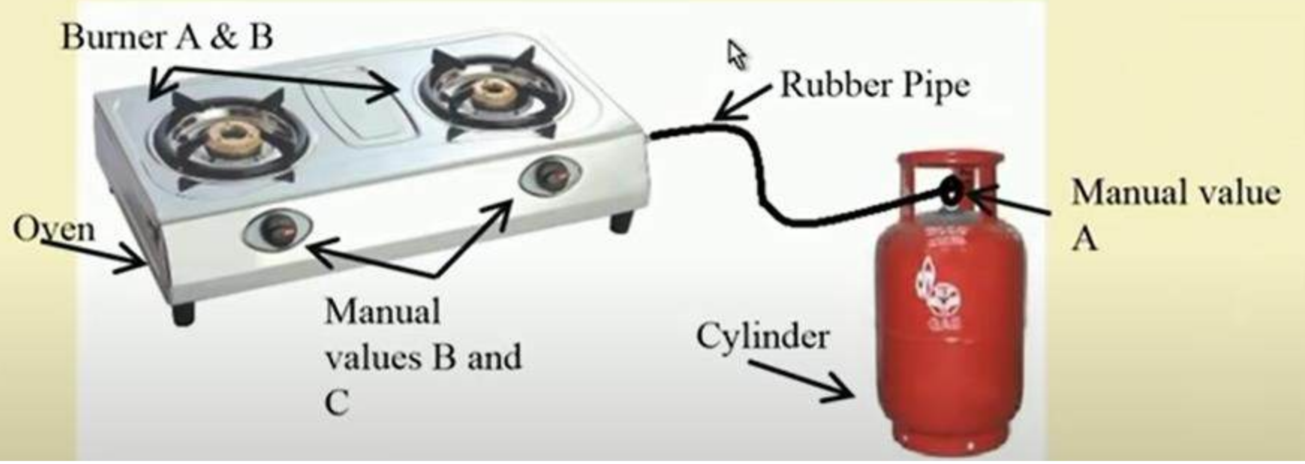
Steps in FT Construction



QE Tools - Fault Tree Analysis (FTA)

Fault Tree Construction Example 1

Now, we develop a fault tree for the gas-oven-system. Let the top event be ‘oven fails to burn’. It may be due to primary failure such as the burners worn out, or secondary failure like problem with lighter (neighboring component) or command failure like ‘no supply of gas’. Pictorially, we can write the phenomenon as shown in figure.



QE Tools - Fault Tree Analysis (FTA)

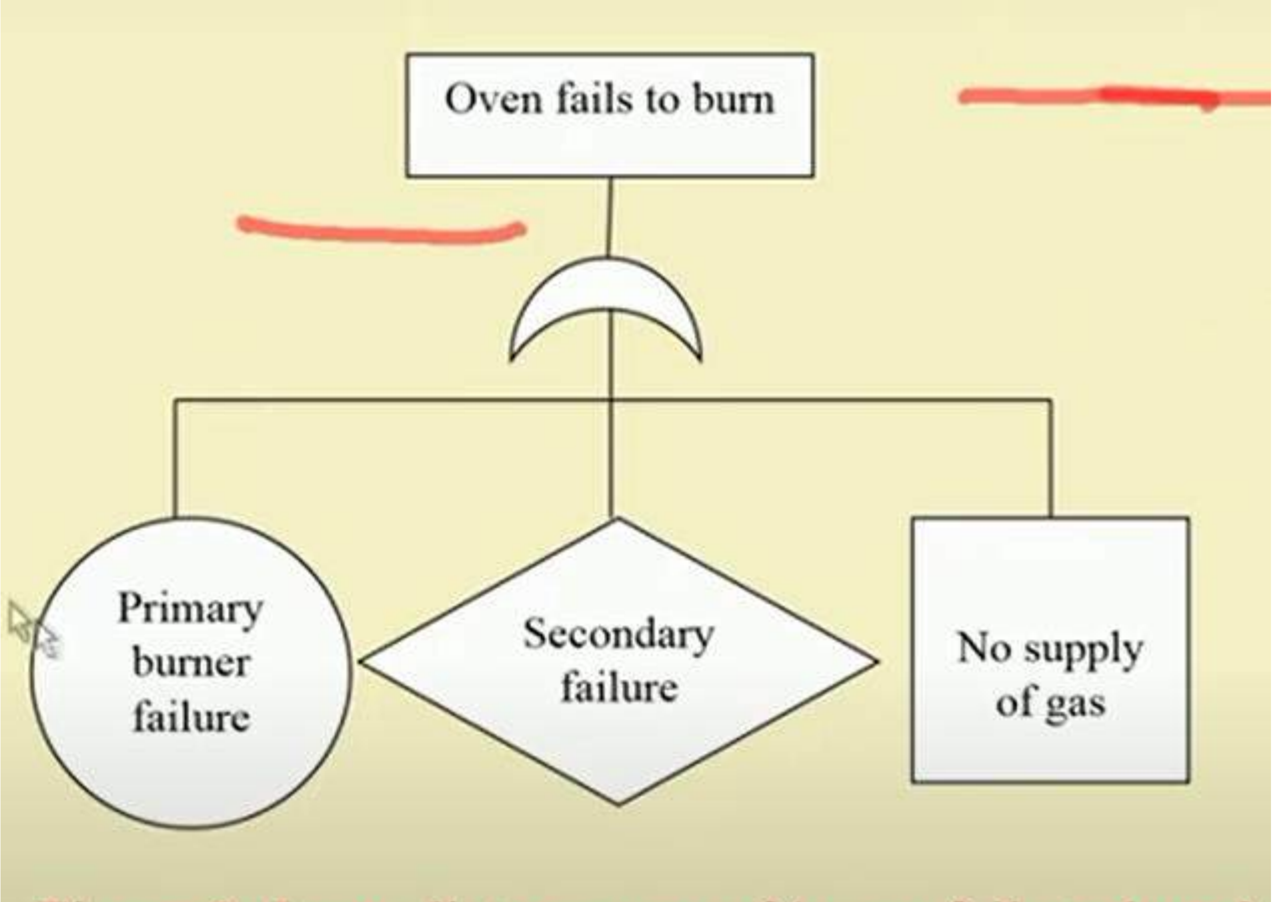
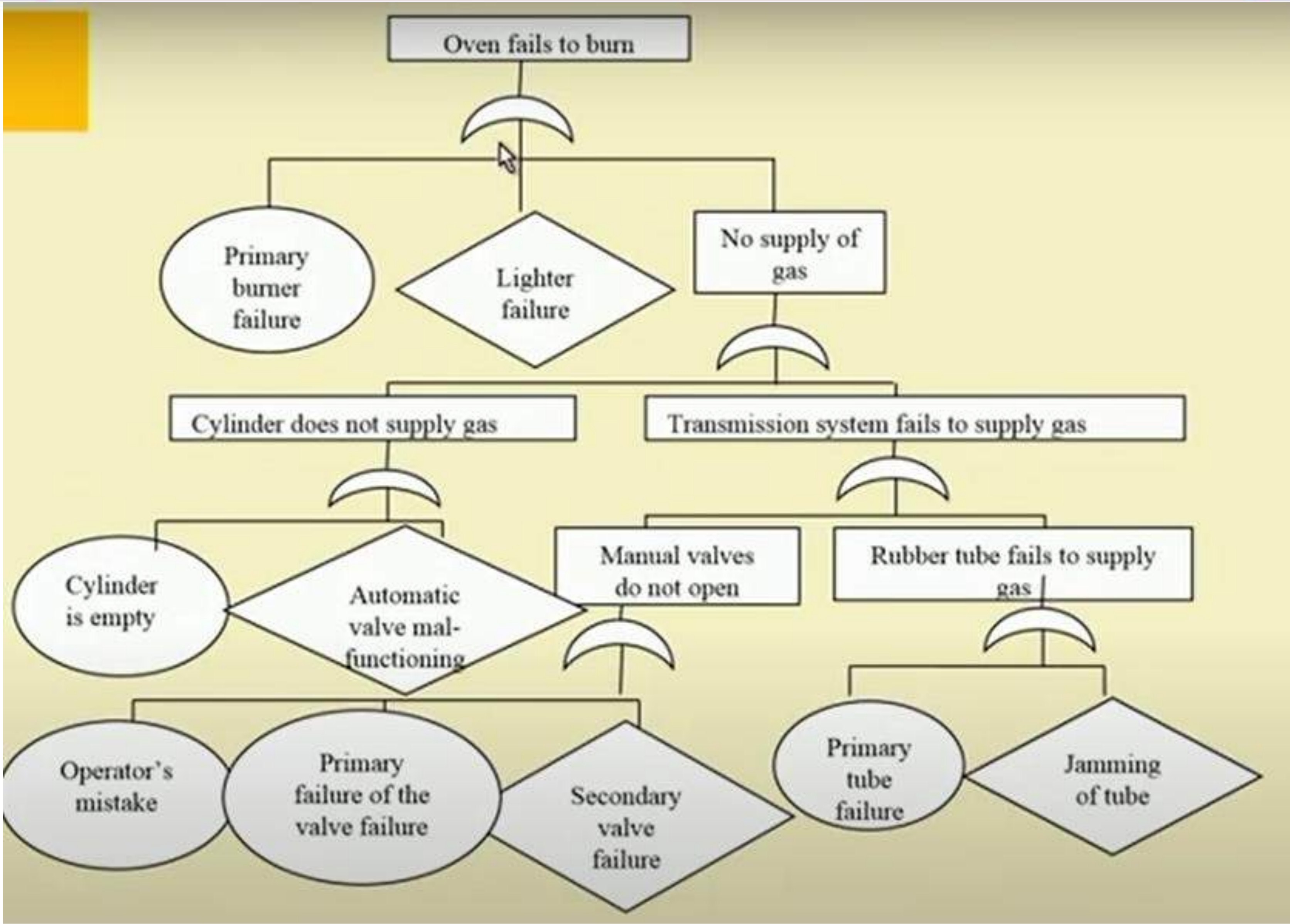
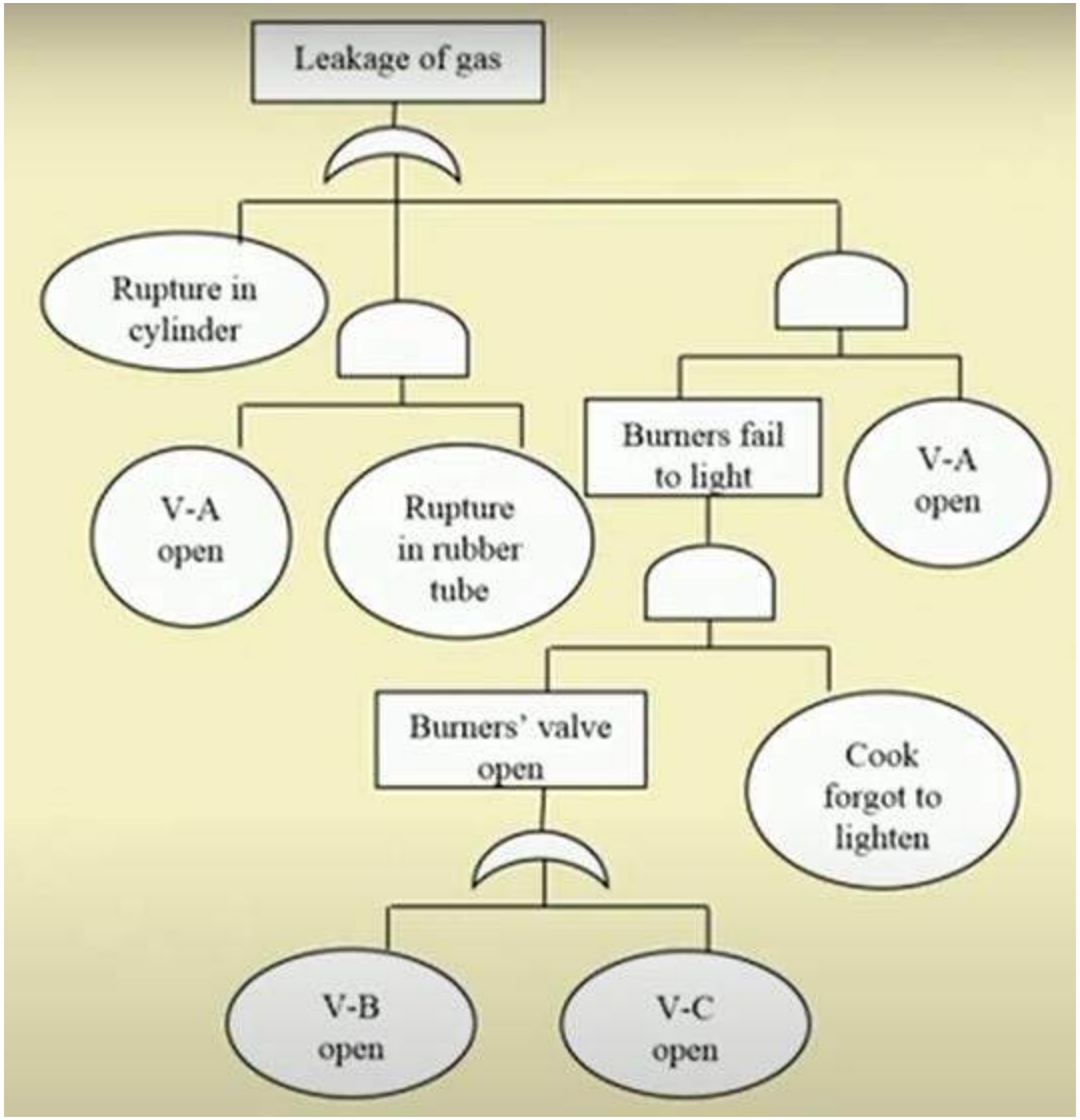


Figure 2. Immediate causes of 'oven fails to burn'

QE Tools - Fault Tree Analysis (FTA)



QE Tools - Fault Tree Analysis (FTA)



QE Tools - Fault Tree Analysis

- Fault tree analysis (FTA) is a graphical tool to explore the causes of system level failures.
- It uses boolean logic to combine a series of lower level events and it is basically a top-down approach to identify the component level failures (basic event) that cause the system level failure (top event) to occur.
- It consists of two elements "events" and "logic gates" which connect the events to identify the cause of the top undesired event.
- The purpose of FTA is to effectively identify cause(s) of system failure and mitigate the risks before it occurs.
- This is an invaluable tool for complex systems that visually displays the logical way of identifying the problem. Moreover system efficiency can be attained by this analysis.
- It can be implemented alone or complement to Failure Mode and Effects Analysis (FMEA).

Procedure to do FTA

- Define the primary failure to be analyzed in other words identify the undesirable top event
- Identify first level contributors which are just below the top level using the available technical information
- Link these contributors to top level event by using logical gates (AND, OR gates), and also see the relationship, so that it will help to identify the appropriate logical gate
- Identify the second level contributors and link to top by using logical gates.
- Identify minimal cut set
- Repeat the same steps till the basic causes
- Finally complete and evaluate the FTA
- Calculate probability of lowest level elements occurrence and also measure the probabilities from bottom up

Advantages of FTA

- Fault tree visually depict the analysis that will help team to work on cause of event in logical way that leads to failure
- Highlights the critical components related to system failure
- Provides an efficient method to analyse the system
- Unlike other analysis methods, human errors are also include in the analysis
- It helps to prioritize the action items to solve the problem
- Provides qualitative and quantitative analysis

Disadvantages of FTA

- Too many gates and events to be consider for large system analysis
- The basic disadvantage is that it examine only one top event
- Common cause failures are not always obvious
- Difficult to capture time related and other delay factors
- Needs experienced individuals to understand the logical gates

EVENT TREE ANALYSIS

Event Tree Analysis (ETA)

- Event trees begin with an initiating event and work towards the final result.
- This method provides information on how a failure can occur and the probability of occurrence.
- An event tree analysis (ETA) is an *inductive* procedure that shows all possible outcomes resulting from an accidental (initiating) event, taking into account whether <u>installed safety barriers are functioning or not, and additional events and factors.</u>

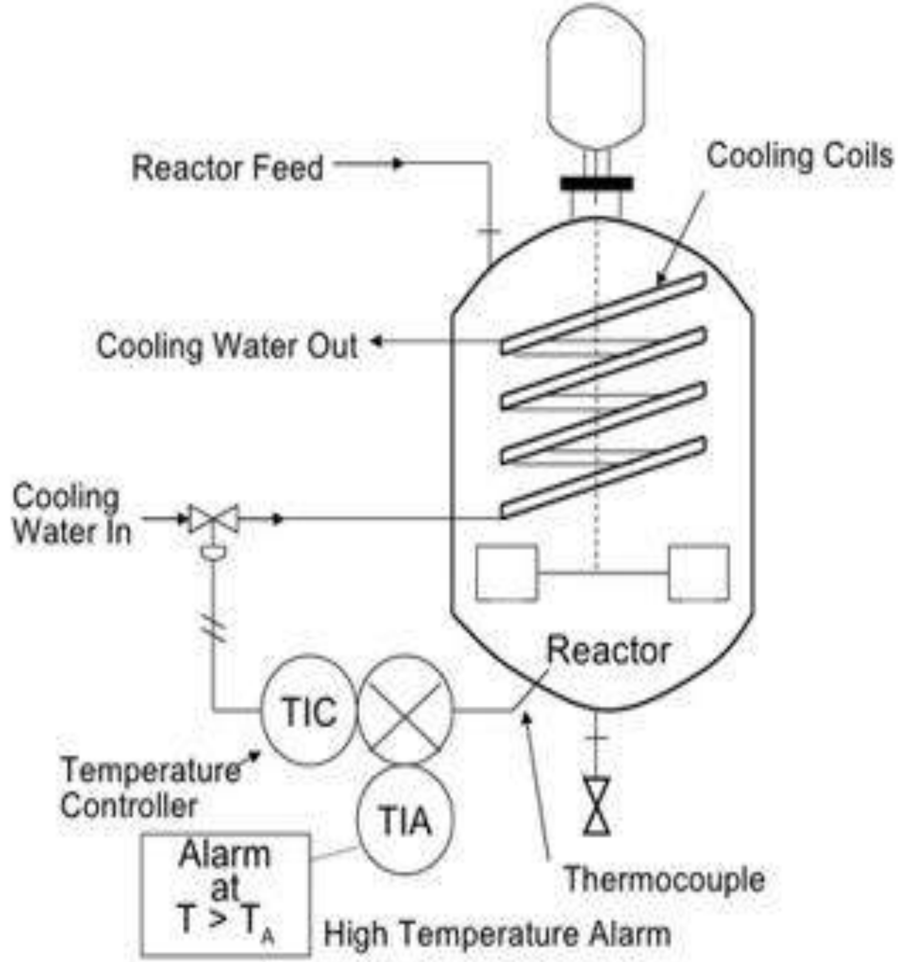
Steps

- Identify an initiating event of interest.
- Identify the safety functions designed to deal with the initiating event.
- Construct the event tree.
- Describe the resulting accident event sequences.

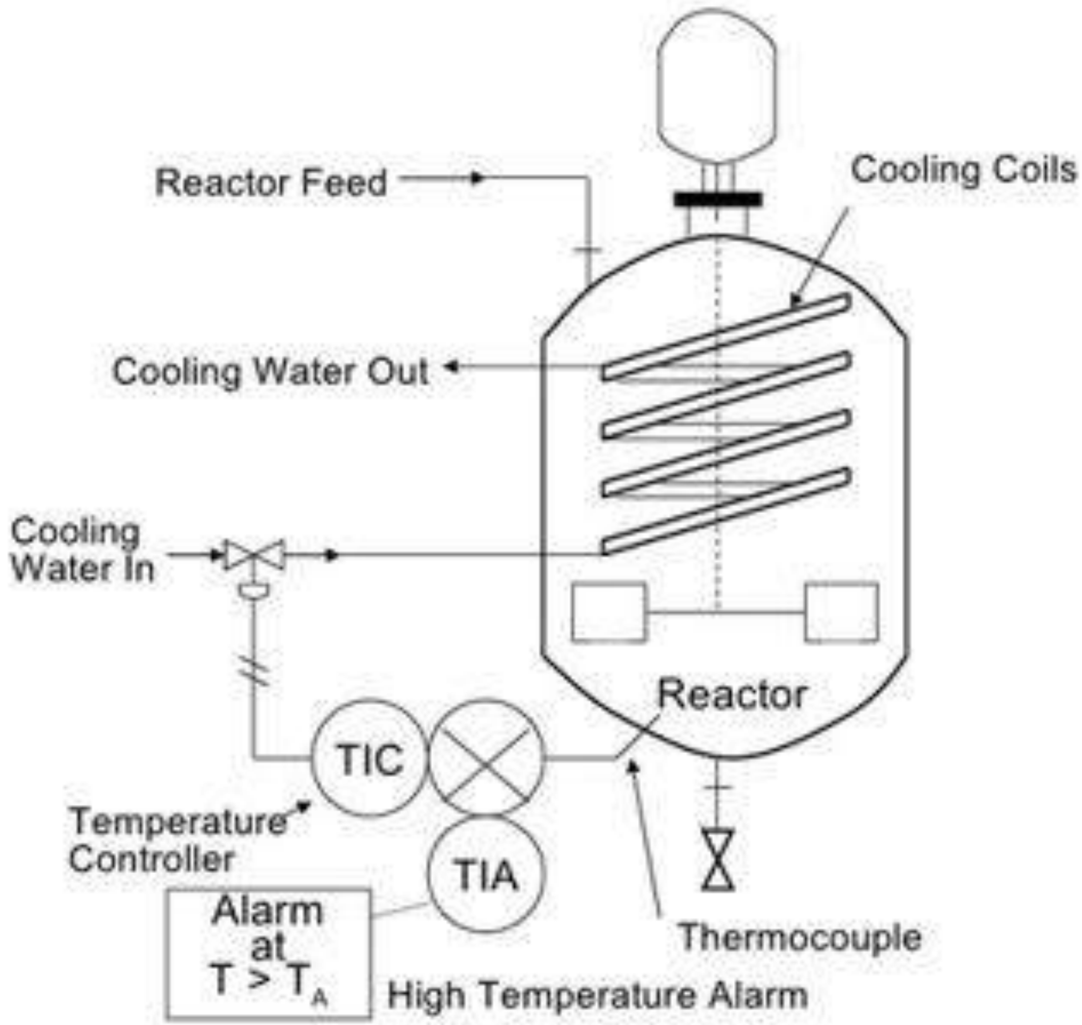
Example

Following safety functions are listed in the order in which they are intended to occur:

- Oxidation reactor high temp. Alarm alerts operator at temp T1.
- Operator re-establish cooling water flow to the oxidation reactor.
- Automatic shutdown system stops reaction at temp T2. (T2>T1).



Example



Reactor Feed
Cooling Coils
Cooling Water Out
Cooling
Water In
Reactor
TIC
Temperature
Controller
TIA
Alarm
at
T > T_A
Thermocouple
High Temperature Alarm

Step 1 – Identify the initiating event

- System or equipment failure
- Human error
- Process upset

- Example,
  - Loss of cooling water to an oxidation reactor

Step 2 – Identify the safety functions designed to deal with the initiating event

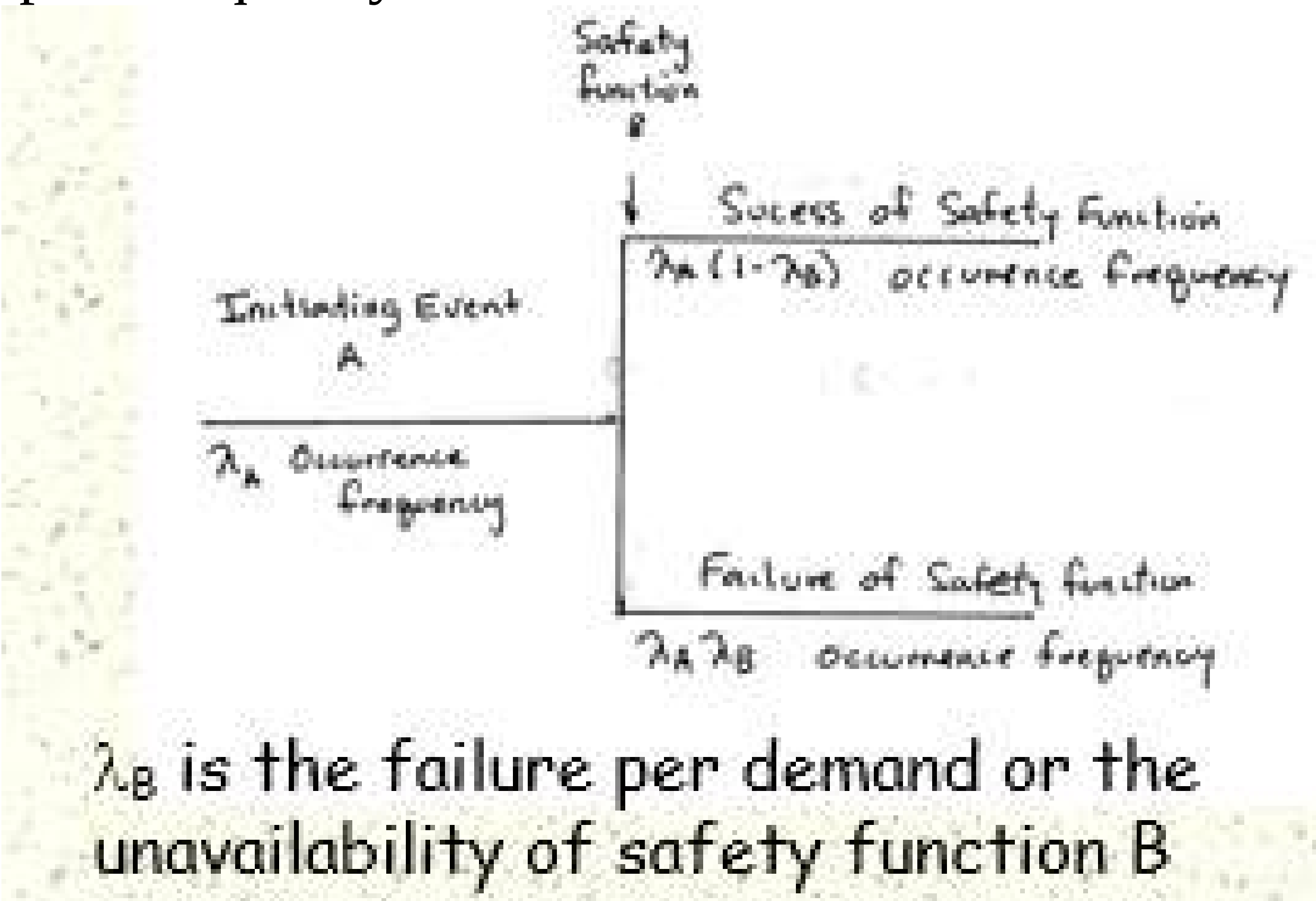
- Safety system that automatically respond to the initiating event.
- Alert the operator when the initiating event occurs and operator actions designed to be performed in response to alarms or required by procedures.
- Barriers or Containment methods that are intended to limit the effects of the initiating event.

Construct event tree

- Horizontal lines are drawn between functions that apply.
- Vertical lines are drawn at each safety function that applies
  - **Success – upward**
  - **Failure – downward**
- Indicate result of event
  - **Circle – acceptable result**
  - **Cross circle – unacceptable result**

Construct event tree

- Compute frequency of failures.



Occurrence frequency

- Follow process through with each step to calculate the frequency of each consequence occurring.

Three final results

- Continuous operations
- Shutdown (safely)
- Runaway or fail

Mean time between shutdown

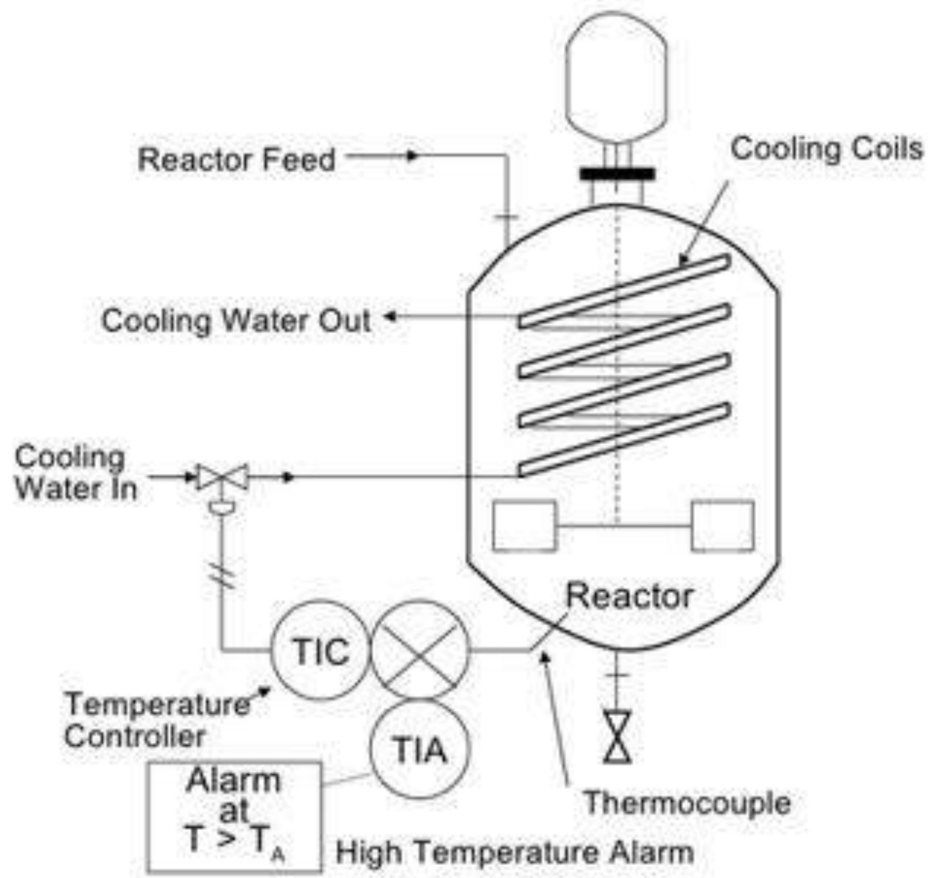
- Mean time between shutdown (MTBS)
  - MTBS = 1 / Σ occurrences of shutdowns

- Mean time between runaway (MTBR)
  - MTBR = 1 / Σ occurrence of runaway

Mean time between shutdown

Four safety interventions

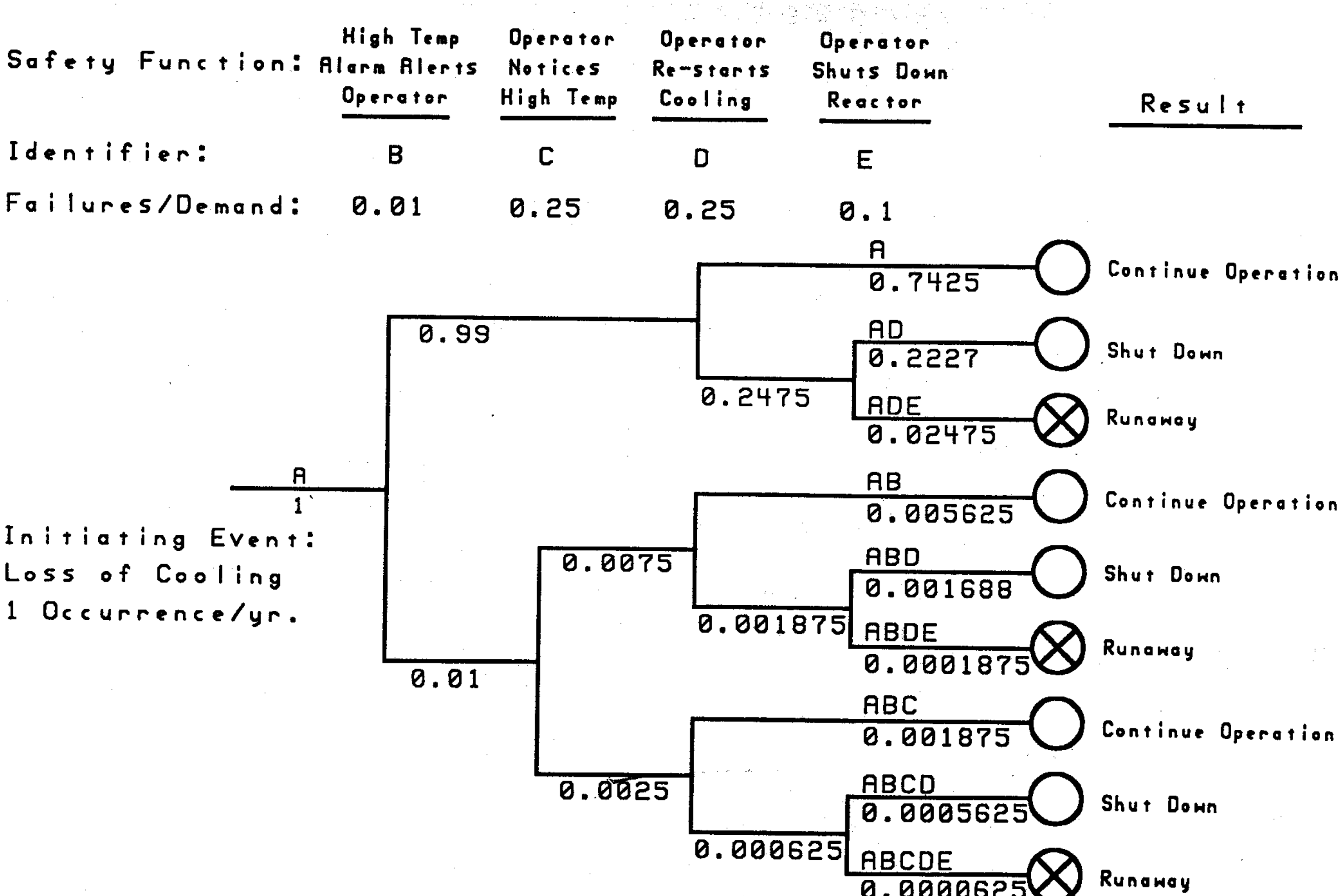
- High temp alarm
- Operating noticing the high temp during normal inspection
- Operator re establishes the coolant flow
- Operator performs the emergency shutdown of reactor



Example – Loss of coolant

- Assume loss of coolant occurs once per year (occurrence frequency 1/yr)
- Alarm fails 1% of time placed in demand (failure rate of 0.01 failures/demand)
- Operator will notice high reactor temperature 3 out of 4 times (0.25 failures/demand)
- Operator will successfully restart coolant flow 3 out of 4 times (0.25 failures/demand)
- Operator successfully shuts down reactor 9 out of 10 times (0.10 failures/demand)

Example – Loss of coolant



Shutdown = 0.2227 + 0.001688 + 0.0005625 = 0.2250 occurrences/yr.

Runaway = 0.02475 + 0.0001875 + 0.0000625 = 0.02500 occurrences/yr.

Step 3 – Construct the event tree

a. Enter the initiating event and safety functions.

SAFETY FUNCTION	Oxidation reactor high temperature alarm alerts operator at temperature T1	Operator reestablishes cooling water flow to oxidation reactor	Automatic shutdown system stops reaction at temperature T2

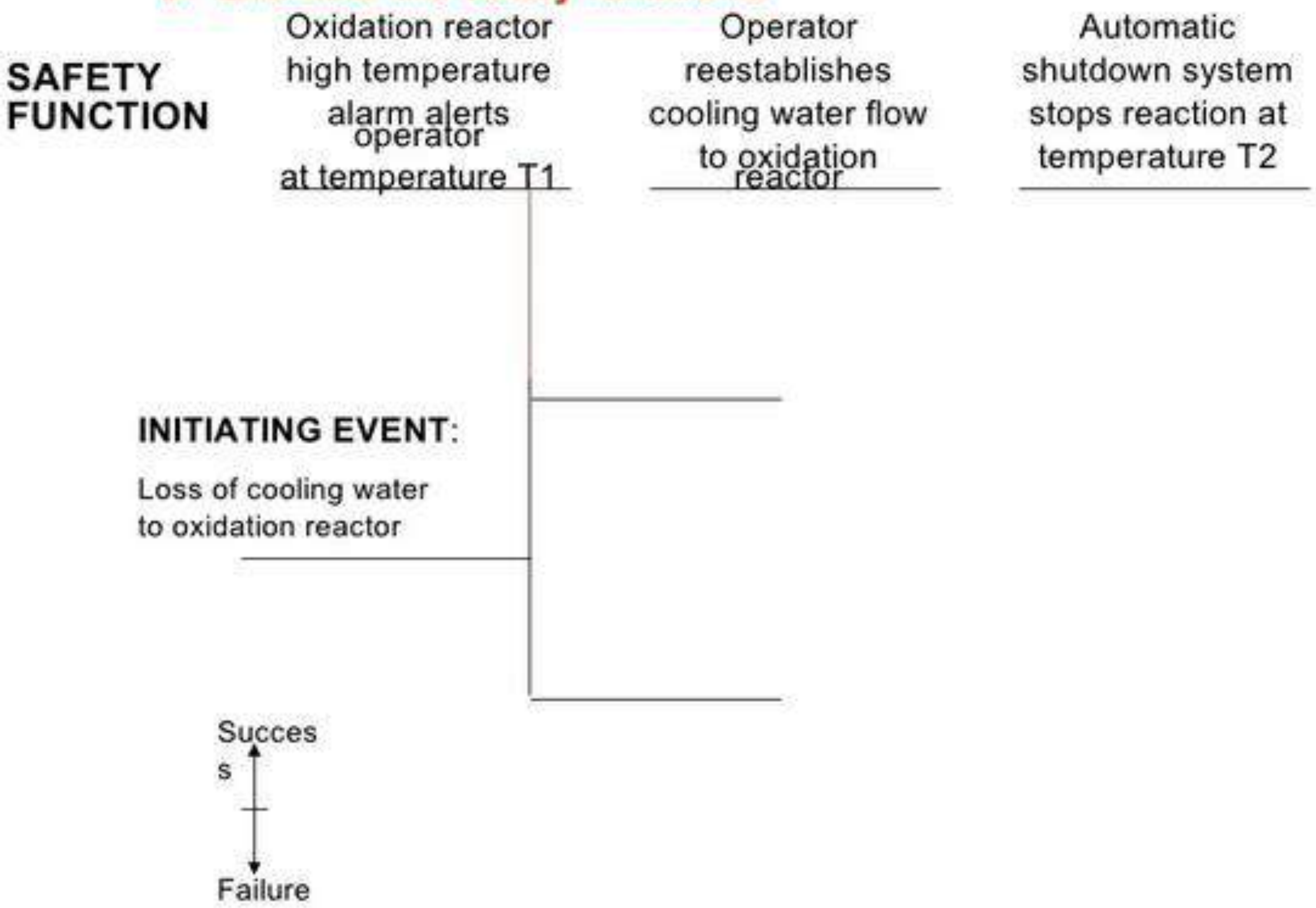
INITIATING EVENT:

Loss of cooling water to oxidation reactor

FIRST STEP IN CONSTRUCTING EVENT TREE

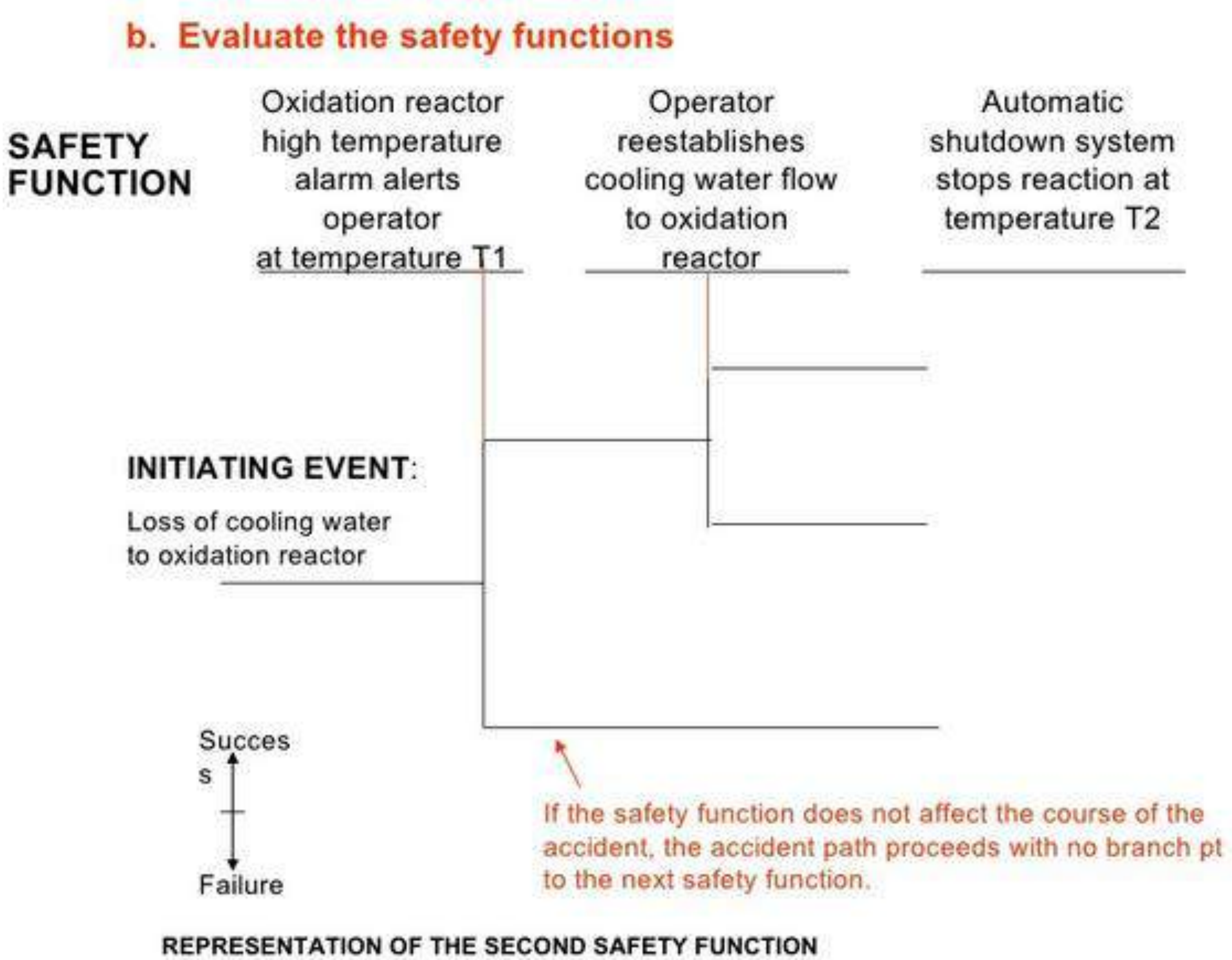
Step 3 – Construct the event tree

b. Evaluate the safety functions



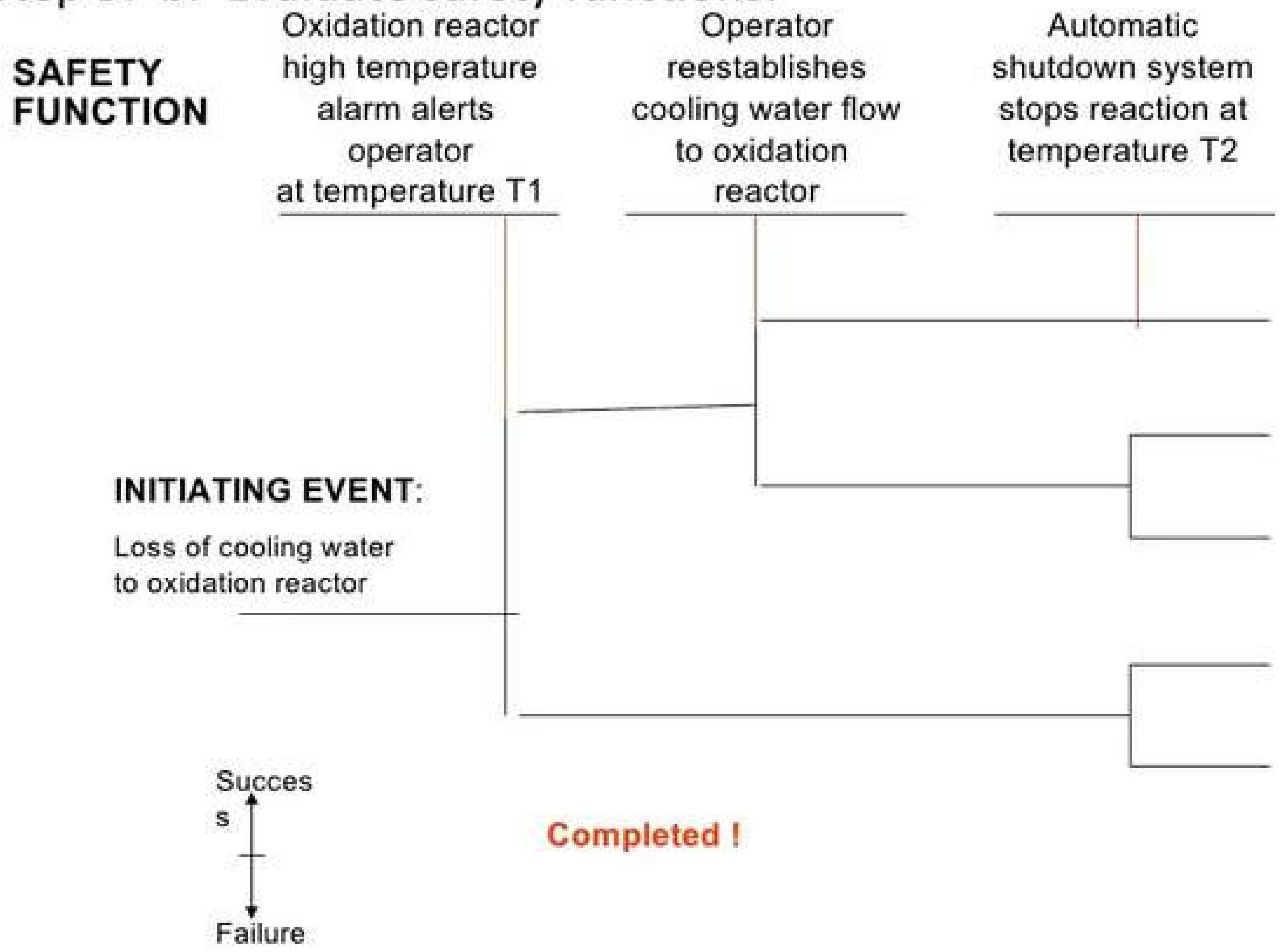
REPRESENTATION OF THE FIRST SAFETY FUNCTION

Step 3 – Construct the event tree



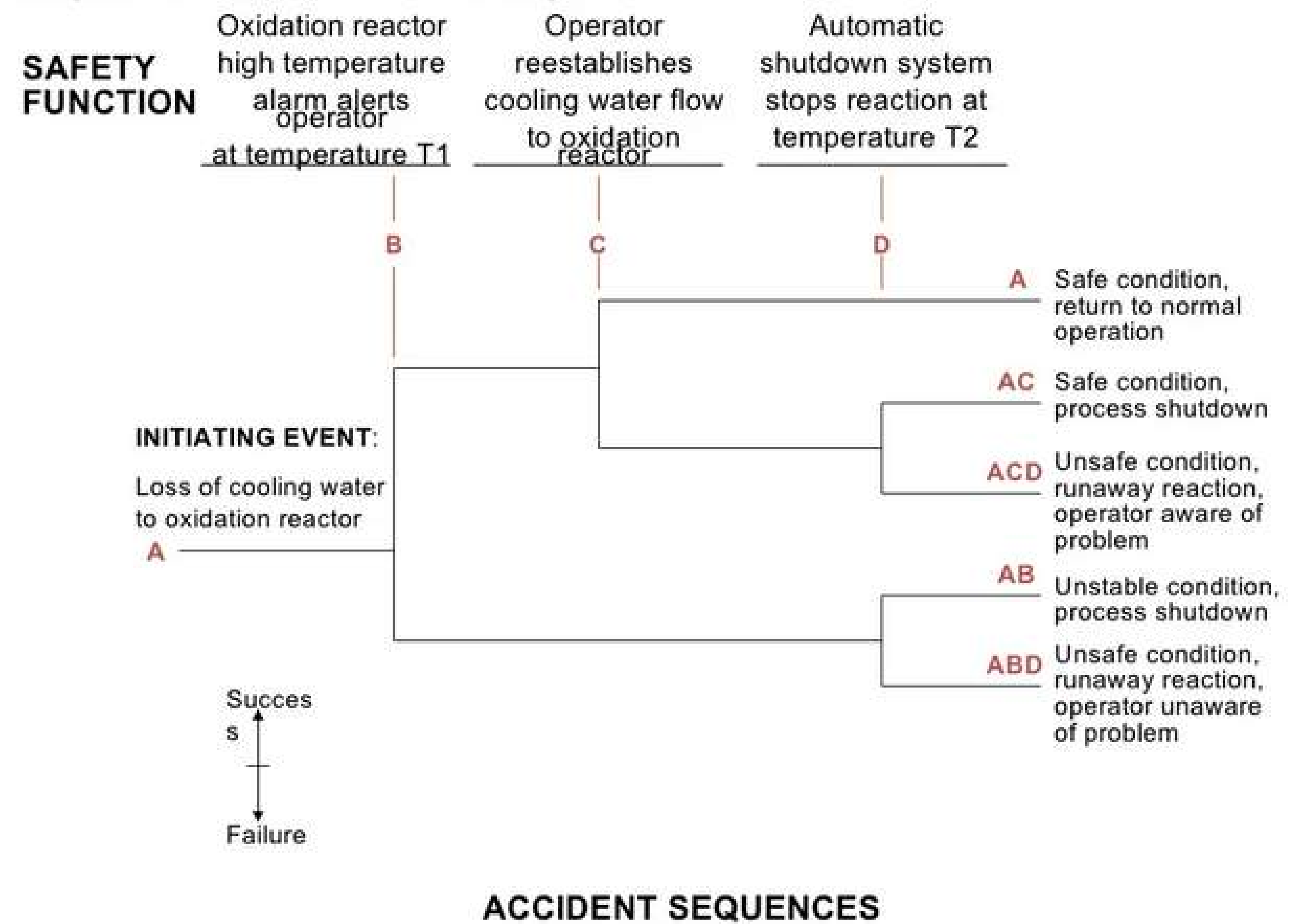
Step 3 – Construct the event tree

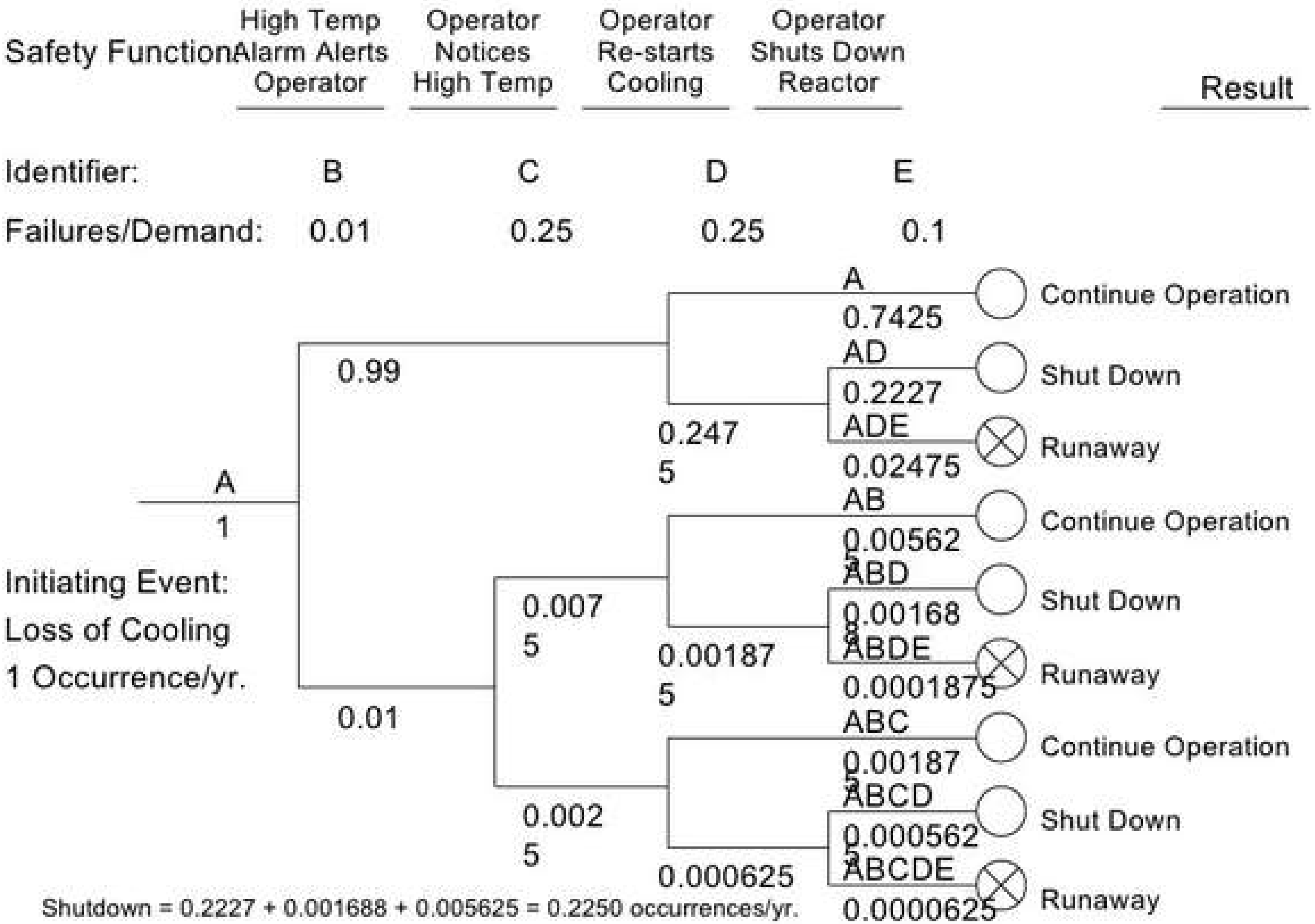
Step 3: b. Evaluate safety functions.



COMPLETED EVENT TREE

Step 3 – Describe the Accident sequence

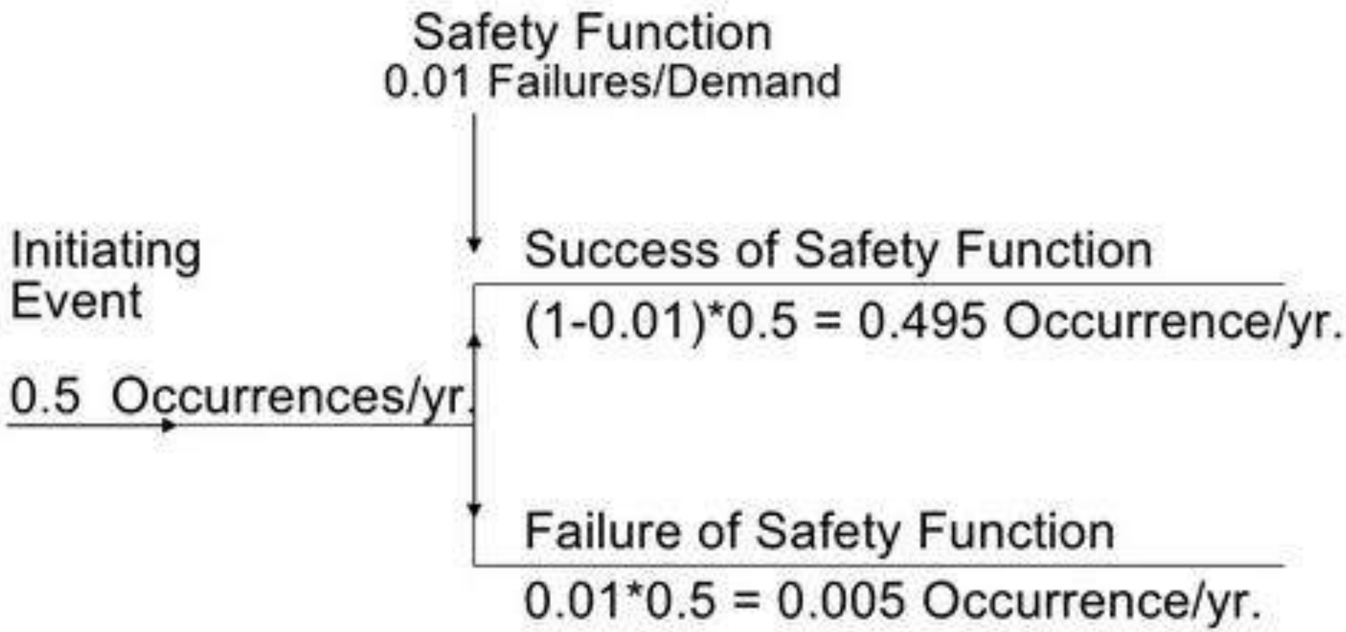


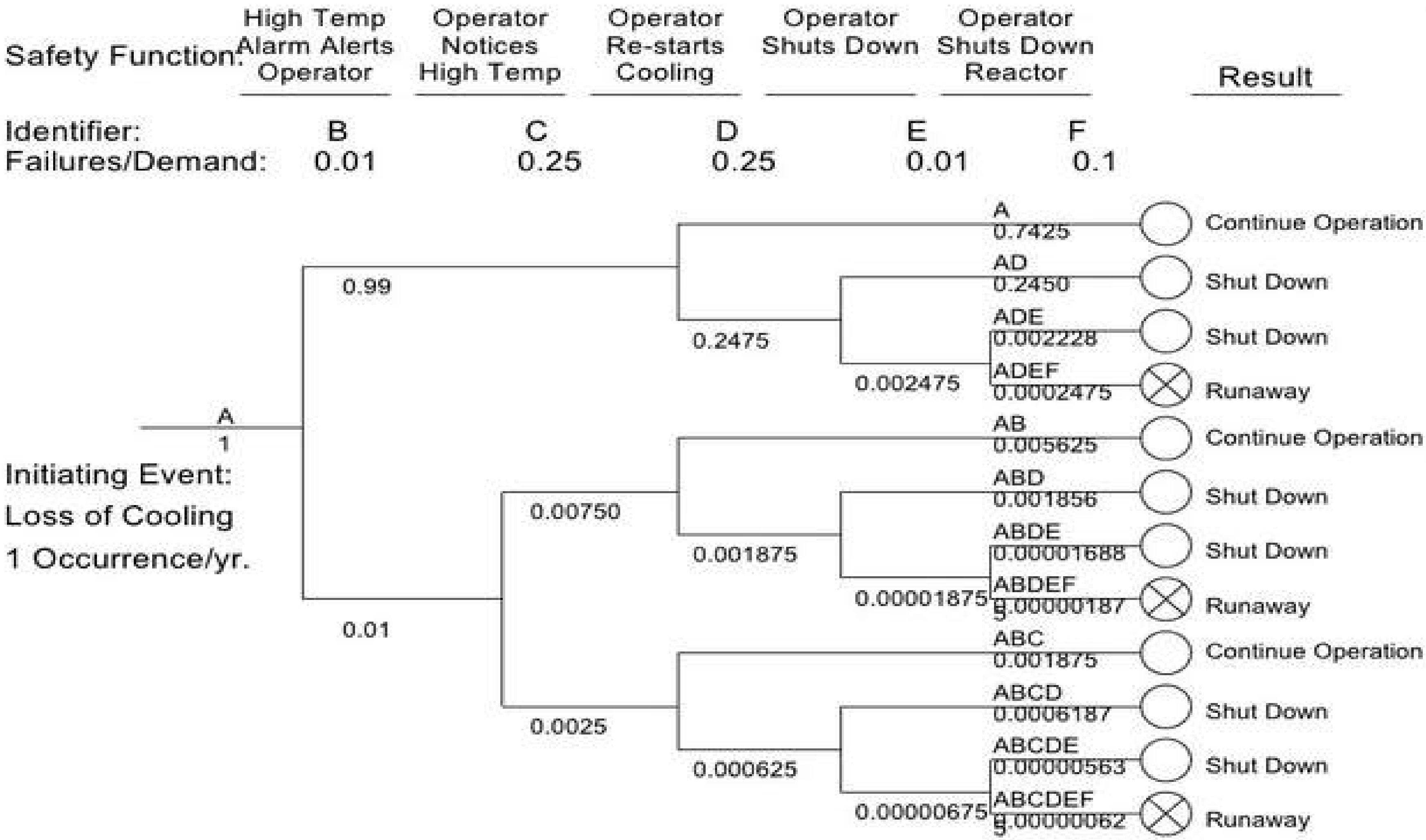


Shutdown = 0.2227 + 0.001688 + 0.005625 = 0.2250 occurrences/yr.

Runaway = 0.02475 + 0.0001875 + 0.0000625 = 0.02500 occurrences/yr.

Figure 11-9 Event tree for a loss of coolant accident for the reactor of Figure 11-8.


Safety Function
0.01 Failures/Demand
Initiating
Event
0.5 Occurrences/yr.
Success of Safety Function
(1-0.01)*0.5 = 0.495 Occurrence/yr.
Failure of Safety Function
0.01*0.5 = 0.005 Occurrence/yr.



Shutdown = 0.2450 + 0.001856 + 0.00001688 + 0.0006187 = 0.2475 occurrences/yr.

Runaway = 0.0002475 + 0.000001875 + 0.000000625 = 0.0002500 occurrences/yr.

Advantages

- Structured, rigorous and methodical approach.
- Can be effectively performed on varying levels of design detail.
- Permits probability assessment.

Failure Modes and Effect Analysis

- Failures modes and effect 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.
- Is an analytical technique that combines the technology and experience of people in identifying foreseeable failure modes of product or process and planning for its eliminations.
  - ✓ Recognize and evaluate the potential failure of a product or process and its effects.
  - ✓ Identify actions that could eliminate or reduce the chance of potential failures.
  - ✓ Document the process.

Failure Modes and Effect Analysis

- Failure modes are any errors or defects in a process, design or item, especially that affect the customer.
- Effect analysis refers to studying the consequences of those failures.

FMEA

History of FMEA:

- First used in the 1960's in the Aerospace industry during the Apollo missions
- In 1974, the Navy developed MIL-STD-1629 regarding the use of FMEA
- In the late 1970's, the automotive industry was driven by liability costs to use FMEA
- Later, the automotive industry saw the advantages of using this tool to reduce risks related to poor quality (QS-9000, VDA and ISO-TS 16949 standard)

FMEA - Main terms

Failure

- Loss of an intended function of a device under stated conditions

Failure mode

- The manner by which a failure is observed - way the failure occurred

Failure effect

- Immediate consequences of a failure on operation, function or functionality.

FMEA - Main terms

<u>Failure cause</u>

- Defects in design, process, quality or part application – which initiate a process which leads to failure

<u>Severity</u>

- Consequences of a failure mode – potential consequences of a failure, determined by the degree of injury, system damage etc

Stages of FMEA

The four stages of FMEA are given below:

1. Specifying Possibilities

a.Functions

b.Possible Failure Modes

c.Root Causes

d.Effects

e.Detection/Prevention

2. Quantifying Risk

a. Probability of Cause

b. Severity of Effect

c. Effectiveness of Control to Prevent Cause

d. Risk Priority Number

3. Correcting High Risk Causes

a. Prioritizing Work

b. Detailing Action

c. Assigning Action Responsibility

d. Check Points on Completion

4. Re-evaluation of Risk

a. Recalculation of Risk Priority Number

Process

Process for conducting an FMEA is typically developed in three main phases

- Step 1 - Severity
- Step 2 – Occurrence
- Step 3 - Detection

FMEA - Steps

1. For each process input 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

RPN = Severity X Occurrence X Detection

FMEA - Steps

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 highest severity

7. Assign the predicted Severity, Occurrence, and Detection levels and compare RPNs (before and after risk reduction)

Severity X Occurrence X Detection = RPN

FMEA

Process/Product
Failure Modes and Effects Analysis Form
(FMEA)

Process or Product Name:	
Responsible:	

Prepared by:	Page____ of____
FMEA Date (Orig)____________ (Rev)____________	

Process Step / Input	Potential Failure Mode	Potential Failure Effects	SEVERITY	Potential Causes	OCCURRENCE	Current Controls	DETECTION	RPN	Actions Recommended	Resp.	Actions Taken	SEVERITY	OCCURRENCE	DETECTION	RPN
What is the process step and Input under investiga-tion?	In what ways does the Key Input go wrong?	What is the impact on the Key Output Variables (Customer Requirements)?		What causes the Key Input to go wrong?		What are the existing controls and procedures (inspection and test) that prevent either the cause or the Failure Mode?			What are the actions for reducing the occurrence of the cause, or improving detection?		What are the completed actions taken with the recalculated RPN?				
								0							0
								0							0
								0							0
								0							0
								0							0

Identify failure modes and their effects

Identify causes of the failure modes and controls

Prioritize

Determine and assess actions

FMEA

- Preferred Scales are1-10
- Adjust Occurrence scales to reality figures for your company

Severity

1 = Not Severe, 10 = Very Severe

Occurrence

1 = Not Likely, 10 = Very Likely

Detection

- 1 = Easy to Detect, 10 = Not easy to Detect

FMEA

Process/Product
Failure Modes and Effects Analysis Form
(FMEA)

Process or Product Name:		Prepared by:	Page ____ of ____
Responsible:		FMEA Date (Orig) ____________ (Rev) ____________	

Process Step / Input	Potential Failure Mode	Potential Failure Effects	SEVERITY	Potential Causes	OCCURRENCE	Current Controls	DETECTION	RPN	Actions Recommended	Resp.	Actions Taken	SEVERITY	OCCURRENCE	DETECTION	RPN
What is the process step and Input under investiga-tion?	In what ways does the Key Input go wrong?	What is the impact on the Key Output Variables (Customer Requirements)?		What causes the Key Input to go wrong?		What are the existing controls and procedures (inspection and test) that prevent either the cause or the Failure Mode?			What are the actions for reducing the occurrence of the cause, or improving detection?		What are the completed actions taken with the recalculated RPN?				
								0							0
								0							0
								0							0
								0							0
								0							0

Identify failure modes and their effects

Identify causes of the failure modes and controls

Prioritize

Determine and assess actions

Severity X Occurrence X Detection = RPN

FMEA

Customer: NMHG BEREA	Customer Part No: 8675309	Revision: 1	FMEA / Document No: 5309
Supplier: ACME WIDGETS	Supplier Part No: X-753 BRAKECALIPERASSEMBLY	Dwg No: X-753	Key Date: 5/17/13

Part Name: BRAKE CALIPER	Process Responsibility: M.E.	Application Date: 6/1/13	Prepared By: JENNY TONE	Date: 5/28/13
Core Team: JENNY TONE, JOHN DOE, JOHN SMITH, BILL CLINTON, SAMMY DAVIS		Approved By: DONALD TRUMP		Date: 6/27/13

Process Description Process Purpose	Potential Failure Mode	Potential Effects(s) of Failure	SEV	Potential Cause(s) of Failure	OCC	Current Control	DET	RPN	Recommended Actions	Area/Individual Responsible & Completion Date	SEV	OCC	DET	RPN

FMEA

Customer: NMHG BEREA	Customer Part No: 8675309	Revision: 1	FMEA / Document No: 5309
Supplier: ACME WIDGETS	Supplier Part No: X-753 BRAKECALIPERASSEMBLY	Dwg No: X-753	Key Date: 5/17/13
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Core Team: JENNY TONE, JOHN DOE, JOHN SMITH, BILL CLINTON, SAMMY DAVIS	Approved By: DONALD TRUMP		Date: 6/27/13

Process Description / Process Purpose	Potential Failure Mode	Potential Effects(s) of Failure	SEV	Potential Cause(s) of Failure	OCC	Current Control	DET	RPN	Recommended Actions	Area/Individual Responsible & Completion Date	SEV	OCC	DET	RPN

Identify failure modes at each process step!

Identify consequences of that failure!

Determine Severity of failure mode!

Identify potential root causes of failure mode!

Potential for occurrence!

Document current process controls!

Risk Priority Number (RPN).
Highest # equals Highest Risk!
Severity x Occurrence x Detectability = RPN
Use Like Pareto Chart to identify what items to address first.

How capable are we of detecting the failure mode with our current controls?

FMEA

Customer: NMHG BEREA	Customer Part No: 8675309	Revision: 1	FMEA / Document No: 5309
Supplier: ACME WIDGETS	Supplier Part No: X-753 BRAKE CALIPER ASSEMBLY	Dwg No: X-753	Key Date: 5/17/13
Part Name: BRAKE CALIPER / Process Responsibility: M.E.	Application Date: 6/1/13	Prepared By: JENNY TONE	Date: 5/28/13
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Process Description / Process Purpose	Potential Failure Mode	Potential Effects(s) of Failure	SEV	Potential Cause(s) of Failure	OCC	Current Control	DET	RPN	Recommended Actions	Area/Individual Responsible & Completion Date	SEV	OCC	DET	RPN
CASTING ATTACH TORQUE	OVER TORQUE	CASTING FRACTURE	10	TORQUE WRENCH NOT CONTROLLED	4	DC TORQUE WRENCH USED / LINKED TO OMS	3	120	ADD TORQUE ALARM AND CALIBRATION AT START UP.	JENNY TONE	10	2	1	20
	UNDER TORQUE	CASTING SEPARATION	9	TORQUE WRENCH NOT USED/ CONTROLLED										
	CROSS THREAD	CASTING SEPARATION	9	NO LEAD IN ON BOLT THREAD										

Severity X Occurrence X Detection = RPN

FMEA - 10 Steps to Conduct a FMEA

1. **Review the process** — Use a process flowchart to identify each process component.
2. **Brainstorm potential failure modes** — Review existing documentation and data for clues.
3. **List potential effects of failure** — There may be more than one for each failure.
4. **Assign Severity rankings** — Based on the severity of the consequences of failure.
5. **Assign Occurrence rankings** —Based on how frequently the cause of the failure is likely to occur.

FMEA

6. Assign Detection rankings — Based on the chances the failure will be detected prior to the customer finding it.

7. Calculate the RPN — Severity X Occurrence X Detection

8. Develop the action plan — Define who will do what by when.

9. Take action — Implement the improvements identified by your PFMEA team.

10. Calculate the resulting RPN — Re-evaluate each of the potential failures once improvements have been made and determine the impact of the improvements.

Thankyou

19ME72
Quality Engineering & Management

Chapter – 4
Quality Management

Course Coordinator

Dr. R. Vishnu / Dr. C. Vivek

Assistant Professor

Department of Mechanical Engineering

Coimbatore Institute of Technology

Course content

19ME72 - QUALITY ENGINEERING AND MANAGEMENT

ASSESSMENT: THEORY

L	T	P	C
3	0	0	3

COURSE OBJECTIVE

To know about basicaspects and tools related to quality engineering and management.

COURSE OUTCOMES

At the end of the course, the students will be able to

CO1: *Outline the quality engineering system with various types of evaluation of loss function.*

CO2: *Analyze the characteristics and schedules in preventive maintenance along with various quality tools.*

CO3: *Design on-line quality control system for various production environments by considering feedback and various process control parameters.*

CO4:*Define quality management axioms and implement Deming philosophy along with action plans.*

CO5:*Demonstrate and implement various quality management tools.*

Course content

Quality Engineering and Loss Function . (9)

Quality value and engineering- overall quality system-quality engineering in product design - quality engineering in design of production processes - quality engineering in production - quality engineering in service.Derivation – loss function for products/system- justification of improvements-loss function and inspection- quality evaluations and tolerances-N type, S type, L type

Quality Engineering and TPM (9)

Preventive Maintenance (PM) schedules- PM schedules for functional characteristics- PM schedules for large scale systems. Quality tools–fault tree analysis, event tree analysis, failure mode and effect analysis.ISO quality systems.

On-Line Quality Control (9)

On-line feedback quality control variable characteristics-control with measurement interval- one unit, multiple units-control systems for lot and batch production. On-line process parameter control variable characteristics- process parameter tolerances- feedback control systems- measurement error and process control parameters.

Course content

Quality Management **(9)**

Definitions of the terms – quality planning, quality control, quality assurance, quality management, total quality management as per ISO 8402 – overview on TQM – the TQM axioms – Commitment – scientific knowledge – involvement Consequences of total quality. Six sigma, C_p, C_{pk}, P_{pk} Deming's fourteen points on quality management – five DDs – implementing the Deming philosophy - action plan – the Deming cycle – Case study.

Techniques in Quality Management **(9)**

Kaizen and innovation – the kaizen management practices – Total Quality Control (TQC) — small group activities – quality circles – Comparison of Kaizen and Deming's approach with illustration. Affinity diagram – brain storming – cause and effect analysis –check list– flow charts – Pareto analysis – quality costing – Quality Function Deployment (QFD) – Training of quality – self managing teams.

TOTAL : 45

Course content

TEXT BOOKS

1. De Feo J A and Barnard WW, "Six Sigma: Breakthrough and Beyond", Tata McGraw-Hill, New Delhi,2005.

2. Pyzdek T and Berger R W, "Quality Engineering Handbook", Tata-McGraw Hill, New Delhi, 1996.

3. LogotheticsN ., —Managing for total quality – From Deming to Taguchi and SPC — , Prentice hall Ltd, New Delhi, 1997.

4. Juran J.M &Gryna F.M., —quality Planning and Analysis – From Product development through use‖,TataMcGrawHill Publishing Limited, new Delhi, 3rd Edition , 1995

REFERENCES

1. KaniskaBedi, "Quality Management", Oxford University Press, Chennai, 2007.

2. Brue G, "Six Sigma for Managers", Tata-McGraw Hill, New Delhi, Second reprint, 2002.

3. Taguchi G, Elsayed E A and Hsiang, T.C.,"Quality Engineering in Production Systems", Mc-Graw-HillBook company, Singapore, 1989.

4. Deming W E, —Out of the Crisis," MIT Press, Cambridge, MA, 1982.

5. Juran J M and Juran on —Leadership for Quality" An Executive Handbook, The Free Press, New York,1989.

6. Salor J.H., —TQM-FleldManual,‖ McGraw Hill, New York, 1992.

7. Crosby P.B., — Quality is Free,‖ McGraw Hill, New York, 1979

Quality Management

- Quality means conformance to specifications and fitness for use.
- Fitness for purpose
- Customer satisfaction
- Conformance to the requirements.

How do we manage quality

- Quality planning.
- Perform quality assurance
- Perform quality control

Quality planning

- Process of identifying which quality standards are relevant to the project and determining how to satisfy them.
- **Input parameters** – Quality policy, scope statement, product description, standards and process output.
- **Methodology** – Benefit/cost analysis, benchmarking, flowcharting and design of experiments.
- **Output** – Quality management plan, operational definitions, checklists.

Plan Quality

Inputs

- Scope Baseline
- Stakeholder Register
- Cost Performance Baseline
- Schedule Baseline
- Risk Register
- Enterprise Environmental Factors
- Organizational Process Assets

Tools & Techniques

- ❑ Cost-benefit analysis
- ❑ Cost of quality
- ❑ Control charts
- ❑ Benchmarking
- ❑ Design of experiments
- ❑ Statistical sampling
- ❑ Flowcharting
- ❑ Proprietary quality management methodologies
- ❑ Additional quality planning tools

Outputs

- Quality Management Plan
- Quality Metrics
- Quality Checklists
- Process Improvement Plan
- Project document updates

Plan Quality → **Perform Quality Assurance** → **Perform Quality Control**

Plan Quality

- *Cost of Quality – Evaluating the cost of conformance with the cost of nonconformance to reach a balance. Includes;*
  - *Prevention Costs*
  - *Appraisal Costs*
  - *Failure Costs*

Deming's Costs of Quality

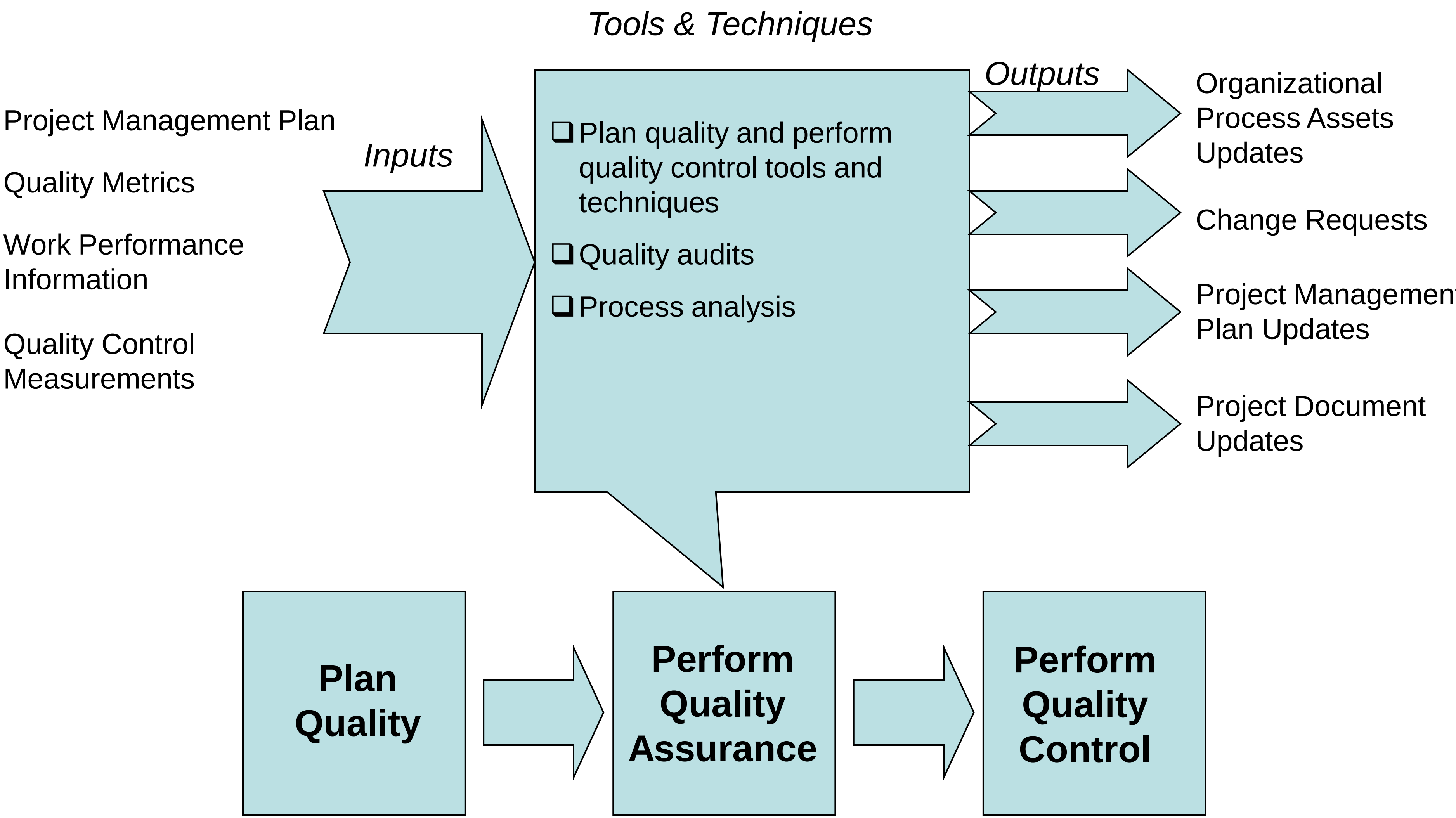
Cost of Conformance	Cost of Non Conformance
Quality training	Rework
Studies	Scrap
Surveys	Inventory Costs
	Warranty Costs

85% of the costs of quality are the direct responsibility of management - Deming

Quality Assurance

- Process of evaluating overall project performance on a regular basis to provide confidence that the project will satisfy the relevant quality standards.
- **Input** – Quality management plan, results of quality control measurements and operational definitions.
- **Methodology** – Quality planning tools, quality audits.
- **Output** - Quality improvements.

Perform Quality Assurance



Quality Control

- Process of monitoring specific project results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance.
- **Input parameters** – Work results, checklist, process plan, management plan.
- **Methodology** – Inspection, control charts, pareto diagrams, statistical sampling.
- **Output** – Quality improvements, acceptance decision, rework, process adjustments.

Perform Quality Control

Inputs

- Project Management Plan
- Quality Metrics
- Quality Checklists
- Work Performance Measurements
- Approved Change Requests
- Deliverables
- Organizational Process Assets

Tools & Techniques

- ❑ Cause and effect diagram
- ❑ Control charts
- ❑ Flowcharting
- ❑ Histogram
- ❑ Pareto Chart
- ❑ Run chart
- ❑ Scatter diagram
- ❑ Statistical sampling
- ❑ Inspection
- ❑ Approved change requests review

Outputs

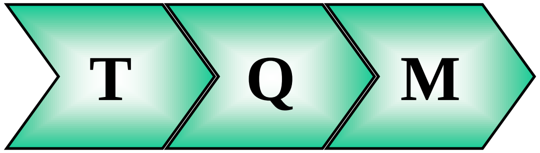
- Quality Control Measurements
- Validated Changes
- Validated Deliverables
- Organizational Process Assets Updates
- Change Requests
- Project Management Plan Updates
- Project Document Updates

Main approaches to Quality and QM

- Deming
- Juran
- Crosby
- TQM
- Six Sigma
- ISO 9000

Total Quality Management

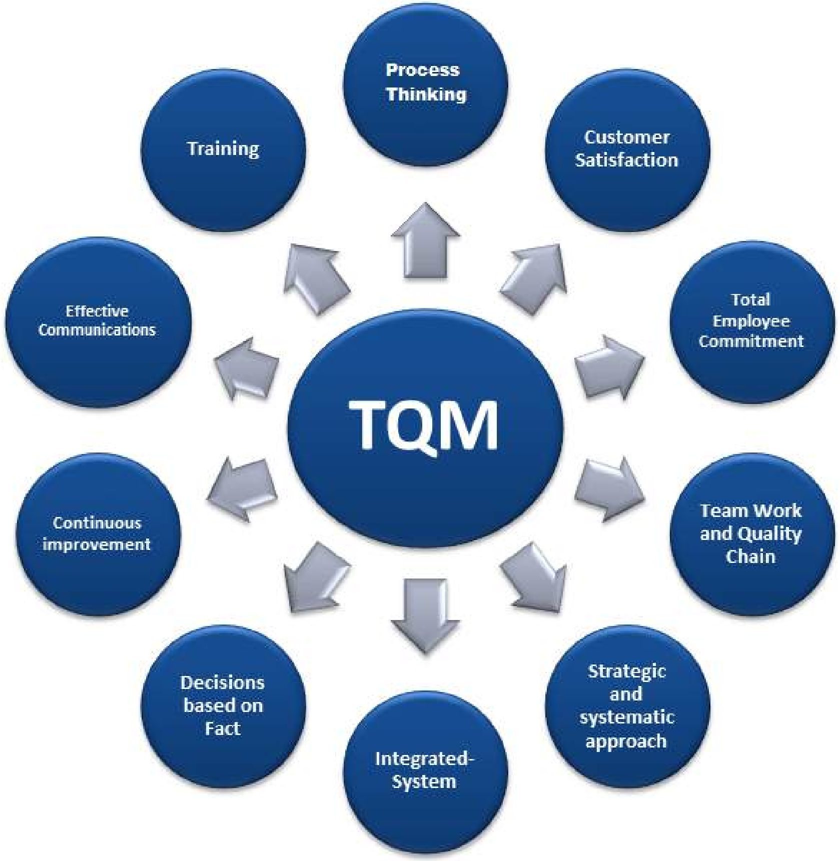
- A philosophy that involves everyone in an organization in a continual effort to improve quality and achieve customer satisfaction



- Continuous improving.
- Involvement of everyone.
- Customer satisfaction.

TQM

- Focuses on meeting customer needs, by providing quality services at reasonable costs.
- Focuses on continuous improvement. Emphasizes teamwork.



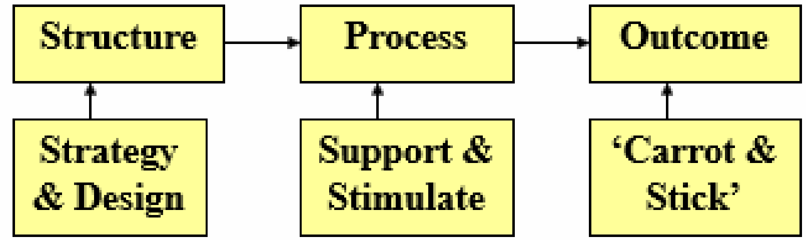
Customer Focus

- Survival of any organization is dependent on customers.
- Customer Satisfaction.

- External Customers:
- Internal Customers:

Continuous Improvement

- Requirement for competitiveness.
- Focus on process & structure
- rather than results.



Teamwork

- Utilizing everyone's knowledge
- Shift away from Internal competition.
- Involve suppliers as well as customers.
- Old theories: F.W. Taylor

Scientific Approach

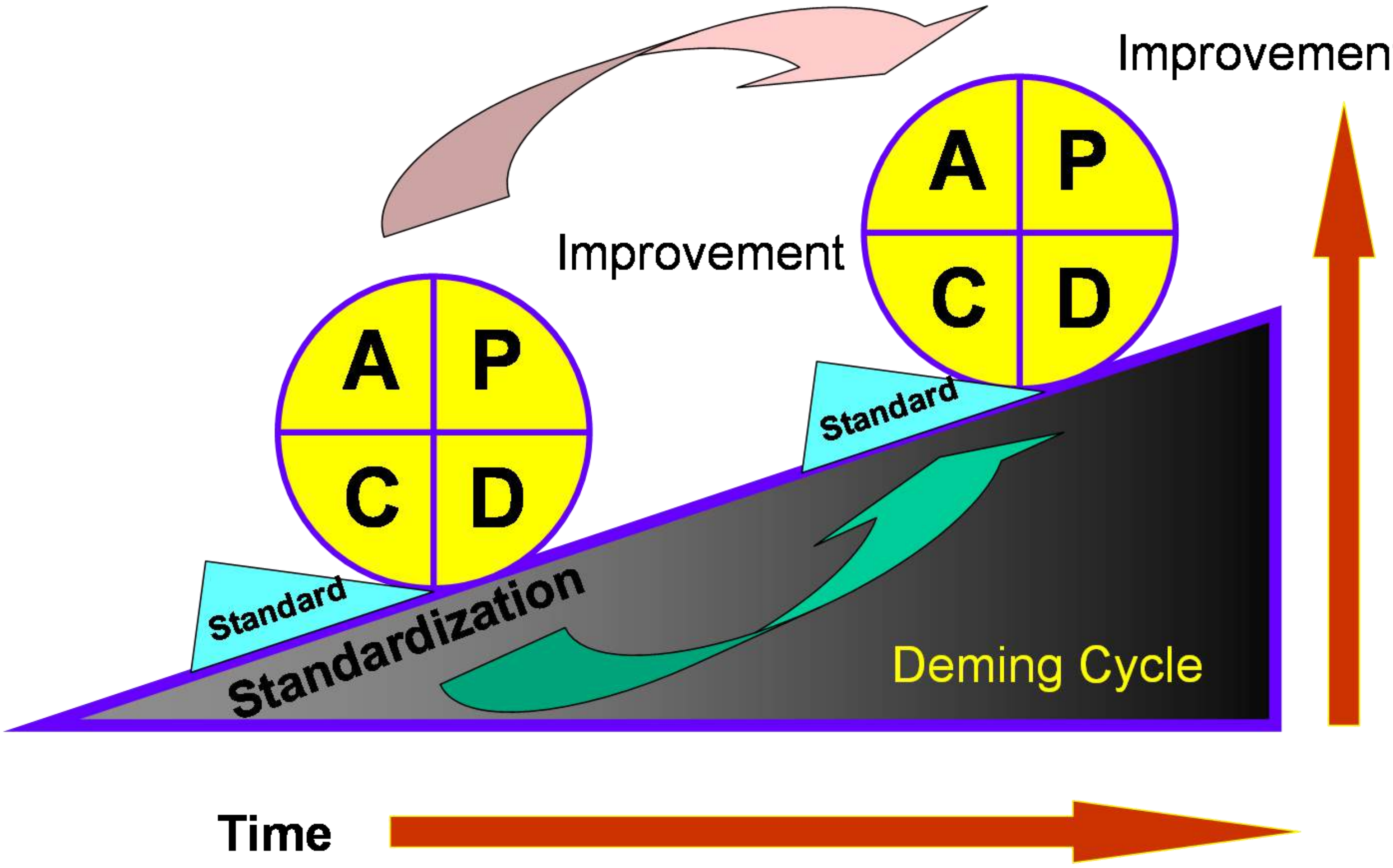
- 7 basic tools of quality.
- Statistical Tools.
- Analytical approach.
- Improvement Methodology (FOCUS)
- Change Methodology (PDSA)

Methodology

- F find a process to improve
- O organize an improvement effort.
- C clarify the current process.
- U Understand process variation
- S select improvement strategies

- P Plan the change
- D Do or implement the change
- C check the results
- A act upon the data to reinforce or modify the change

Methodology



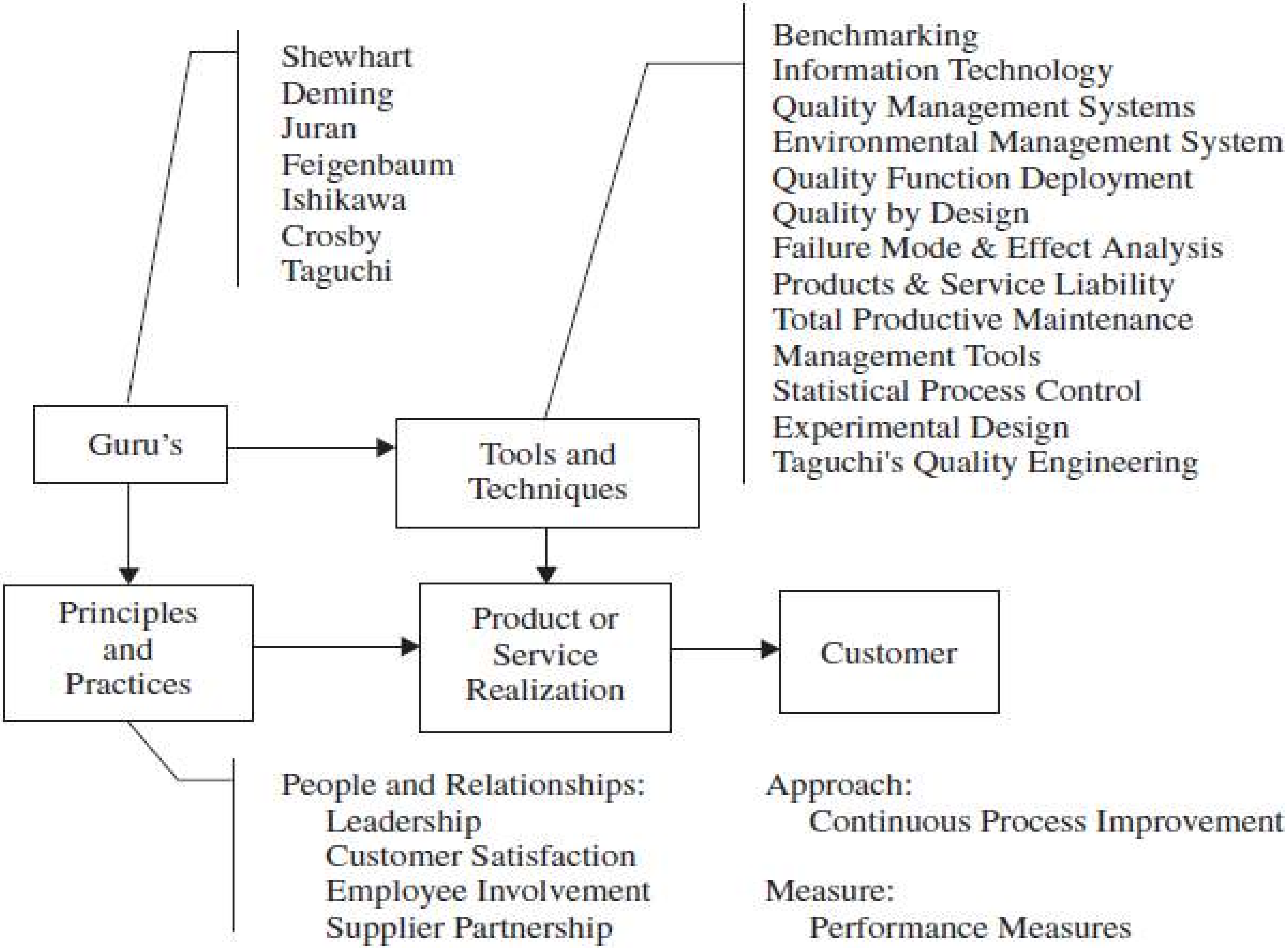
TQM Approach

- Find out what the customer wants
- Design a product or service that meets or exceeds customer wants
- Design processes that facilitates doing the job the first time
  - Poka-yoke = mistake fool proofing
    - Laptop – projector plug shapes.
- Keep track of results
- Extend these concept to suppliers

Elements of TQM

1. Continual improvement – Kaizen
2. Competitive benchmarking
3. Employee empowerment
4. Team approach
5. Knowledge of tools
6. Supplier quality
7. Quality at the source

TQM Framework



TQM Framework

The Deming Theory

The Deming Theory of Management is a management philosophy based on four principles:

(1) an appreciation for systems

(2) a knowledge of variation

(3) a theory of knowledge, and

(4) psychology.

Deming’s fourteen points for TQM

1. Create and Publish the Aims and Purposes of the Organization
2. Learn the New Philosophy
3. Understand the Purpose of Inspection
4. Stop Awarding Business Based on Price Alone
5. Improve Constantly and Forever the System
6. Institute Training
7. Teach and Institute Leadership

Deming's fourteen points for TQM (Contd..)

8. Drive Out Fear, Create Trust, and Create a Climate for Innovation

9. Optimize the Efforts of Teams, Groups, and Staff Areas

10. Eliminate Exhortations for the Work Force

11. A. Eliminate Numerical Quotas for the Work Force

11. b. Eliminate Management by Objective

12. Remove Barriers That Rob People of Pride of Workmanship

13. Encourage Education and Self-Improvement for Everyone

14. Take Action to Accomplish the Transformation

Seven Deadly Diseases

Deming compiled a list of seven deadly diseases that have inhibited change in the style of management.

- Lack of constancy of purpose.
- Emphasis on short-term profits: short-term thinking (just the opposite from constancy of purpose to stay in business).
- Management by fear.
- Mobility of management: job hopping.
- Use of visible figures only for management, with little or no consideration of figures that are unknown or unknowable.
- Excessive medical costs.
- Excessive costs of liability, fueled by lawyers that work on contingency fees.

Steps in implementing TQM

1 Obtain CEO Commitment

2 Educate Upper-Level Management

3 Create Steering Committee

4 Outline the Vision Statement, Mission Statement, & Guiding Principles

5 Prepare a Flow Diagram of Company Processes

6 Focus on the Owner/Customer (External) & Surveys

7 Consider the Employee as an Internal Owner/customer

8 Provide a Quality Training Program

9 Establish Quality Improvement Teams

10 Implement Process Improvements

11 Use the Tools of TQM

12 Know the Benefits of TQM

Steps in implementing TQM

1. *Obtain CEO Commitment.*
2. *Educate upper level management*.

To educate the upper level management we have to conduct the following:

- Undergo quality training
- Commit to TQM and provide the necessary resources.
- Assist in the development.
- Serve as a model of expected behavior.
- Actively lead the way.
- Drive fear out of the organization
- Provide suitable recognition.
- Drive decision making and problem resolution.

Steps in implementing TQM

3. *Create a steering committee*.

   Upon completion of upper management's commitment and training, a steering committee must be created to guide the company through the process of implementing TQM.

- Steering committee roles are…….
  - Review and evaluate customer surveys.
  - Determine processes to be improved.
  - Appoint task process improvement teams.
  - Monitor process improvement.
  - Oversee employee recognition for quality improvement.
  - Communicate successes and progress.

Steps in implementing TQM

4. *Outline the Vision Statement, Mission Statement, & Guiding Principles*

Establishing guiding principles: Important principles to consider including in the company's vision statement, mission statement, and guiding principles are as follows:

- Owner/customer Satisfaction.
- Improved Safety.
- Elimination of errors and defects.
- Doing things right, the first time.
- Reputation as the best in the field.
- Continuous Improvement.
- Employee Empowerment.

Steps in implementing TQM

5. *Prepare a Flow Diagram of Company Processes:*

A mechanical engineering firm created the TQM flow diagram illustrated in the figure below:

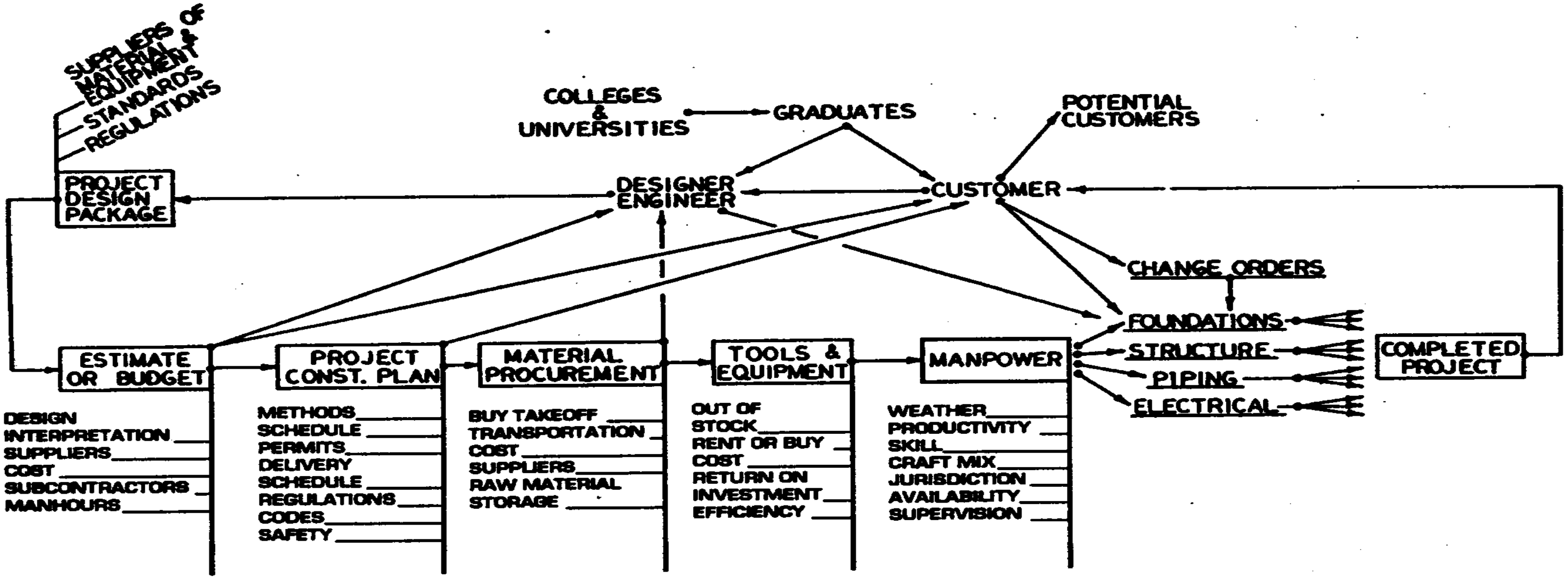


Figure 1.9. Construction service viewed as a system.

Steps in implementing TQM

6. *Focus on the Owner/Customer (External) & Surveys*

Focusing on a customer's concerns

Several areas to survey, and to take care to provide or honor, are listed here:

- ✓ Safe operating procedures
- ✓ Accident experience
- ✓ Attitude
- ✓ Professional competence
- ✓ Technical competence of the work force
- ✓ Overall responsiveness to owner/customer requests
- ✓ Planning
- ✓ Condition of equipment
- ✓ Timeliness

Steps in implementing TQM

Successful TQM companies have asked their owner/customers the following questions:

- How well do we deliver what we promise?
- How often do we do things right the first time?
- How often do we do things right on time?
- How quickly do we respond to your request?
- How accessible are we when you need to contact us?
- How helpful and polite are we?
- How well do we speak your language?
- How well do we listen to you?
- How hard do you think we work at keeping you a satisfied owner/customer?
- How much confidence do you have in our products or services? Etc…

Steps in implementing TQM

7. *Consider the Employee as an Internal Owner/Customer*

In order to conduct an analysis of the internal processes following steps should be applied:

- List several of your internal owners/customers within your company
- Choose one of these owners/customers to focus on for the application of this technique
- Determine the *Outputs* (products, services, information) that must be provided to this internal owner/customer
- Determine the work *Processes* your company uses to produce these *Outputs*
- Learn how your customer's expectations are met and how satisfaction is measured

Steps in implementing TQM

8. *Provide a Quality Training Program*

Which employees are trained first?

The successful TQM company provides training to employees in the order illustrated in the list below:

- Upper Management
- Remaining Management
- In-House Trainers & Facilitators
- Front-Line Supervisors
- Non-Supervisory Employees
- Team Training
- Training of Subcontractors & Suppliers

Steps in implementing TQM

9. *Establish quality improvement teams*

A quality improvement teams focuses on following areas for improvement:

- Increased Employee Value
- Informed Employees
- Technical Training
- Quality Training
- Employee Suggestions
- Employee Participation
- Higher Quality of Artistry
- Personal Development

Steps in implementing TQM

- **The quality improvement team tasks are:**
  - Identify the customers of the process
  - Determine customer expectations
  - Flowchart the process
  - Identify all of the inputs and interfaces
  - Identify the output(s)
  - Systematically review the procedures currently being used in the process
  - Collect and analyze available quantitative data
  - Determine the need for additional data
  - Identify the problem(s)
  - Determine the root cause of the problem
  - Determine potential solutions
  - Select a trial solution
  - Present recommendations to the steering committee
  - Implement the solution on a pilot-project basis
  - Analyze the data to discern if there has been improvement

Steps in implementing TQM

10. Implement Process Improvements:

The structure approach to process improvement is as follows:

- Problem is brought to the attention of the steering committee
- Steering committee forms a team to examine the process and make necessary recommendations for improvement
- Team meets, reviews its mission, and determines how often it will meet
- Training is initiated for team members
- Team meets weekly for an hour or two to analyze the problem and develop a solution
- Solution is initiated on a pilot basis
- Results of pilot study are examined
- Solution is implemented company-wide

Steps in implementing TQM

Administrative	Project Management and Engineering	Logistical	Construction
Payroll Invoices Personnel actions Investments Insurance Marketing Training (safety, quality, technical	Subcontracts Partial payment requests Progress review meetings Estimating Scheduling Interfacing with architect/engineer Shop drawing review Survey and layout Testing	Storage Warehousing Delivery Maintenance	Layout Rough grading Forming Placing concrete Placing reinforcing Erecting precast panels Framing drywall Pulling electrical cable Hanging ductwork

Steps in implementing TQM

11. Use of Tools:

Seven *classical* tools of quality and process improvement, plus one, are presented below.

Flowchart: Portrays all the steps in a process. Helps understand the process.

Cause and Effect Diagram: Portrays possible causes of a process problem. Helps determine root cause

Control Chart: Shows if a process has too much variation.

Steps in implementing TQM

Seven Classical Tools (Contd…)

<u>Histogram</u> : Portrays the frequency of occurrence.

<u>Check Sheet</u> : Tabulates frequency of occurrence.

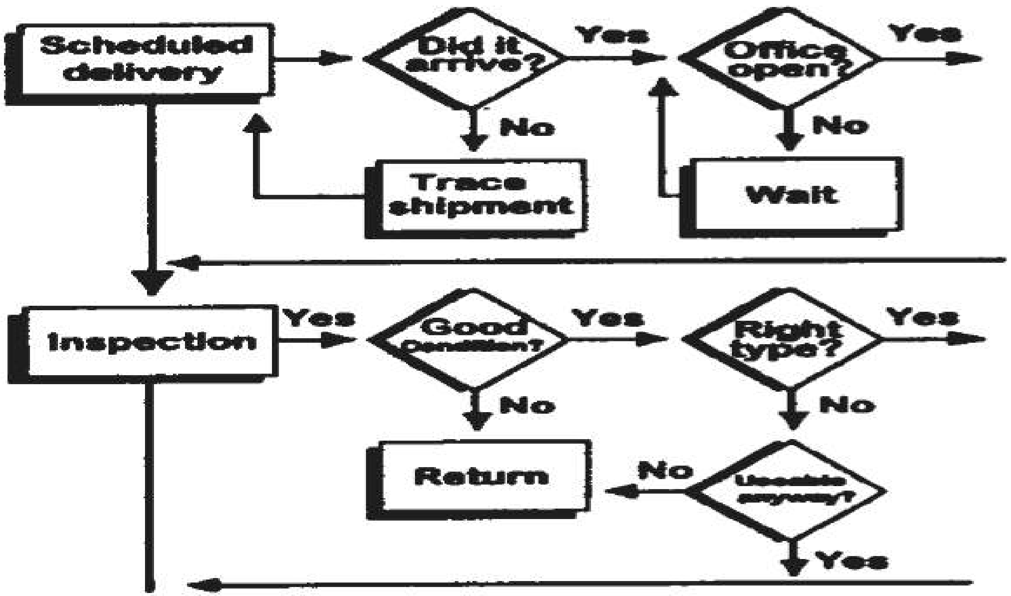
<u>Pareto Diagram</u> : Visually portrays problems and causes in order of severity or frequency. Helps determine which problem or cause to tackle first.

<u>Scatter Diagram</u> : Helps determine if two variables are related.

<u>Run Chart</u> : Shows variation and trends with time. Provides baseline data, and helps to determine if a process is improving or not.

Steps in implementing TQM

- Examples of the seven classical tools used for continuous improvement:



Flow Chart

Steps in implementing TQM

12. What are the benefits of TQM?

The cost of quality:

Why do we implement the information related to TQM into our companies? To make more money and/or to stay in business. If you don't implement TQM/CI, it will cost your firm money.

Cost of Quality = Cost of Nonconformance + Cost Prevention

Thankyou

19ME72
Quality Engineering & Management

Chapter – 5
Techniques in Quality Management

Course Coordinator

Dr. R. Vishnu / Dr. C. Vivek

Assistant Professor

Department of Mechanical Engineering

Coimbatore Institute of Technology

Course content

19ME72 - QUALITY ENGINEERING AND MANAGEMENT

ASSESSMENT: THEORY

L	T	P	C
3	0	0	3

COURSE OBJECTIVE

To know about basicaspects and tools related to quality engineering and management.

COURSE OUTCOMES

At the end of the course, the students will be able to

CO1: *Outline the quality engineering system with various types of evaluation of loss function.*

CO2: *Analyze the characteristics and schedules in preventive maintenance along with various quality tools.*

CO3: *Design on-line quality control system for various production environments by considering feedback and various process control parameters.*

CO4:_Define quality management axioms and implement Deming philosophy along with action plans._

CO5:_Demonstrate and implement various quality management tools._

Course content

Quality Engineering and Loss Function . **(9)**

Quality value and engineering- overall quality system-quality engineering in product design - quality engineering in design of production processes - quality engineering in production - quality engineering in service.Derivation – loss function for products/system- justification of improvements-loss function and inspection- quality evaluations and tolerances-N type, S type, L type

Quality Engineering and TPM **(9)**

Preventive Maintenance (PM) schedules- PM schedules for functional characteristics- PM schedules for large scale systems. Quality tools–fault tree analysis, event tree analysis, failure mode and effect analysis.ISO quality systems.

On-Line Quality Control **(9)**

On-line feedback quality control variable characteristics-control with measurement interval- one unit, multiple units-control systems for lot and batch production. On-line process parameter control variable characteristics- process parameter tolerances- feedback control systems- measurement error and process control parameters.

Course content

Quality Management **(9)**

Definitions of the terms – quality planning, quality control, quality assurance, quality management, total quality management as per ISO 8402 – overview on TQM – the TQM axioms – Commitment – scientific knowledge – involvement Consequences of total quality. Six sigma, C_p, C_{pk}, P_{pk} Deming's fourteen points on quality management – five DDs – implementing the Deming philosophy - action plan – the Deming cycle – Case study.

Techniques in Quality Management **(9)**

Kaizen and innovation – the kaizen management practices – Total Quality Control (TQC) — small group activities – quality circles – Comparison of Kaizen and Deming's approach with illustration. Affinity diagram – brain storming – cause and effect analysis –check list– flow charts – Pareto analysis – quality costing – Quality Function Deployment (QFD) – Training of quality – self managing teams.

TOTAL : 45

Course content

TEXT BOOKS

1. De Feo J A and Barnard WW, “Six Sigma: Breakthrough and Beyond”, Tata McGraw-Hill, New Delhi,2005.

2. Pyzdek T and Berger R W, “Quality Engineering Handbook”, Tata-McGraw Hill, New Delhi, 1996.

3. LogotheticsN ., —Managing for total quality – From Deming to Taguchi and SPC — , Prentice hall Ltd, New Delhi, 1997.

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1. KaniskaBedi, “Quality Management”, Oxford University Press, Chennai, 2007.

2. Brue G, “Six Sigma for Managers”, Tata-McGraw Hill, New Delhi, Second reprint, 2002.

3. Taguchi G, Elsayed E A and Hsiang, T.C.,”Quality Engineering in Production Systems”, Mc-Graw-HillBook company, Singapore, 1989.

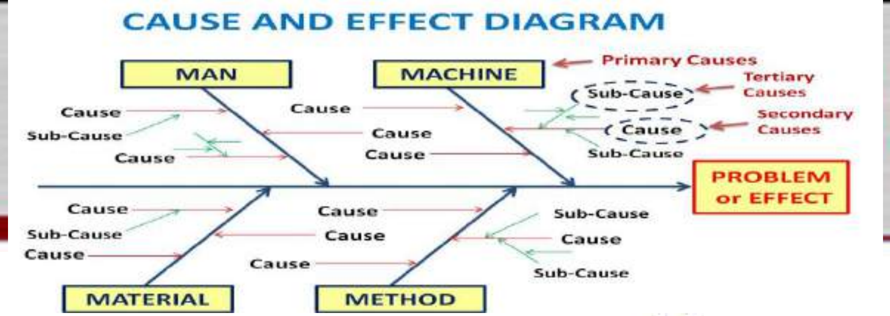
4. Deming W E, —Out of the Crisis," MIT Press, Cambridge, MA, 1982.

5. Juran J M and Juran on —Leadership for Quality" An Executive Handbook, The Free Press, New York,1989.

6. Salor J.H., —TQM-FleldManual,‖ McGraw Hill, New York, 1992.

7. Crosby P.B., — Quality is Free,‖ McGraw Hill, New York, 1979

QE & TPM



Techniques in Quality Management

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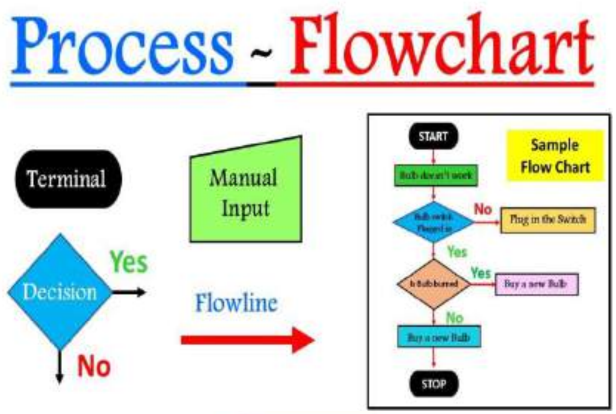
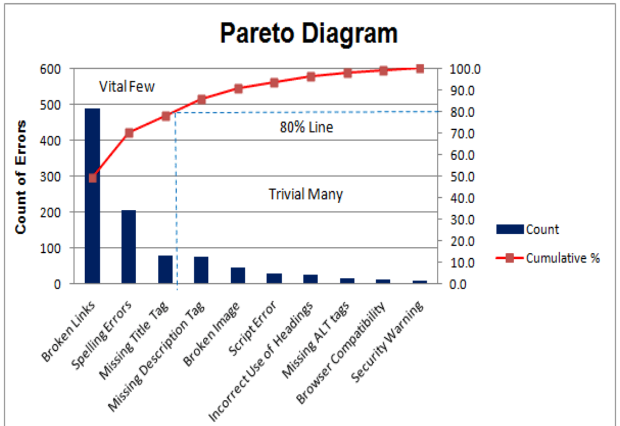
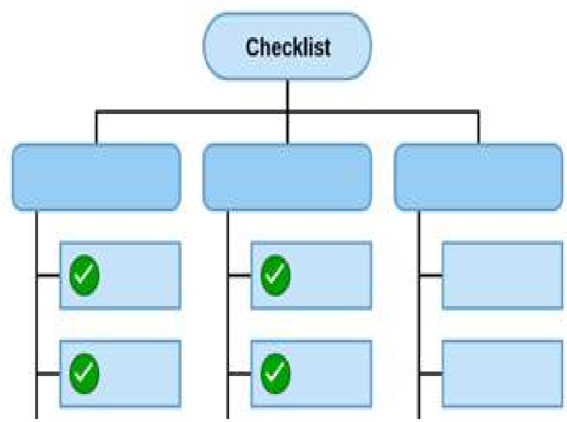






QE & TPM – Various tools in QE

- **Pareto Diagram**
- **Fishbone/Ishikawa Diagram**
- **Check list / Flow Chart**
- Process Flow Diagram
- Scatter & **Affinity Diagram**
- Histogram
- Control Chart
- Acceptance Sampling
- Random Sampling
- Reliability
- FMEA / FTA / ETA analysis
- **Quality Function Deployment**
- ISO Series
- Benchmarking
- **Brainstorming & Quality Circles**
- Total Productive Maintenance
- Management and Planning Tools
- Lean/**Kaizen**
- Quality Issues
- Six Sigma
- Design of Experiments (DOE)
- Process Analysis Tools

Assignment / Tutorial

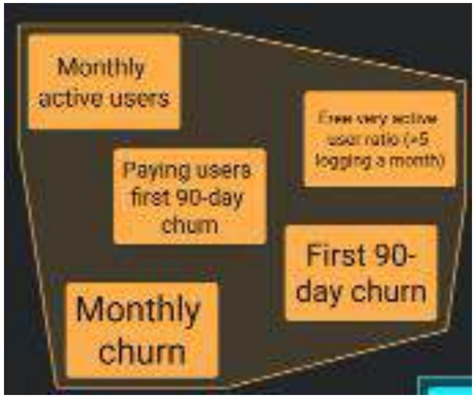
1. Draw the **Cause and Effect Diagram** for you own case example.
2. Illustrate the **Process Flow Diagram** for any type of product / process with its steps.
3. Draw the **Affinity Diagram** for 'Issues involved in missing shipping dates" for any batch of products.
4. Prepare a **Check List** for a manufacturing shop floor supervision for a batch of components in CNC machining.
5. Prepare a separate **Flow Chart** for lending & returning books in our CIT library.

Affinity Diagram

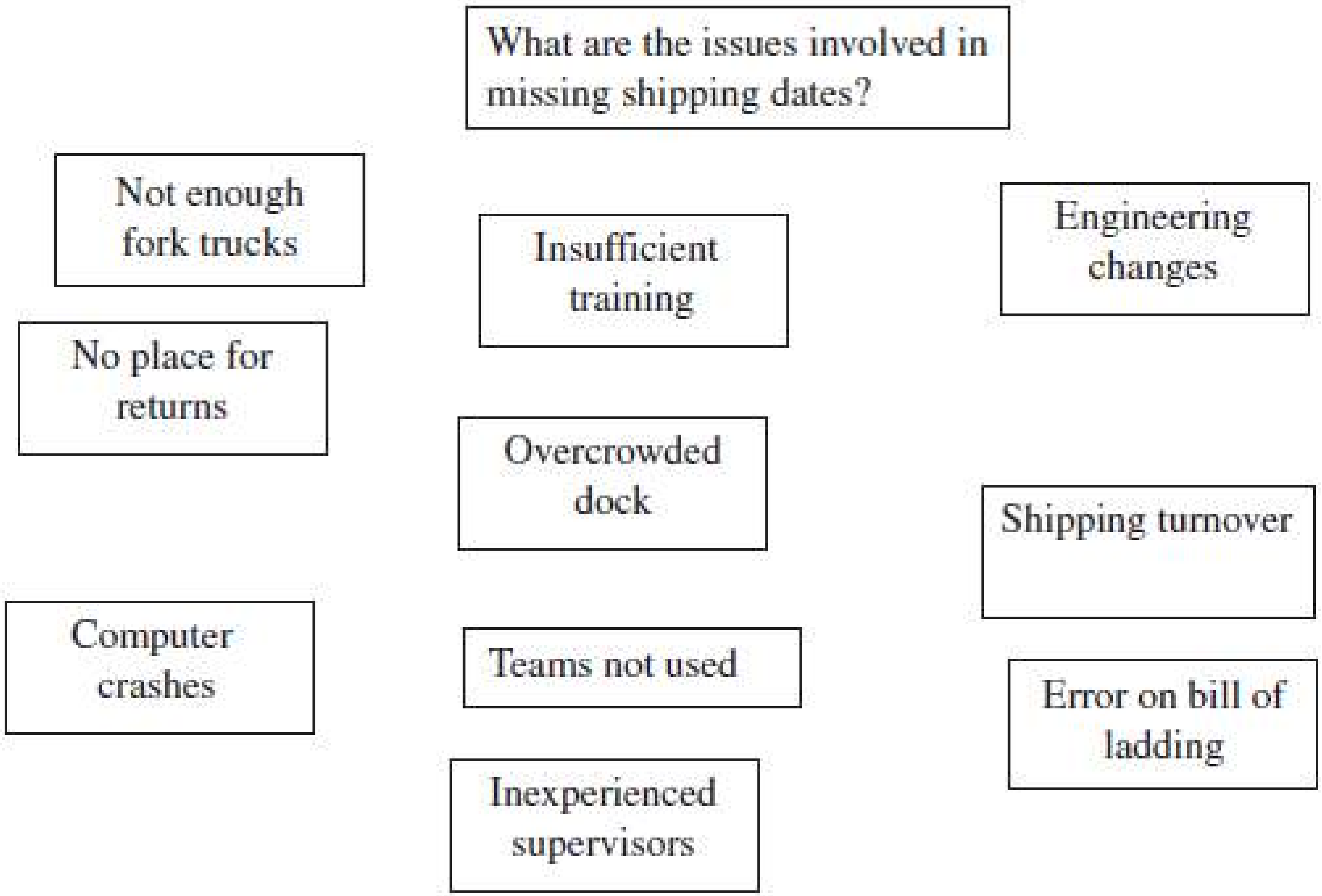
It allows the team to creatively generate a large number of issues/ideas & then logically group them for problem understanding and possible breakthrough solution.

Procedure

1. To state the issue in a full sentence.
2. Brainstorm using short sentences on self-adhesive notes.
3. Post them for the team to see.
4. Sort ideas into logical groups
5. Create concise descriptive headings for each group.

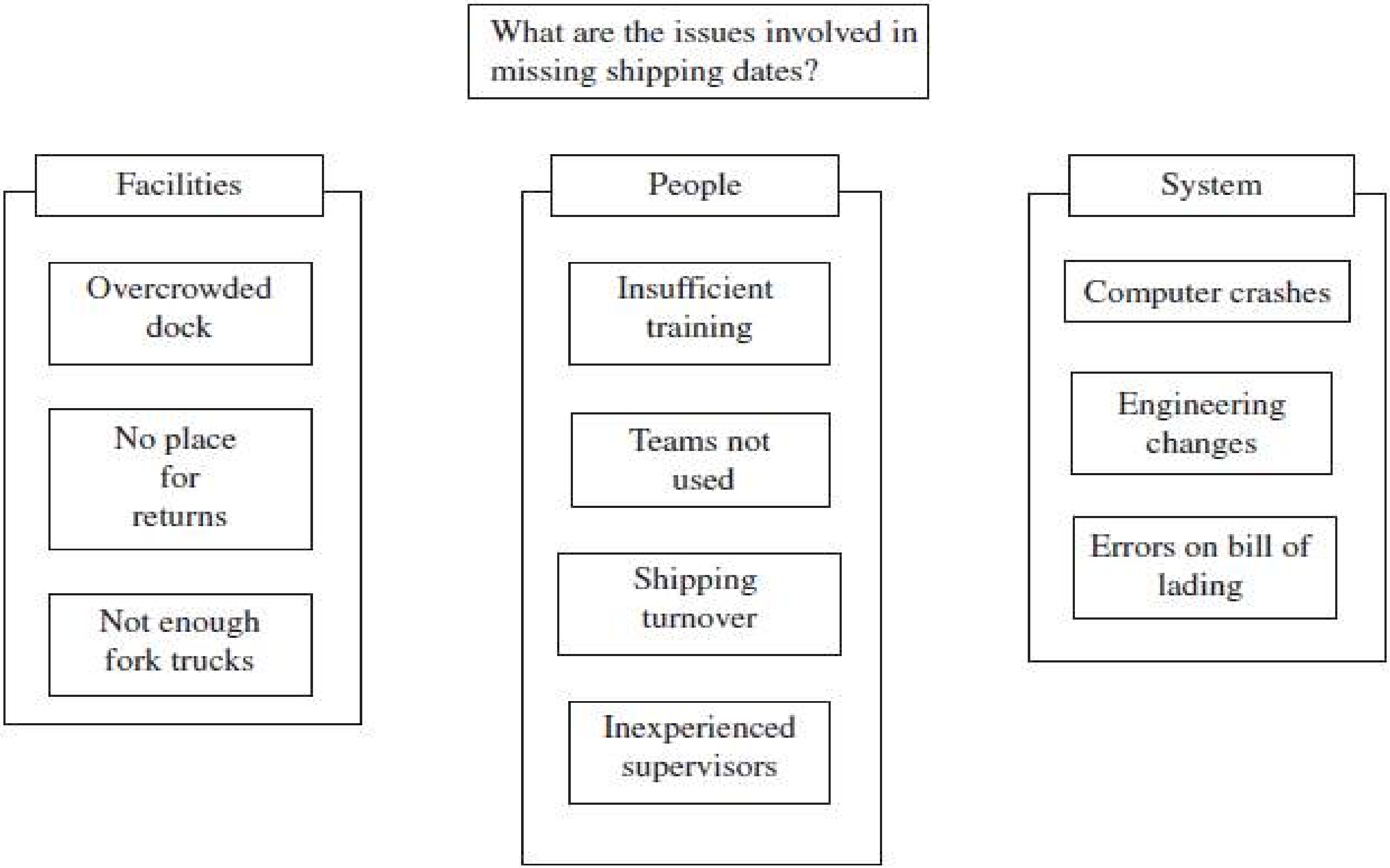


Affinity Diagram



(a) Scrambled ideas

Affinity Diagram



(b) Ordered ideas

Affinity Diagram

- Large groups should be divided into smaller groups with appropriate headings.
- Notes that stand alone could become headers or placed in a miscellaneous category.
- Affinity diagrams encourage team creativity, break down barriers, facilitate breakthroughs, and stimulate ownership of the process.

Affinity Diagram

Check List

- **Checklists** can be a great tool to standardize routine tasks that have to be run regularly.
- In the same fashion, a Preventive Maintenance **PM-Checklist** can be used to streamline a variety of preventive maintenance tasks.

Why we need preventive maintenance checklists

1) Workflow standardization and increased productivity
2) Improved safety
3) Faster troubleshooting
4) Better maintenance planning

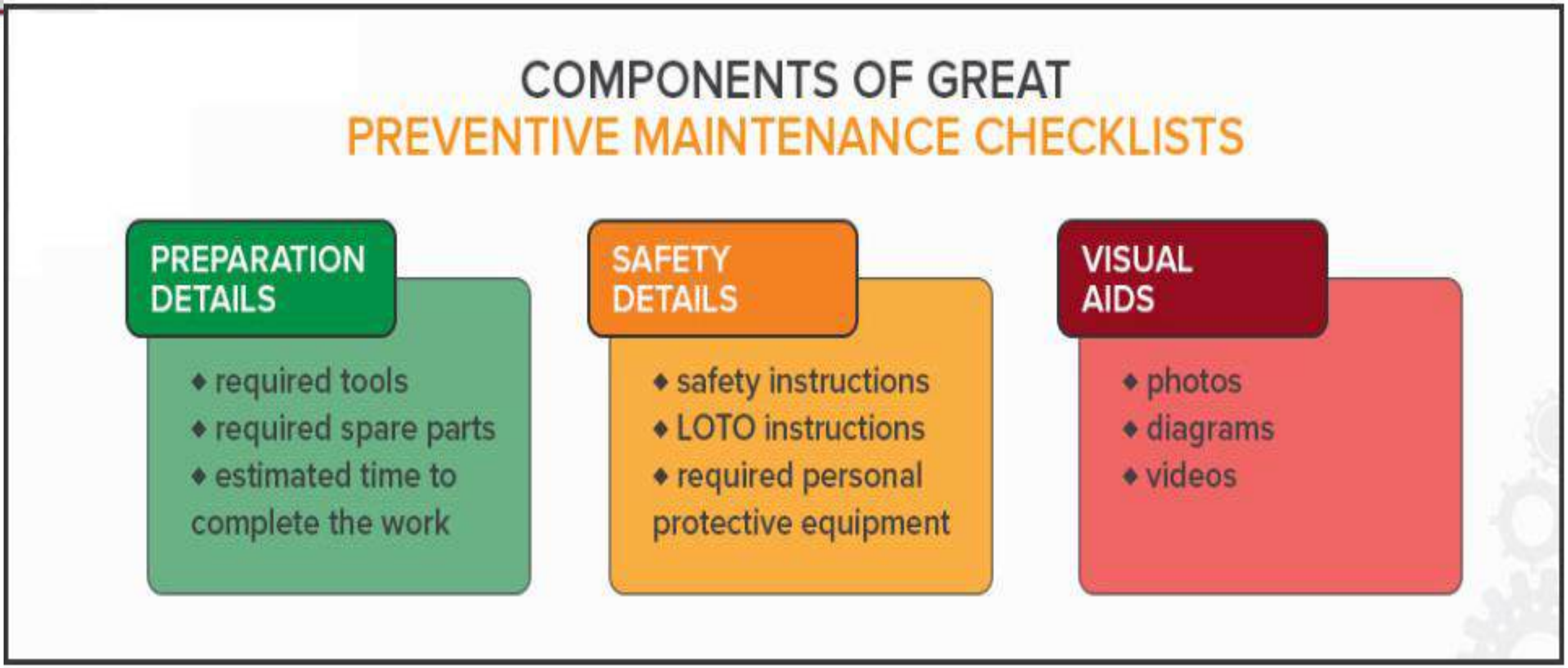
Check List

How to prepare a preventive maintenance checklist ?

Three things you should do before creating PM checklists

- Create a list of assets that need PMs
- Gather original equipment manufacturer (OEM) manuals.
- Review asset history.

Check List



COMPONENTS OF GREAT
PREVENTIVE MAINTENANCE CHECKLISTS
PREPARATION DETAILS
♦ required tools
♦ required spare parts
♦ estimated time to complete the work
SAFETY DETAILS
♦ safety instructions
♦ LOTO instructions
♦ required personal protective equipment
VISUAL AIDS
♦ photos
♦ diagrams
♦ videos

DANGER
LOCKED OUT
©2020 Creative Safety Supply

DANGER
DO NOT OPERATE
EQUIPMENT LOCKED OUT

Check List

- **Clear & Concise** - Avoid writing long paragraphs / Use diagram or a picture / Every step should have a purpose / Be precise
- **Sequential** - Followed in the exact order
- **Update** - Not set & forget(Optimized and Customized regularly)

Bonus Tip

- When you have your preventive maintenance checklist ready, run it by an experienced maintenance technician to ensure you didn't miss/skip a step or two.
- Alternatively, you can ask a senior technician to create it in the first place.

Check List

Example - HVAC PM-Checklist for AC

- ❑ Check and adjust the thermostat.
- ❑ Check the condenser coil to determine if it needs cleaning.
- ❑ Check all wiring connections & electrical connections.
- ❑ Check blower belt wear, tension, and adjust.
- ❑ Check voltage & amperage draw on all motors with a meter.
- ❑ Check the compressor contactor.
- ❑ Visually inspect compressor and check amp draw.
- ❑ Check start capacitor and potential relay.
- ❑ Check the pressure switch cut-out setting.
- ❑ Replace air filter or clean reusable type filter.

Check List

PREVENTIVE MAINTENANCE CHECKLIST

(This list contains many examples of items that can be used for preventive maintenance issues by school districts. It is not a complete list. Each district should adjust the checklist to meet their local needs, requirements and abilities. Space has been provided under each category for additional items)

______________________ ______________________________ ____________

School/Facility ***Name(s) of Inspectors*** ***Date***

ITEM	Completed	Needs Further Attention
LIGHTING (EXTERIOR & INTERIOR)		
Building Exterior		
Pedestrian Walkways		
Parking Areas		
Athletic and Sports Fields		
Building Interior		
Emergency		
All lights working		
Glassware conditions		
Fixture support conditions		
Wire conditions		
Ballast conditions		
Timers/sensors		
Junction box and cover conditions		
Switch conditions		
Outlet and cord conditions		
Protective caging conditions		

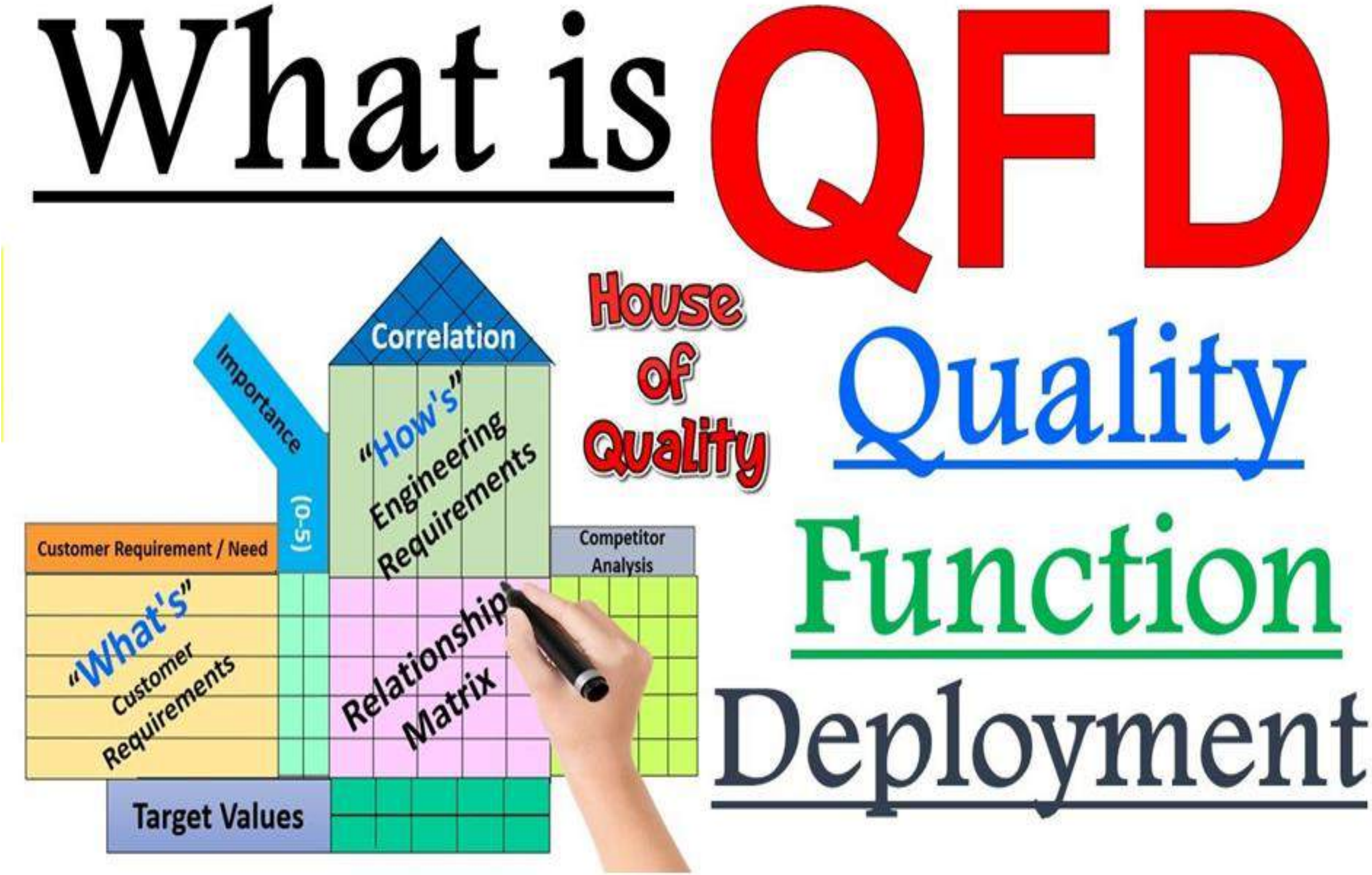
Check List

ITEM	Completed	Needs Further Attention
CLASSROOMS		
Fire safety		
Furniture: desks/chairs/tables/shelves		
Marker board		
Electronic board		
Audio-visual equipment		
Computers/work stations/wiring		
Partitions		
Flooring for tripping hazards		
Plumbing (if applicable)		
PA speaker system operation		
Emergency/panic call button (if applicable)		
Wall map(s)		
Exit access		

Check List

AUDITORIUMS		
Fire safety		
Seating		
Passageway clearance and markings		
Exit lighting		
Aisle/walkway lighting		
Markers for edges of stage areas		
Risers		
Stage		
Curtains		
Changing rooms		
Area lighting		
Stage lighting		
Staging equipment		
Sound system		
Lobby/entrance area		
Concession area		

Quality Function Deployment (QFD)

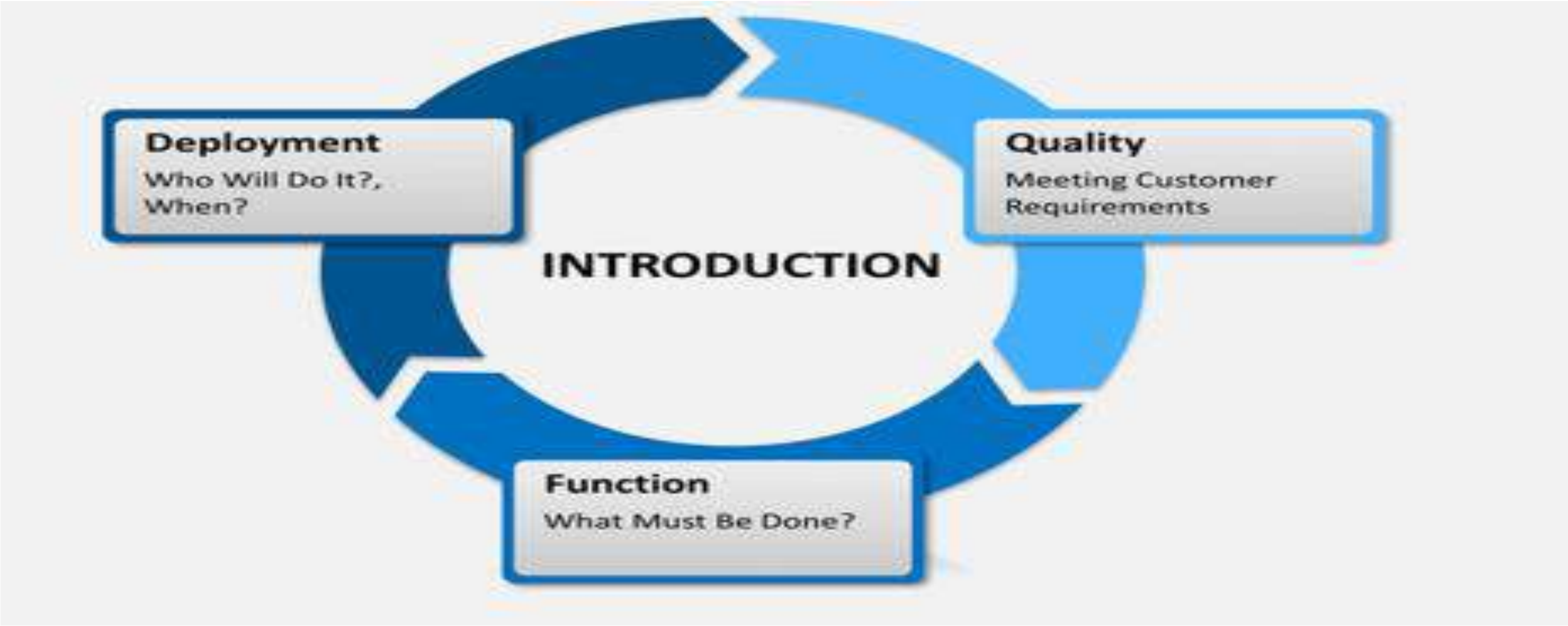


Quality Function Deployment

- Dr. Mizuno, professor emeritus of the Tokyo Institute of Technology, is credited with initiating the quality function deployment (QFD) system.
- The first application of QFD was at Mitsubishi, Heavy Industries, Ltd., in the Kobe Shipyard, Japan, in 1972.
- After four years of case study development, refinement, and training. QFD was successfully implemented in the production of mini-vans by Toyota.
- Using 1977 as a base, a 20% reduction in startup costs was reported in the launch of the new van in October 1979, a 38% reduction by November 1982, and a cumulative 61% reduction by April 1984.

Quality Function Deployment

- QFD was first introduced in the United States in 1984 by Dr. Clausing of Xerox.
- QFD can be applied to practically any manufacturing or service industry.
- It has become a standard practice by most leading organizations, who also require it of their suppliers.



Quality Function Deployment

- Quality function deployment (QFD) is a planning tool used to fulfill customer expectations.
- It is a disciplined approach to product design, engineering, and production and provides in-depth evaluation of a product.
- An organization that correctly implements QFD can improve engineering knowledge, productivity, and quality and reduce costs, product development time, and engineering changes.
- QFD focuses on customer expectations or requirements, often referred to as the voice of the customer.
- It is employed to translate customer expectations, in terms of specific requirements, into directions and actions, in terms of engineering or technical characteristics.

Product planning
Part development

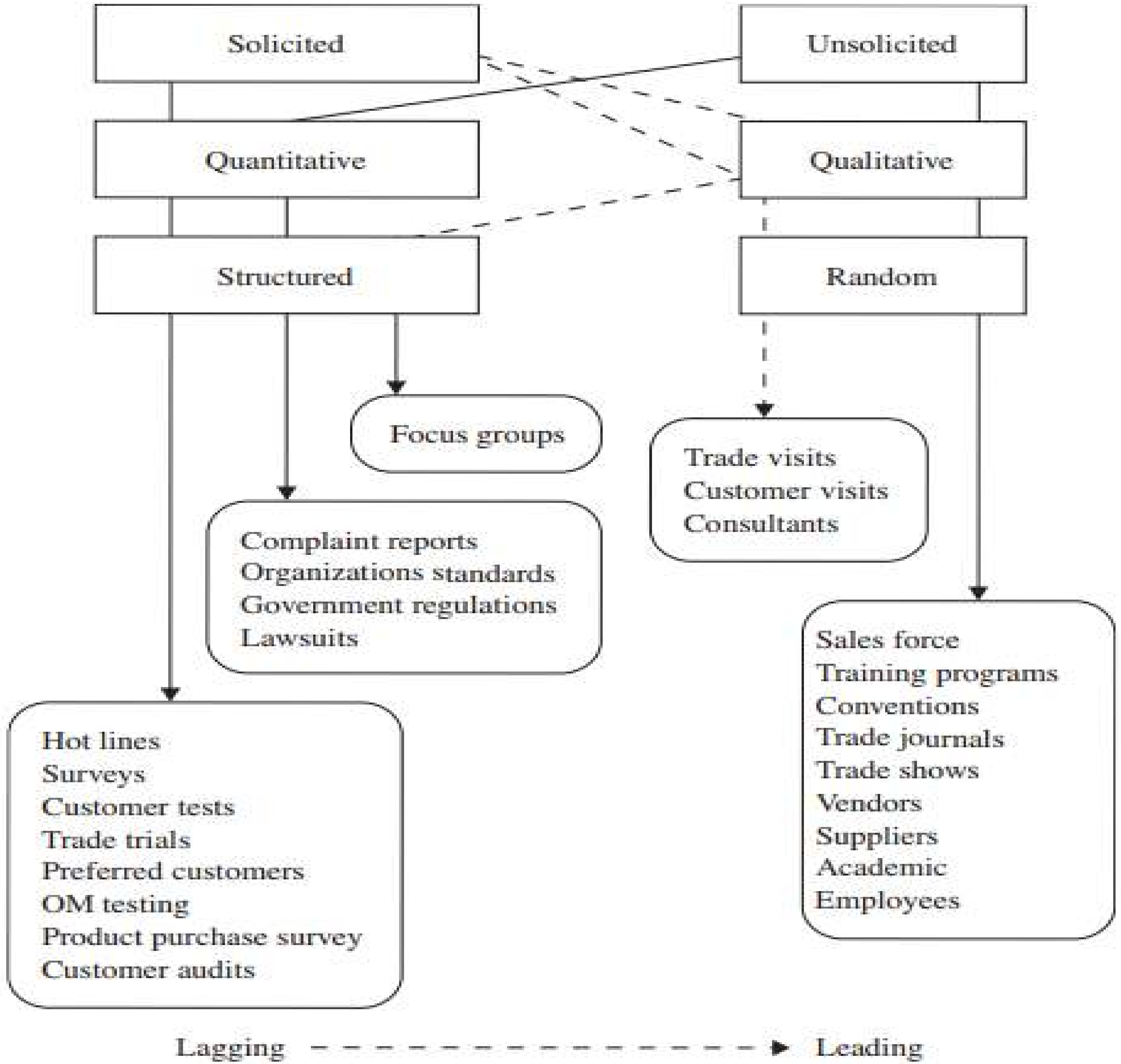
Process planning
Production planning
Service industries

Quality Function Deployment

Benefit	Details
Improves customer satisfaction	Creates focus on customer requirements Uses competitive information effectively Prioritizes resources Identifies items that can be acted upon Structures resident experience/information
Reduces implementation time	Decreases midstream design changes Limits post introduction problems Avoids future development redundancies Identifies future application opportunities Surfaces missing assumptions
Promotes teamwork	Based on concensus Creates communication at interfaces Identifies actions at interfaces Creates global view out of details
Provides documentation	Documents rationale for design Is easy to assimilate Adds structure to the information Adapts to changes (a living document) Provides framework for sensitivity analysis

Benefits of QFD

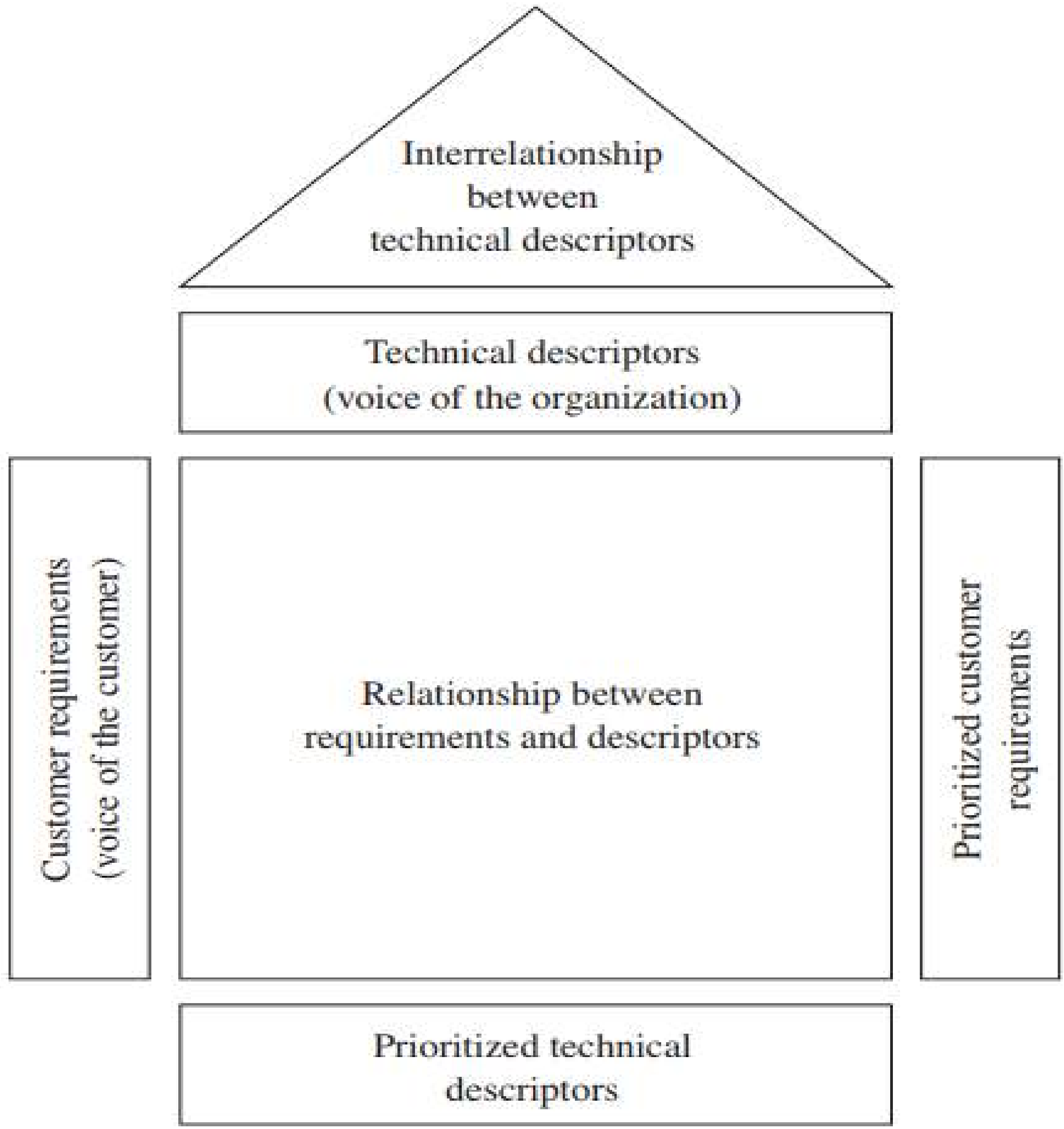
QFD



Types of Customer Information and How to Collect It

Quality Function Deployment

House of Quality



Qua

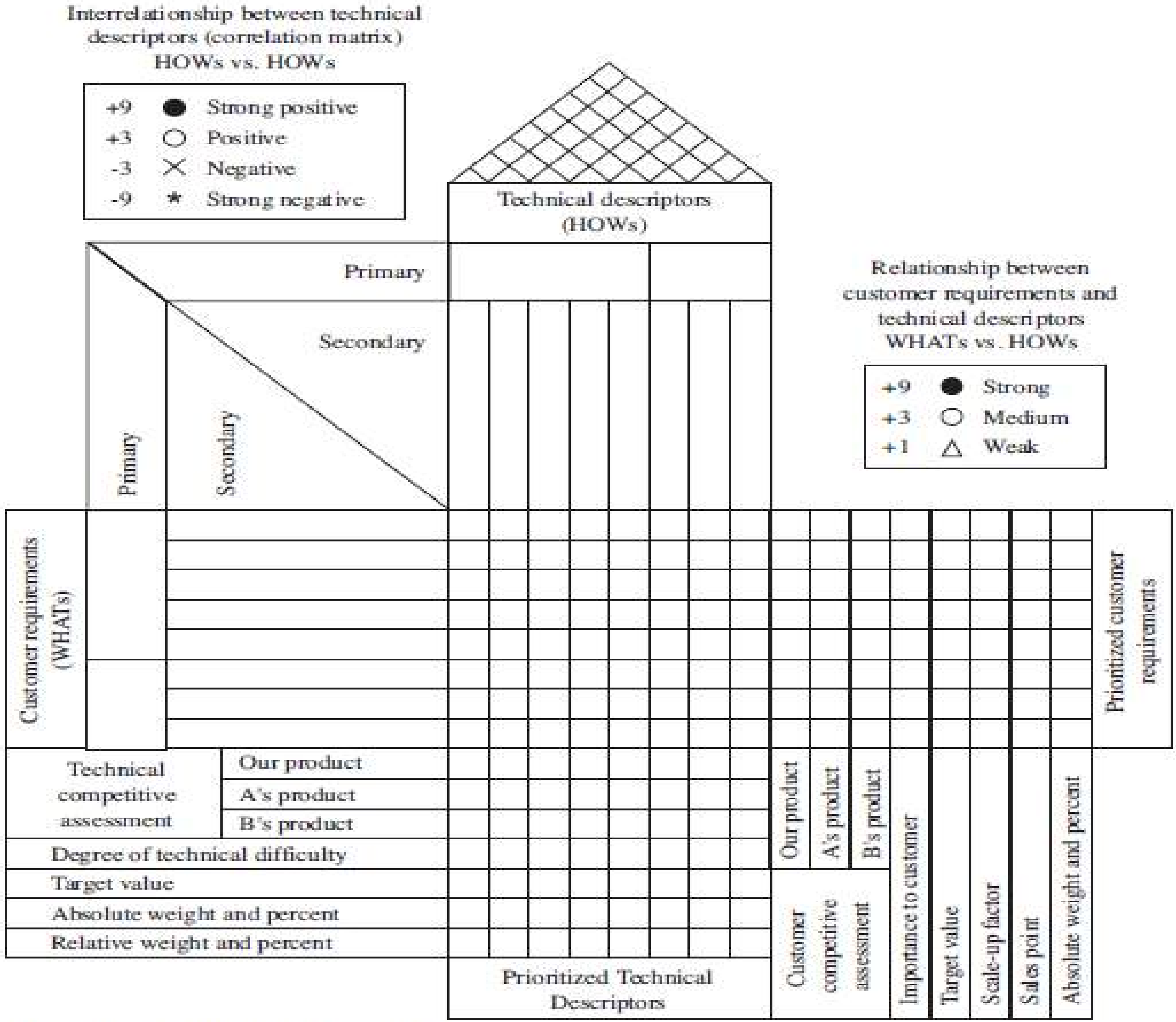
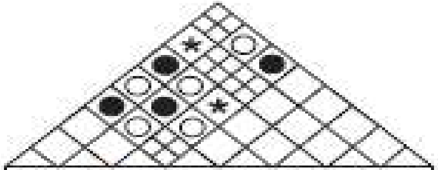


Figure 10-4 Basic House of Quality Matrix

Qua

Interrelationship between technical descriptors (correlation matrix) HOWs vs. HOWs



+ 9	●	Strong Positive
+ 3	○	Positive
− 3	×	Negative
− 9	★	Strong negative

Relationship between customer requirements and technical descriptors WHATs vs. HOWs

+ 9	●	Strong
+ 3	○	Medium
+ 1	△	Weak

Customer requirements (WHATs) — Primary	Secondary	Material selection: Steel	Material selection: Aluminum	Material selection: Titanium	Manufacturing process: Welding	Manufacturing process: Die casting	Manufacturing process: Sand casting	Manufacturing process: Forging	Manufacturing process: Powder metallurgy	Customer competitive assessment: Our product	Customer competitive assessment: A's product	Customer competitive assessment: B's product	Importance to customer	Target value	Scale-up factor	Sales point	Absolute weight
Aesthetics	Reasonable cost	●	●	△	●	○	●	○	△	3	4	2	8	4	1.3	1.5	16
Aesthetics	Aerodynamic look		△	△	△	●	○	○	●	4	5	3	5	4	1	1.5	8
Aesthetics	Nice Finish	○	●	●	△	●	△	○	●	4	5	3	5	4	1	1	5
Aesthetics	Corrosion resistant	△	●	●	△	○	○	○	○	4	4	2	2	4	1	1	2
Performance	Lightweight	△	●	●					△	3	4	2	7	4	1.3	2	18
Performance	Strength	●	○	●	△	○	○	●	△	3	3	4	5	3	1	1	5
Performance	Durable	●	○	○	△	●	○	●	○	3	3	4	3	3	1	1	3
Technical competitive assessment	Our product	0	5	0	0	5	0	0	0								
Technical competitive assessment	A's product	0	0	5	0	5	0	0	0								
Technical competitive assessment	B's product	5	0	0	4	0	0	0	0								
Degree of technical difficulty		1	6	9	4	7	3	6	9								
Target value		5	5	5	4	5	0	0	0								
Absolute weight		168	227	193	92	162	122	132	125								
Relative weight		251	401	303	167	213	203	165	171								

Technical descriptors (HOWs)

Prioritized customer requirements

Prioritized technical descriptors

e 10-13 **Adding Prioritized Technical Descriptors to the House of Quality**

Quality Function Deployment

ABSOLUTE WEIGHT

The last two rows of the prioritized technical descriptors are the absolute weight and relative weight. A popular and easy method for determining the weights is to assign numerical values to symbols in the relationship matrix symbols, as shown previously in Figure 10-8. The absolute weight for the *j*th technical descriptor is then given by

$$a_j = \sum_{i=1}^{n} R_{ij} C_i$$

where a_j = row vector of absolute weights for the technical descriptors $(i = 1, \ldots, m)$

R_{ij} = weights assigned to the relationship matrix $(i = 1, \ldots, n, j = 1, \ldots, m)$

c_i = column vector of importance to customer for the customer requirements $(i = 1, \ldots, n)$

m = number of technical descriptors

n = number of customer requirements

The absolute weight for each technical descriptor is determined by taking the dot product of the column in the relationship matrix and the column for importance to customer. For instance, for aluminum the absolute weight is

$$9 \times 8 + 1 \times 5 + 9 \times 5 + 9 \times 2 + 9 \times 7 + 3 \times 5 + 3 \times 3 = 227.$$

Quality Function Deployment

RELATIVE WEIGHT

In a similar manner, the relative weight for the *j*th technical descriptor is then given by replacing the degree of importance for the customer requirements with the absolute weight for customer requirements. It is

$$b_j = \sum_{i=1}^{n} R_{ij} d_i$$

where b = row vector of relative weights for the technical descriptors ($j = 1,\ldots, m$)
d_i = column vector of absolute weights for the customer requirements ($i = 1,\ldots, n$)

The relative weight for each technical descriptor is determined by taking the dot product of the column in the relationship matrix and the column for absolute weight in the prioritized customer requirements. For instance, for die casting the relative weight is

$$3 \times 16 + 9 \times 8 + 9 \times 5 + 3 \times 2 + 0 \times 18 + 3 \times 5 + 9 \times 3 = 213.$$

BRAINSTORMING

- Brainstorming is a group problem-solving method that involves the spontaneous contribution of creative ideas and solutions.
- Brainstorming is also one of the quality tool for problem solving.
- This technique requires intensive, freewheeling discussion in which every member of the group is encouraged to think aloud and suggest as many ideas as possible based on their diverse knowledge.

RULES OF BRAINSTORMING

1. Do not comment on, judge or critique ideas as offered.
2. Encourage creative and offbeat ideas.
3. A large number of ideas is the goal.
4. Evaluate ideas later.

BRAINSTORMING EXAMPLE

TYPES OF BRAINSTORMING

There are two types of brainstorming. It should be selected based on its advantages and disadvantages for maximum benefits.

STRUCTURED BRAINSTORMING: Members of group will sit in a circle. The leader facilitates the brainstorming. The facilitator will write their ideas in a rotational form on the board. This exercise will be carried out in particular order till each person contributes an idea. If a member is not ready with his/her idea it can passed, latter he or she may provide idea or pass again.

UNSTRUCTURED BRAINSTORMING: Members of group can sit in a circle or in a room in any form of arrangement. There is no order of response. The facilitator will motivate everyone to provide his/her idea.

PROBLEM SOLVING PROCESS

When problem is identified then brainstorming can used to solve or find out solution of raised problem. Following steps are involved in problem solving process.

- Problem identification
- Problem definition
- Problem analysis
- Identifying causes
- Find out the root causes
- Data analysis
- Solution generation
- Identifying resistances
- Plan for solution implementation
- Implementation
- Observation
- Standardization

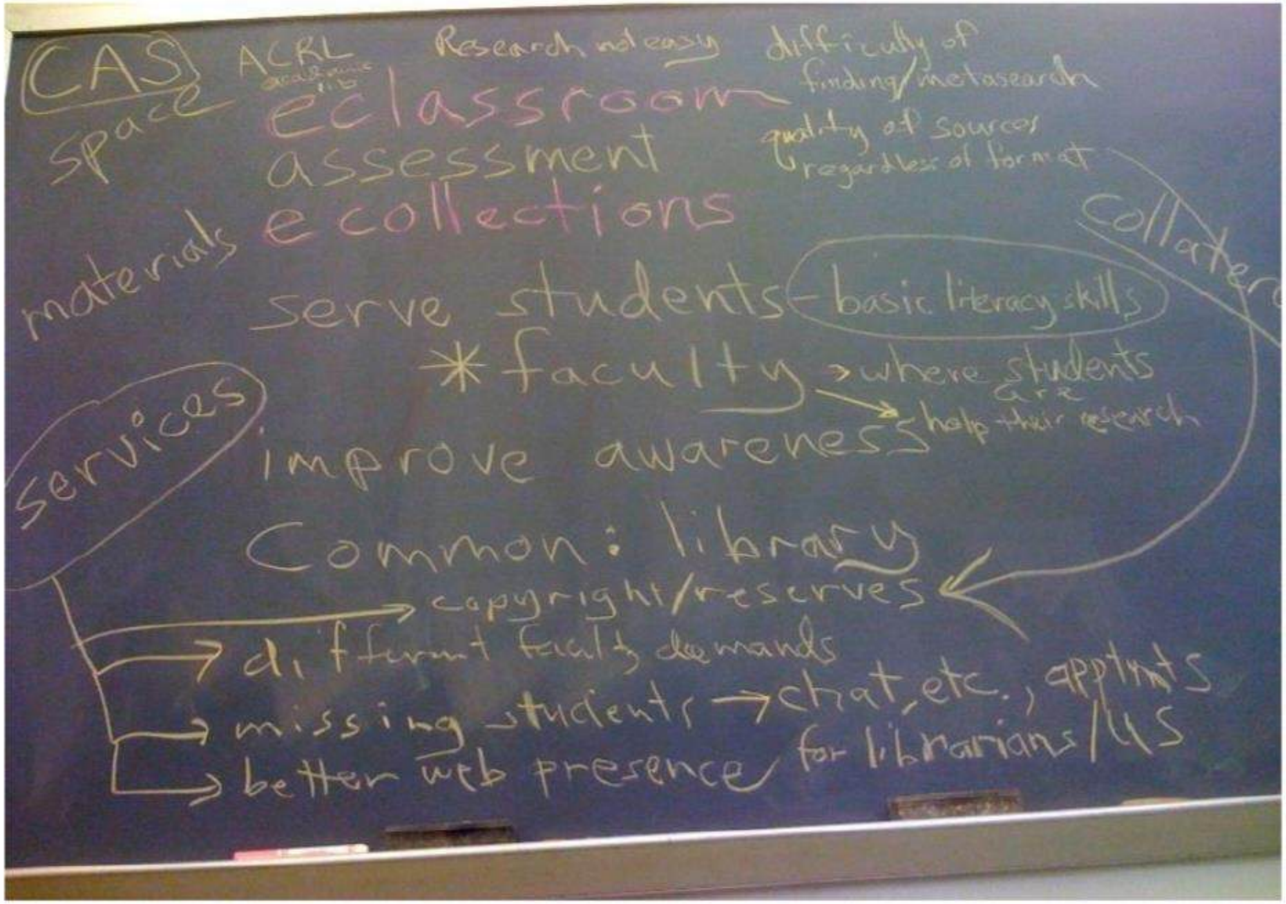
STEPS IN BRAINSTORMING

1. **SELECT THE GROUPS**: facilitator must select the members not less than 5 or more than 20.
2. **SPECIFY THE OBJECTIVE**: Facilitator should build objectives and define why he wants to brainstorm. He will find out about all members interested and happy for selected central question. Allow people to make noise, shout, laugh, and enjoy.
3. **DEFINE THE ROLES:** facilitator must decide the role of leader, recorder etc.
4. **EXPLAINE THE RULES**: facilitator should explain the rules to every one before discussion begins. Every one must be clear about question.
5. **START THE DISCUSSION:** begin to start discussion rounds, they should take some rounds and produce ideas.
6. **RECORD THE IDEAS:** Ideas must be recorded and arranged.
7. **ENCOURAGE THE IDEAS**: wait for ideas, don’t hurry, participants must get sufficient time to think and present better idea. Facilitator should encourage the members to present ideas and appreciate all ideas.
8. Do end on the wild ideas.

CASE STUDY ON BRAINSTORMING

BOSTON UNIVERSITY LIBRARIES STRATEGIC PLAN-2010-2015

1. Create a “One BU” Libraries experience for all users
2. Enhance faculty teaching, research and scholarship
3. Strengthen library services and programs to support graduate research and education
4. Provide a learning environment, both physical and online, for undergraduates
5. Enhance the Libraries’ support for the College of Arts and Sciences
6. Strengthen Library services for the four key professional Schools: Law, Medicine, Management, and Fine Arts
7. Develop, describe and preserve a wide range of high-quality networked information resources for Boston University scholars, students, alumni, and the broader global community
8. Maximize the Libraries’ ability to meet the research and learning needs of the University by adapting to the increasingly global, digital and distributed information landscape


CAS
ACRL
Research not easy
difficulty of finding/metasearch
space
eclassroom
assessment
quality of sources regardless of format
materials
e collections
Collateral
serve students
basic literacy skills
services
* faculty
where students are
help their research
improve awareness
Common: library
copyright/reserves
different faculty demands
missing students
chat, etc., apptmts
better web presence
for librarians/LIS

PARETO ANALYSIS

Pareto analysis is premised on the idea that 80% of a project's benefit can be achieved by doing 20% of the work or, conversely, 80% of problems can be traced to 20% of the causes. Pareto analysis is a powerful quality and decision-making tool.

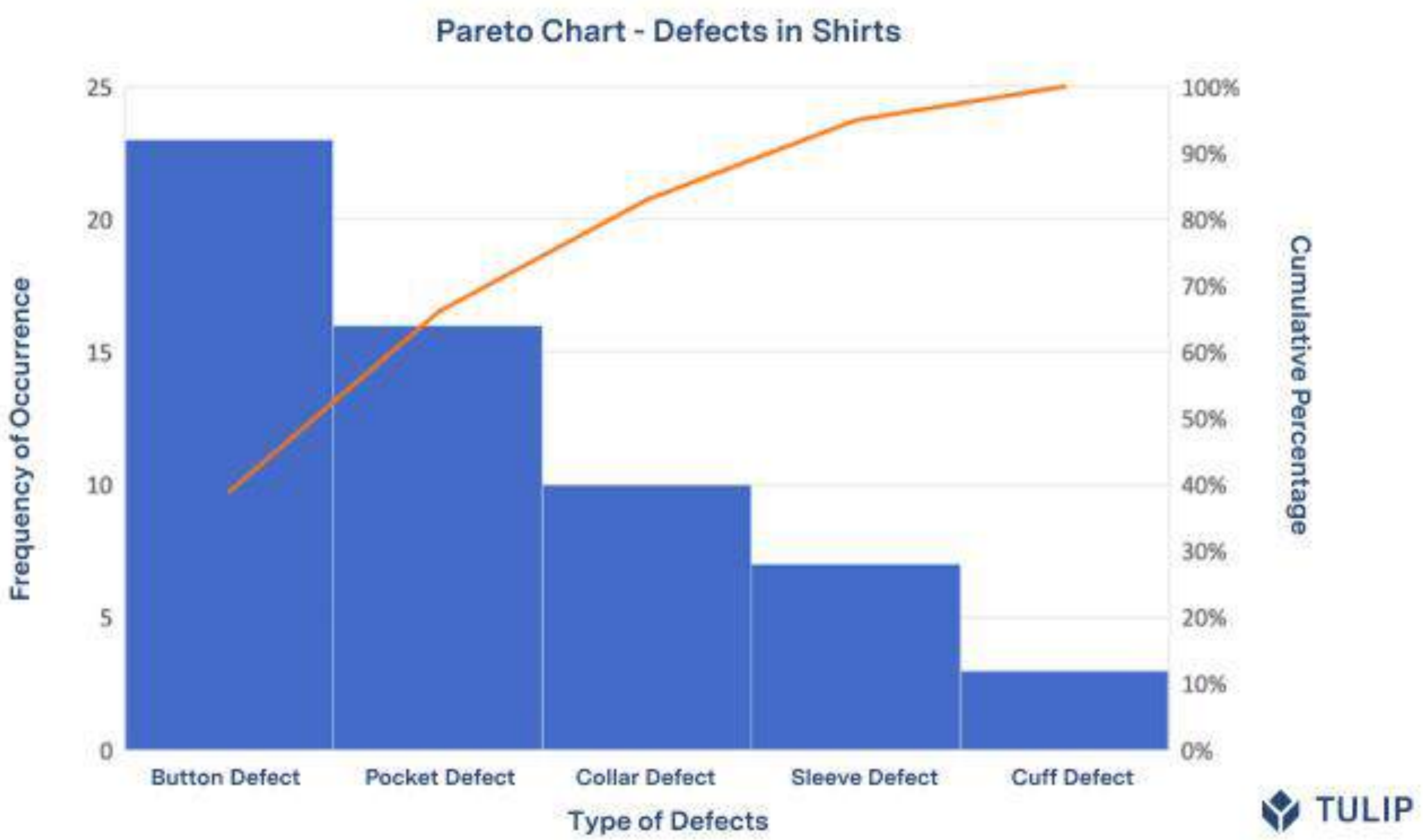
What is 80/20 rule pareto analysis?

80/20 Rule – The Pareto Principle. The 80/20 Rule (also known as the Pareto principle or the law of the vital few & trivial many) states that, for many events, roughly 80% of the effects come from 20% of the causes.

PARETO CHART

- A Pareto Chart is a combination of a bar graph and a line graph. Notice the presence of both bars and a line on the Pareto Chart below.
- Each bar usually represents a type of defect or problem. The height of the bar represents any important unit of measure — often the frequency of occurrence or cost.
- The bars are presented in descending order (from tallest to shortest). Therefore, you can see which defects are more frequent at a glance.
- The line represents the cumulative percentage of defects.
- In manufacturing, Pareto Charts are used as a quality management tool they help analyze and prioritize issue resolution.
- The Pareto Principle can analyze Pareto Charts, also known as the 80/20 rule.

EXAMPLE OF PARETO CHART



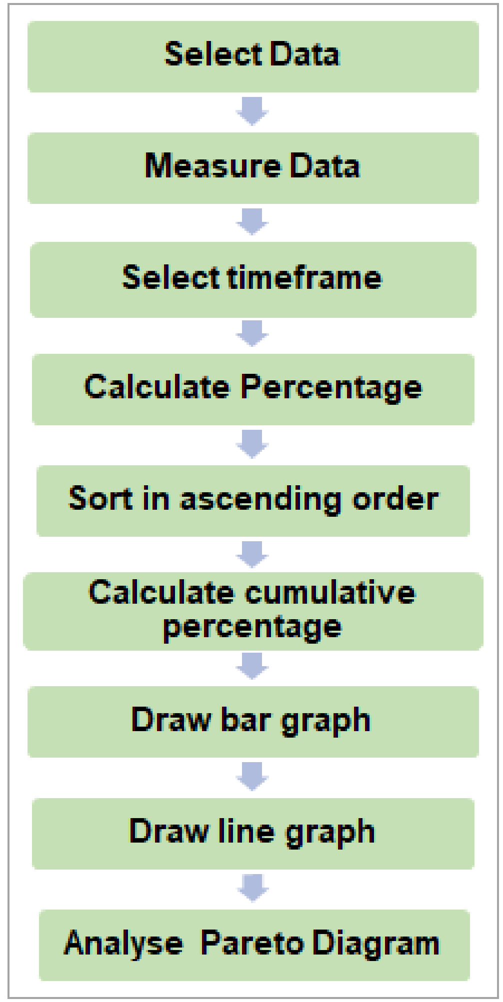
BENEFITS OF PARETO ANALYSIS

- It helps to identify top root causes.
- Helps to prioritize the top issue for a problem and try to eliminate it first.
- Gives an idea of the cumulative impact of issues.
- Corrective and Preventive action can be better planned.
- Gives a focussed, simple, and clear way to find vital few causes.
- Helps to improve problem-solving and decision-making skills.
- Improves the effectiveness of quality management.
- Useful in every form of leadership decision.
- Helps in time management, be at work, or personal.
- Helps in general performance management.
- Helps in planning, analysis, and troubleshooting as well.
- Helps in problem-solving and decision making.
- Helps in change management.
- Helps in time management.

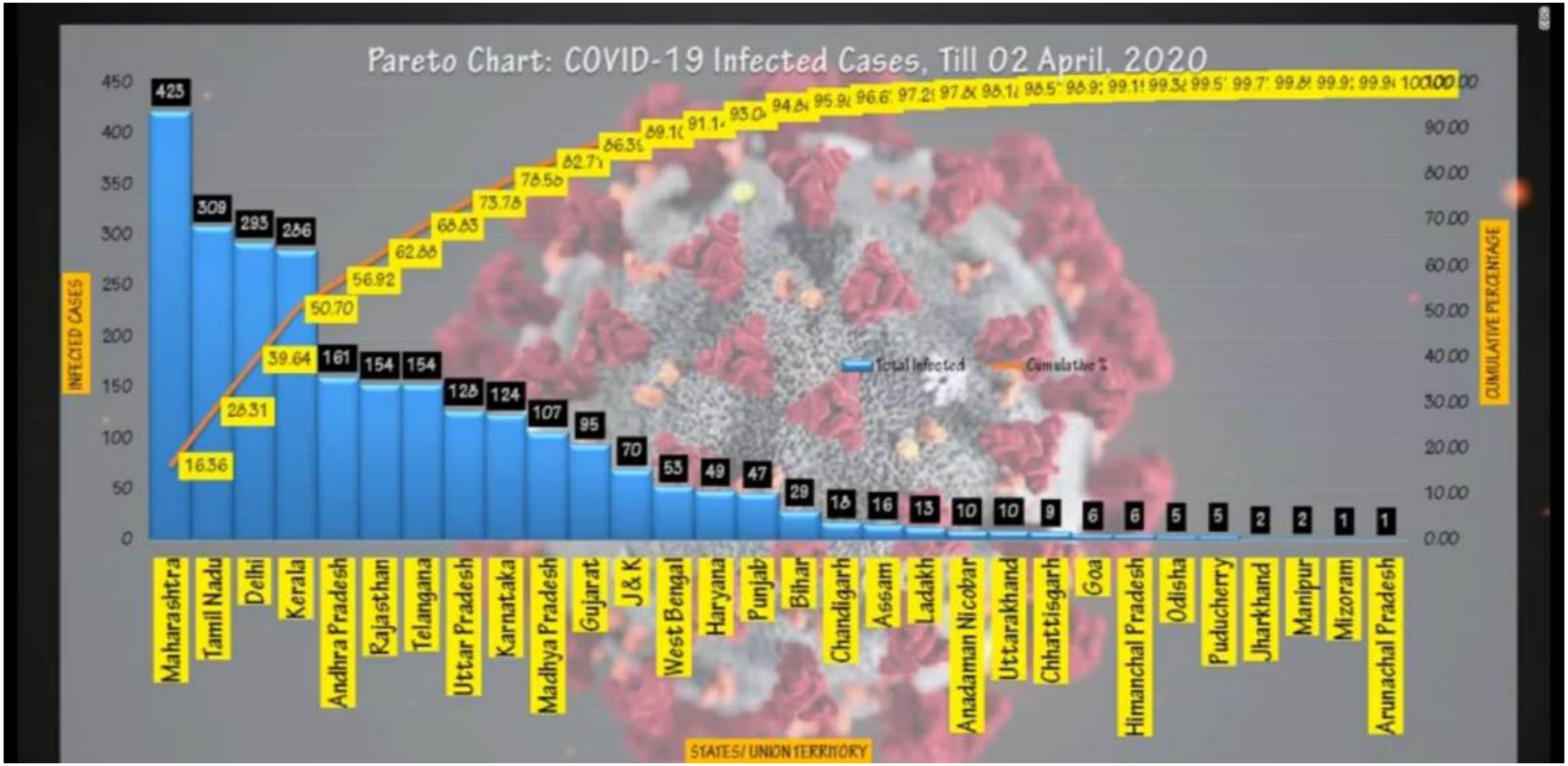
LIMITATIONS OF PARETO ANALYSIS

- Pareto Analysis cannot find root causes by itself. It needs to be used along with other Root Causes Analysis tools to derive the root causes.
- It doesn't show the severity of the problem.
- It focuses on past data where damage has already happened. Sometimes it might not be relevant for future scenarios.
- It cannot be applied to all cases.

STEPS INVOLVED IN DOING PARETO ANALYSIS



CASE STUDY



Pareto Chart: COVID-19 Infected Cases, Till 02 April, 2020
INFECTED CASES
CUMULATIVE PERCENTAGE
STATES/ UNION TERRITORY
Total Infected
Cumulative %
Maharashtra
Tamil Nadu
Delhi
Kerala
Andhra Pradesh
Rajasthan
Telangana
Uttar Pradesh
Karnataka
Madhya Pradesh
Gujarat
J&K
West Bengal
Haryana
Punjab
Bihar
Chandigarh
Assam
Ladakh
Anadaman Nicobar
Uttarakhand
Chhattisgarh
Goa
Himanchal Pradesh
Odisha
Puducherry
Jharkhand
Manipur
Mizoram
Arunachal Pradesh
423
309
293
286
161
154
154
128
124
107
95
70
53
49
47
29
18
16
13
10
10
9
6
6
5
5
2
2
1
1
16.36
28.31
39.64
50.70
56.92
62.88
68.83
73.78
78.56
82.71

Thankyou

19ME72
Quality Engineering & Management

Chapter – 1
Quality Engineering & Loss Function

Course Coordinator

Dr. R. Vishnu / Dr. C. Vivek

Assistant Professor

Department of Mechanical Engineering

Coimbatore Institute of Technology

Overview

- Course content
- Evaluation method & Contact hours
- Introduction
- Quality Engineering (QE) & Management
- QE in Product & process design

Quality Aspects of Product Design

Course content

19ME72 - QUALITY ENGINEERING AND MANAGEMENT

ASSESSMENT: THEORY

L	T	P	C
3	0	0	3

COURSE OBJECTIVE

To know about basicaspects and tools related to quality engineering and management.

COURSE OUTCOMES

At the end of the course, the students will be able to

CO1: *Outline the quality engineering system with various types of evaluation of loss function.*

CO2: *Analyze the characteristics and schedules in preventive maintenance along with various quality tools.*

CO3: *Design on-line quality control system for various production environments by considering feedback and various process control parameters.*

CO4:*Define quality management axioms and implement Deming philosophy along with action plans.*

CO5:*Demonstrate and implement various quality management tools.*

Course content

Quality Engineering and Loss Function . **(9)**

Quality value and engineering- overall quality system-quality engineering in product design - quality engineering in design of production processes - quality engineering in production - quality engineering in service.Derivation – loss function for products/system- justification of improvements-loss function and inspection- quality evaluations and tolerances-N type, S type, L type

Quality Engineering and TPM **(9)**

Preventive Maintenance (PM) schedules- PM schedules for functional characteristics- PM schedules for large scale systems. Quality tools–fault tree analysis, event tree analysis, failure mode and effect analysis.ISO quality systems.

On-Line Quality Control **(9)**

On-line feedback quality control variable characteristics-control with measurement interval- one unit, multiple units-control systems for lot and batch production. On-line process parameter control variable characteristics- process parameter tolerances- feedback control systems- measurement error and process control parameters.

Course content

Quality Management **(9)**

Definitions of the terms – quality planning, quality control, quality assurance, quality management, total quality management as per ISO 8402 – overview on TQM – the TQM axioms – Commitment – scientific knowledge – involvement Consequences of total quality. Six sigma, C_p, C_{pk}, P_{pk} Deming's fourteen points on quality management – five DDs – implementing the Deming philosophy - action plan – the Deming cycle – Case study.

Techniques in Quality Management **(9)**

Kaizen and innovation – the kaizen management practices – Total Quality Control (TQC) — small group activities – quality circles – Comparison of Kaizen and Deming's approach with illustration. Affinity diagram – brain storming – cause and effect analysis –check list– flow charts – Pareto analysis – quality costing – Quality Function Deployment (QFD) – Training of quality – self managing teams.

TOTAL : 45

Course content

TEXT BOOKS

1. De Feo J A and Barnard WW, "Six Sigma: Breakthrough and Beyond", Tata McGraw-Hill, New Delhi,2005.

2. Pyzdek T and Berger R W, "Quality Engineering Handbook", Tata-McGraw Hill, New Delhi, 1996.

3. LogotheticsN ., —Managing for total quality – From Deming to Taguchi and SPC — , Prentice hall Ltd, New Delhi, 1997.

4. Juran J.M &Gryna F.M., —quality Planning and Analysis – From Product development through use‖,TataMcGrawHill Publishing Limited, new Delhi, 3rd Edition , 1995

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1. KaniskaBedi, "Quality Management", Oxford University Press, Chennai, 2007.

2. Brue G, "Six Sigma for Managers", Tata-McGraw Hill, New Delhi, Second reprint, 2002.

3. Taguchi G, Elsayed E A and Hsiang, T.C.,"Quality Engineering in Production Systems", Mc-Graw-HillBook company, Singapore, 1989.

4. Deming W E, —Out of the Crisis," MIT Press, Cambridge, MA, 1982.

5. Juran J M and Juran on —Leadership for Quality" An Executive Handbook, The Free Press, New York,1989.

6. Salor J.H., —TQM-FleldManual,‖ McGraw Hill, New York, 1992.

7. Crosby P.B., — Quality is Free,‖ McGraw Hill, New York, 1979

Introduction

- **Understanding Quality By Design:** The concept was given first time by Joseph M. Juran

Note: The sum of all features is the new product, service, or process

Steps involved in Quality by design

1. • Establish the project design targets and goals
2. • Define the market and customers that will be targeted.
3. • Discover the market, customers, and societal needs
4. • Develop the features of the new design that will meet needs
5. • Develop or redevelop the processes to produce the features.
6. • Develop process controls to be able to transfer the new designs to operations

Example: Quality by design in Pharmaceutical Industry

- A quality target product profile (QTPP) that identifies the critical quality attributes (CQAs) of the drug product
- Product design and understanding including identification of critical material attributes (CMAs)
- Process design and understanding including identification of critical process parameters (CPPs), linking CMAs to CQAs
- A control strategy that includes specifications for the drug substance(s), excipient(s), and drug product as well as controls for each step of the manufacturing process; and
- Process capability and continual improvement. Quality by Design tools and studies include prior knowledge, risk assessment, mechanistic models, design of experiments (DoE) and data analysis, and process analytical technology (PAT).

Quality Aspects of Product & Process Design

E.g. if an engineering component manufacturer specifies the diameter of a steel pin as 2.525 $\pm$ 0.005 mm, the value 2.525 is the target value and $\pm$ 0.005 is the tolerance.

8 Dimensions of Quality

Quality Aspects of Product & Process Design

The five aspects of Product Quality

Producing	• Providing an product or service
Checking	• Confirming that a product or service has been produced correctly.
Quality Control	• Controlling a process to ensure that the outcomes are predictable.
Quality Management	• Directing an organization so that it improves performance through analysis and innovation
Quality Assurance	• Obtaining confirmation that a product or service will be satisfactory.

Quality is considered a non-functional requirement in engineering, affecting the execution and evolution of a product. Product qualities can be divided into two main categories:

- ➢ Execution qualities, such as security and usability.
- ➢ Evolution qualities, such as testability, maintainability, extensibility, portability, and scalability.

Understanding Quality Aspects of Product in Toyota

- Toyota has achieved a reputation for high quality vehicles because of its approach towards quality control and quality assurance which is unique to Toyota.
- Toyota considers quality control as a key part of the activities to produce products or services economically and to be of a standard, which exceeds customer needs.
- Customer satisfaction is at the heart of all Toyota activities.
- Toyota follows a "Company Wide Quality Control" approach as everybody from research and development to manufacturing, retailing and servicing contribute to the quality control process.

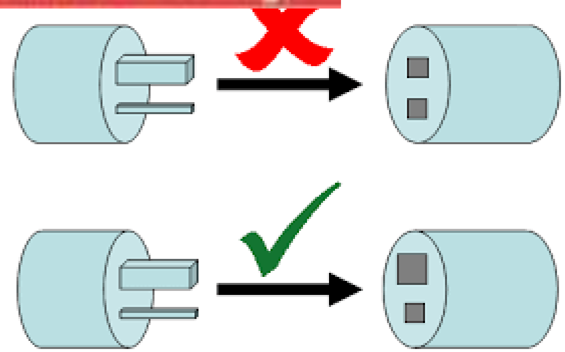
Understanding Quality Aspects of Product in Toyota….

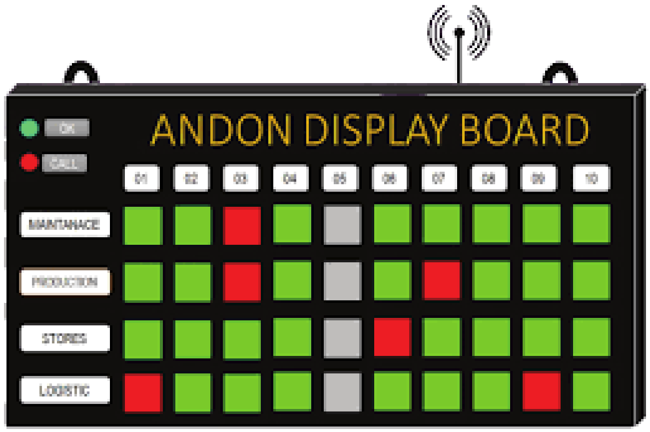
- At Toyota, total quality control is carried out using two basic principles:
  - quality is built in at every stage
  - and quality is continually improved

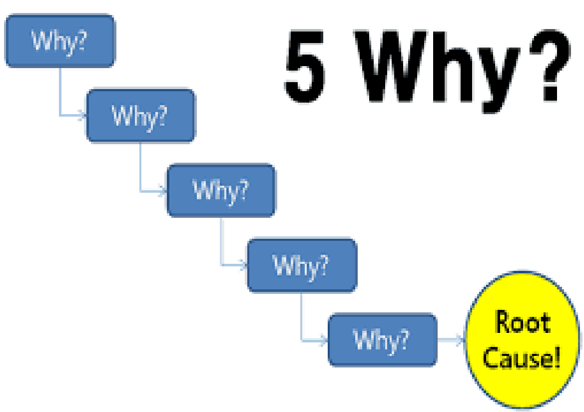
- The use of standardized work together with visual control clearly indicate the current status and make it very easy to spot problems or unusual conditions as they occur.

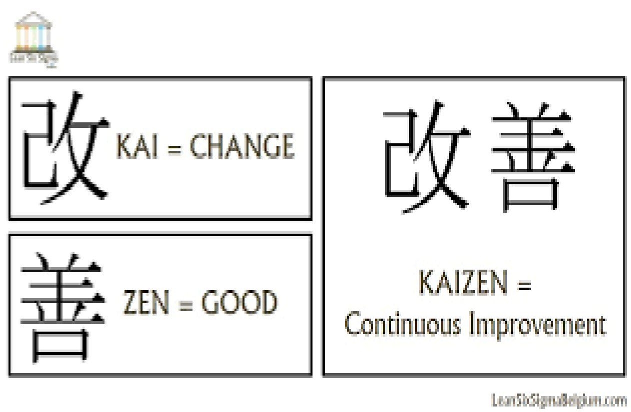
- Other principles that help in making quality products in Toyota are:
  - Poka-yoke
  - Use of Andon Boards
  - 5 Why Analysis
  - Kaizen or Continuous Improvement

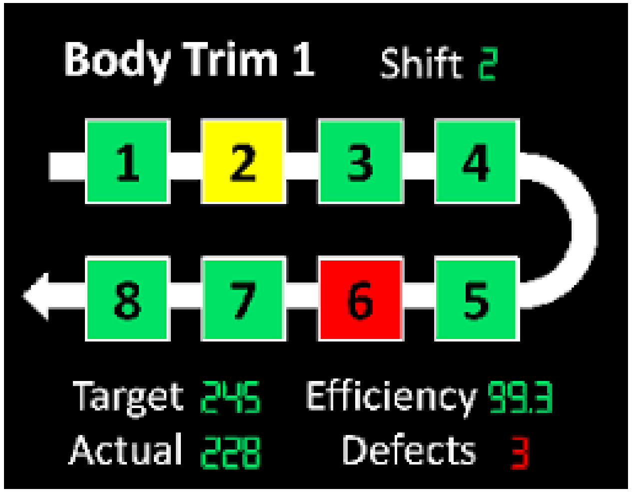
Quality Aspects of Product & Process Design



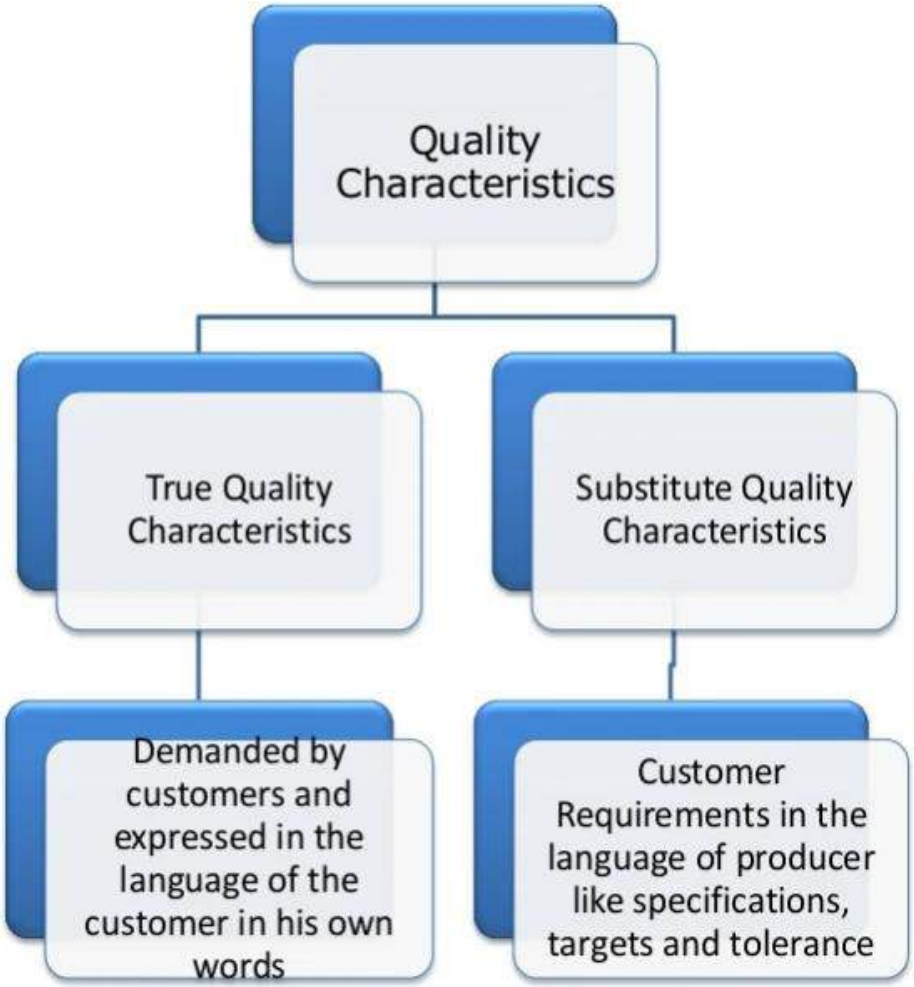








Quality characteristics of a Product



Forward Looking Quality: That are positive advantage of the product – the special features that make it superior to competing products and can be used as sales points, such as, 'easy to use', 'comfortable to use.

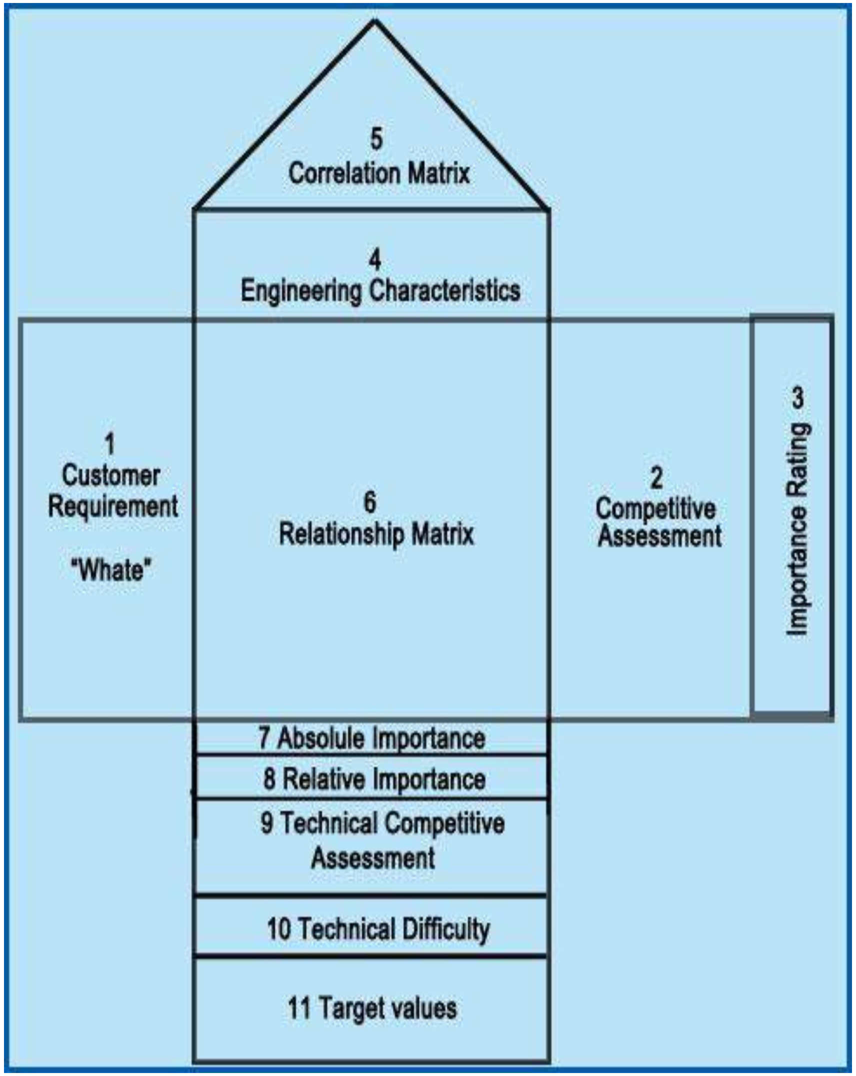
Backward Looking Quality: the absence of defects is a backward looking quality or a must-be quality, bcoz it is essential, but not a sufficient condition for selling in competitive situations.

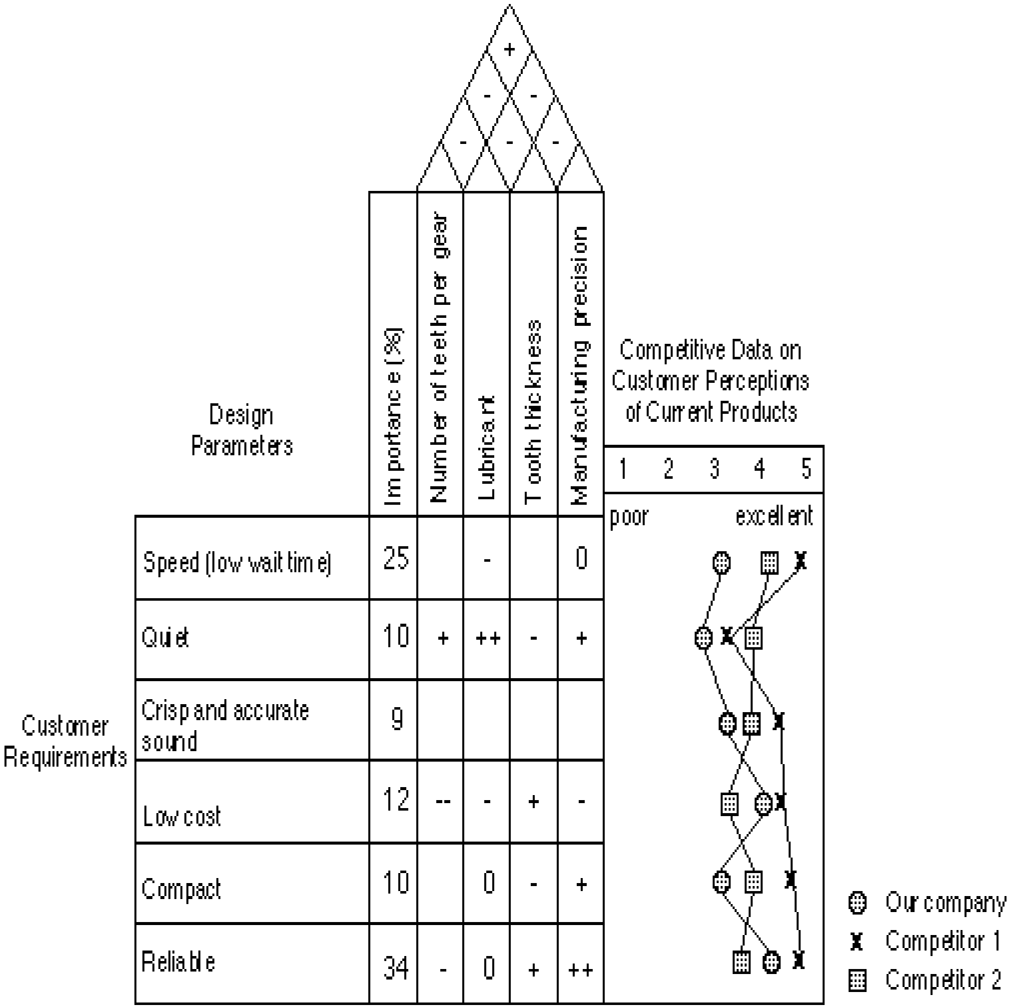
Quality Functional Deployment(QFD)

- It provides a set of planning and communication tools that focuses on customer requirements in co-coordinating the design, production and marketing of customer- driven quality products.
- It provides a means of translating customers' requirements (VOC) into appropriate technical parameters for each stage of product development and production.
- The voice of customer expressed in the form of 'whats' is translated into technical language – the 'hows' that determine the means which meet customer attributes.

Eg. : A customer wants higher mileage from a new model of a car, then by use of QFD a car can be designed which can meet the customer requirements.

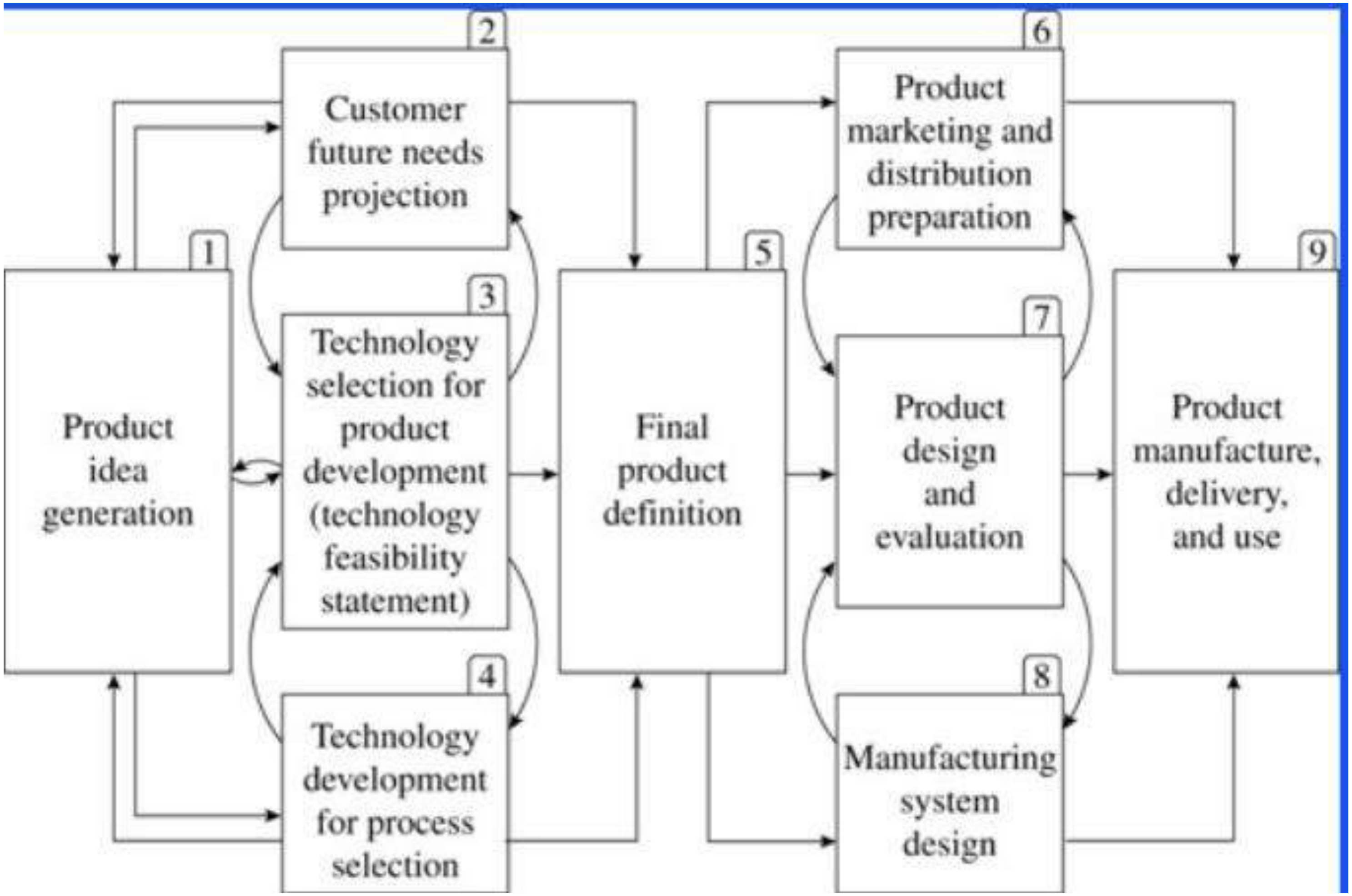
Quality Aspects of Product & Process Design





Customer Requirements	Importance (%)	Number of teeth per gear	Lubricant	Tooth thickness	Manufacturing precision
Speed (low wait time)	25		-		0
Quiet	10	+	++	-	+
Crisp and accurate sound	9				
Low cost	12	--	-	+	-
Compact	10		0	-	+
Reliable	34	-	0	+	++

Designing Products for Quality



Quality Aspects of Product & Process Design

Stage 1: Product idea generation

External and internal sources brainstorm new concepts. Internal sources include marketing, management, R&D, and employee suggestions. The primary source for external product ideas is the customer.

Stage 2: Customer future needs projection

This stage uses data to predict future customer needs.

Stage 3: Technology selection for product development

Designers choose the materials and technologies that will provide the best performance for the customer at an acceptable cost.

Quality Aspects of Product & Process Design

Stage 4: Technology development for process design

Designers choose the processes that will be used to transform the materials picked in the prior stage into final products.

Stage 5: Final product definition

Results in final drawings and specifications for the product with product families by identifying base product and derivative products.

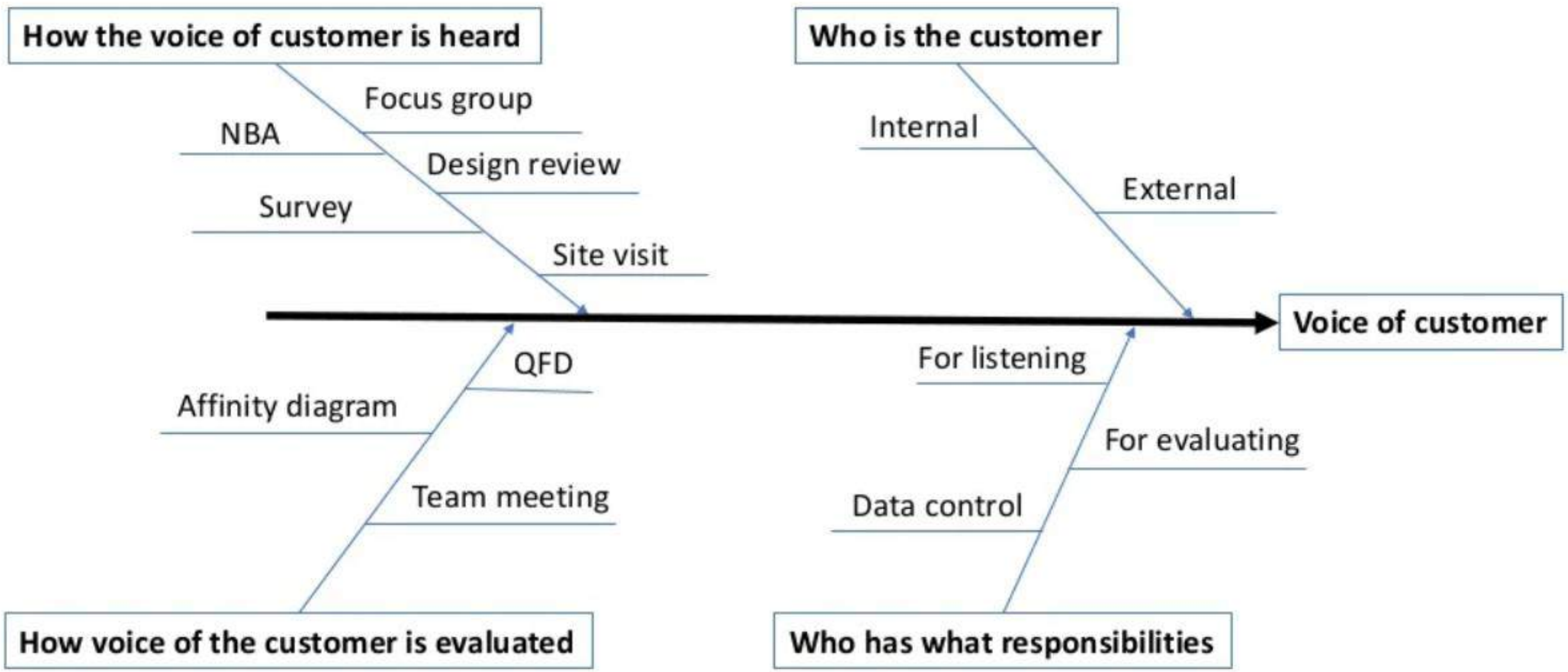
Stage 6: Product marketing and distribution

Preparation includes activities such as the marketing plan.

Difference between new and old culture

Quality element	Old culture	TQM
Definition	Product oriented	Customer oriented
Decision	Short term	Long term
Emphasis	detection	prevention
Responsibility	Quality control	Everyone
Problem solving	managers	Team
Manager's role	Plan, control and detection	Coach, facilitate and deligate

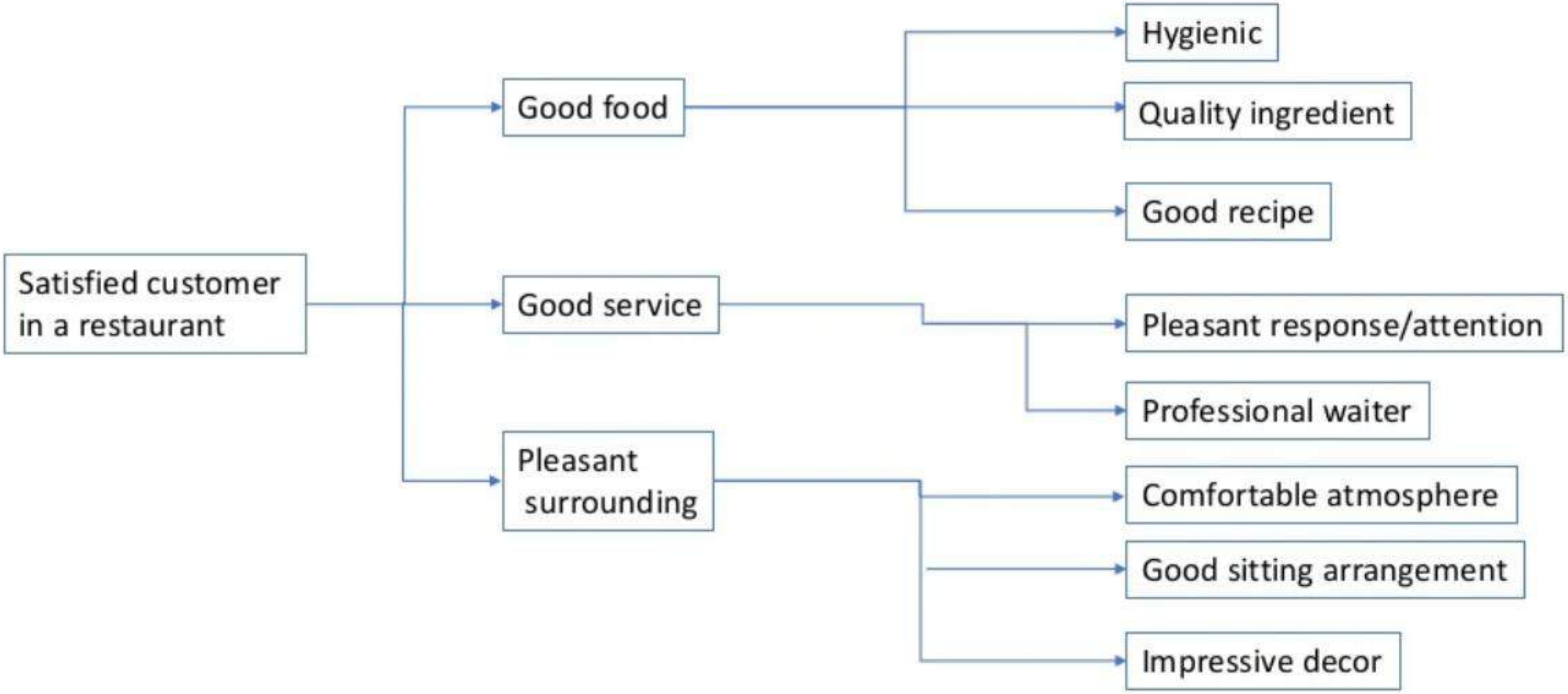
Voice of customer



Customer feedback collections tools

- Comment card
- Survey
- Focus group
- Toll free telephone number/email/chat/tweeter etc.
- Customer visit
- Report card

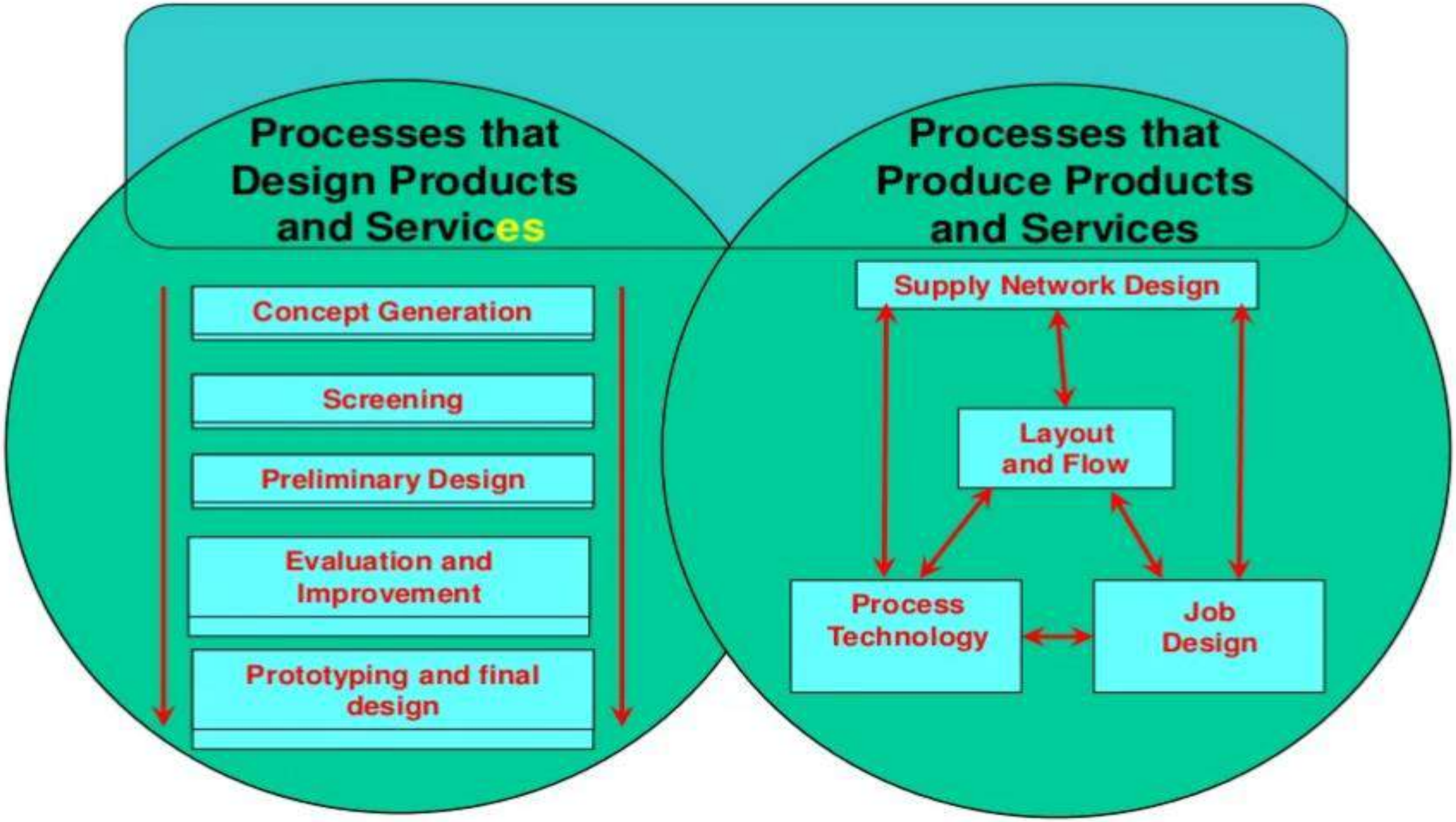
Tree diagram



Quality Aspects of Process Design

The activity of determining the workflow, equipment needs, & implementation requirements for a particular process. Process design typically uses a number of tools including flowcharting, process simulation software, and scale models.

Process Design



Aspects of Process Quality

Aspects of process quality which will be covered by quality assessments are outlined below:

- **Clarity of process:** This refers to the extent to which the process for producing statistics is clear as evidenced by the existence of documentation describing the process.
- **Repeatability of process:** This refers to the extent to which systems and documentation are in place to allow a process to be repeated.
- **Monitoring of process:** This refers to the existence of management systems and metrics which enable the monitoring of process performance.
- **Evaluation and review of processes:** This refers to whether a system of evaluation and review of processes and outputs is in place. Such systems are important to ensure improvement of process performance, and hence data quality, over time.

Quality Engineering

- "Optimize" quality (not maximize)
  - Preferred tradeoff among multiple objectives
  - E.g. Achieve desired quality levels within cost bounds
- Aim is to design systems and systematic approaches that continually work towards this optimum

Limitation of Quality Engg

- Quality frameworks define what to do and how to do it, and measure the outcomes.
- They can identify and eliminate problems.

- But their effectiveness depends on the people who do the activities involved.
- Frameworks cannot deliver excellence. Only people can deliver excellence.

QE in Production and Services

Just In Time Production System

Concurrent Engineering

Lean Manufacturing

World Class Manufacturing

Agile manufacturing

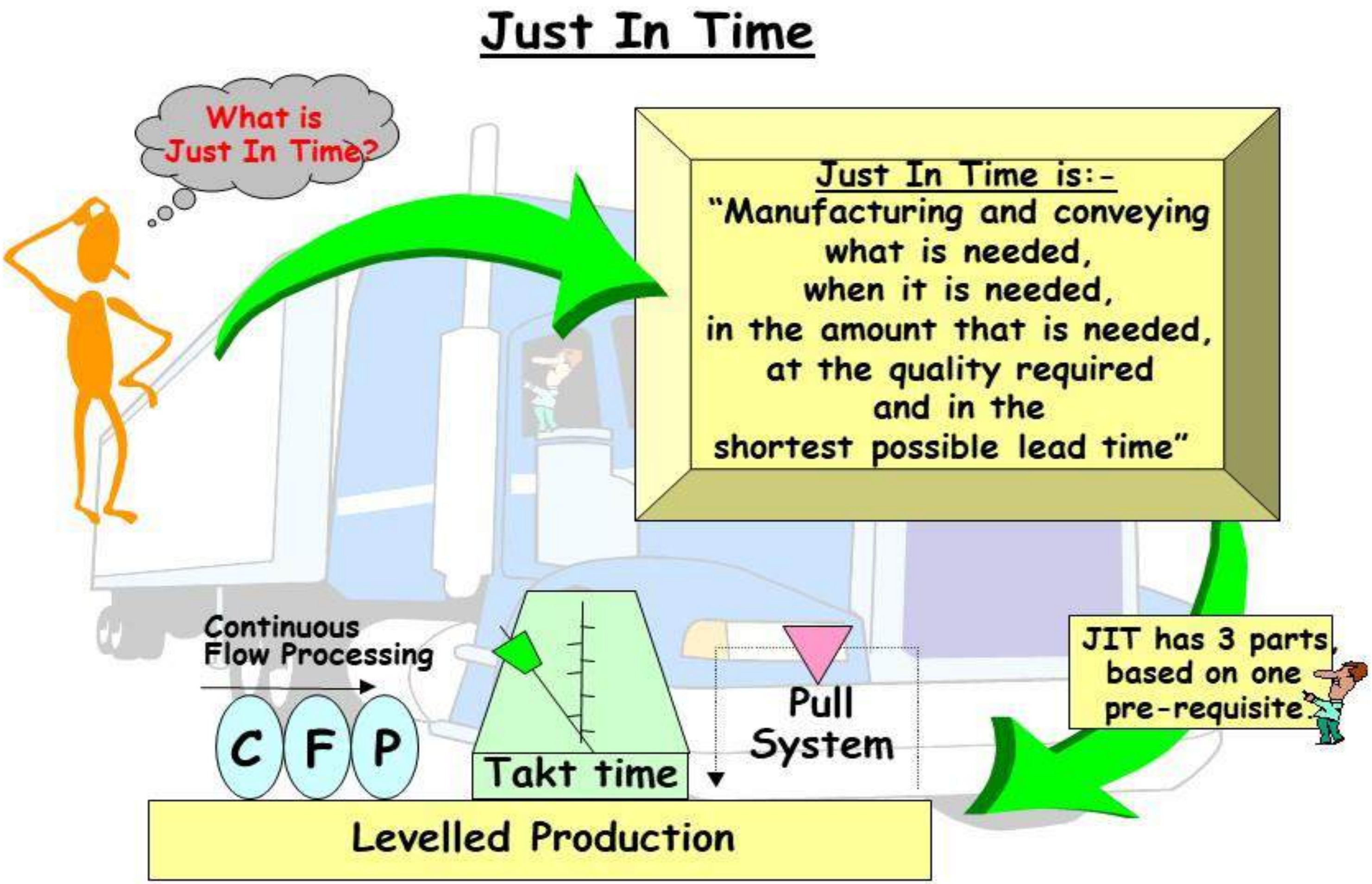
Just in Time or JIT

- Management philosophy that strives to eliminate the sources of manufacturing waste by producing the right part in the right place at the right time.

Principles of JIT (how to implement JIT):

1. Set up production flow process.
2. Solve problems concurrently.
3. Reduce inventory more.
4. Improve product and process.
5. Apply scrap/quality control.
6. Apply kanban pull system.
7. Stabilize master production schedule
8. Work with suppliers.

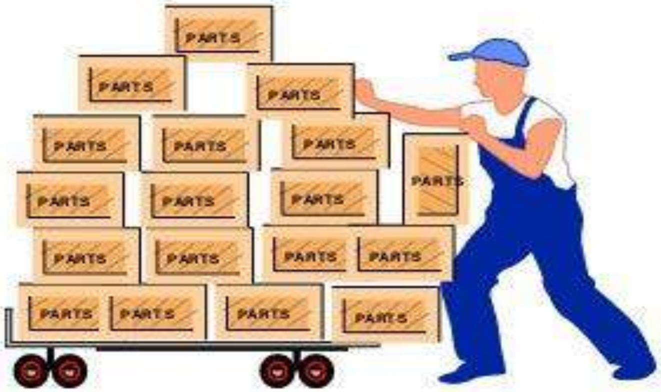
QE in Production and Services



QE in Production and Services

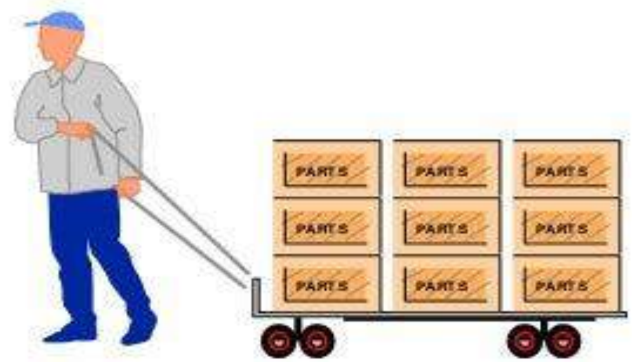
Push vs. Pull

Make all we can just in case.



- Production Approximation
- Anticipated Usage's
- Large Lots
- High Inventories
- Waste
- Management by Firefighting
- Poor Communication

Make what's needed when we need it



- Production Precision
- Actual Consumption
- Small Lots
- Low Inventories
- Waste Reduction
- Management by Sight
- Better Communication

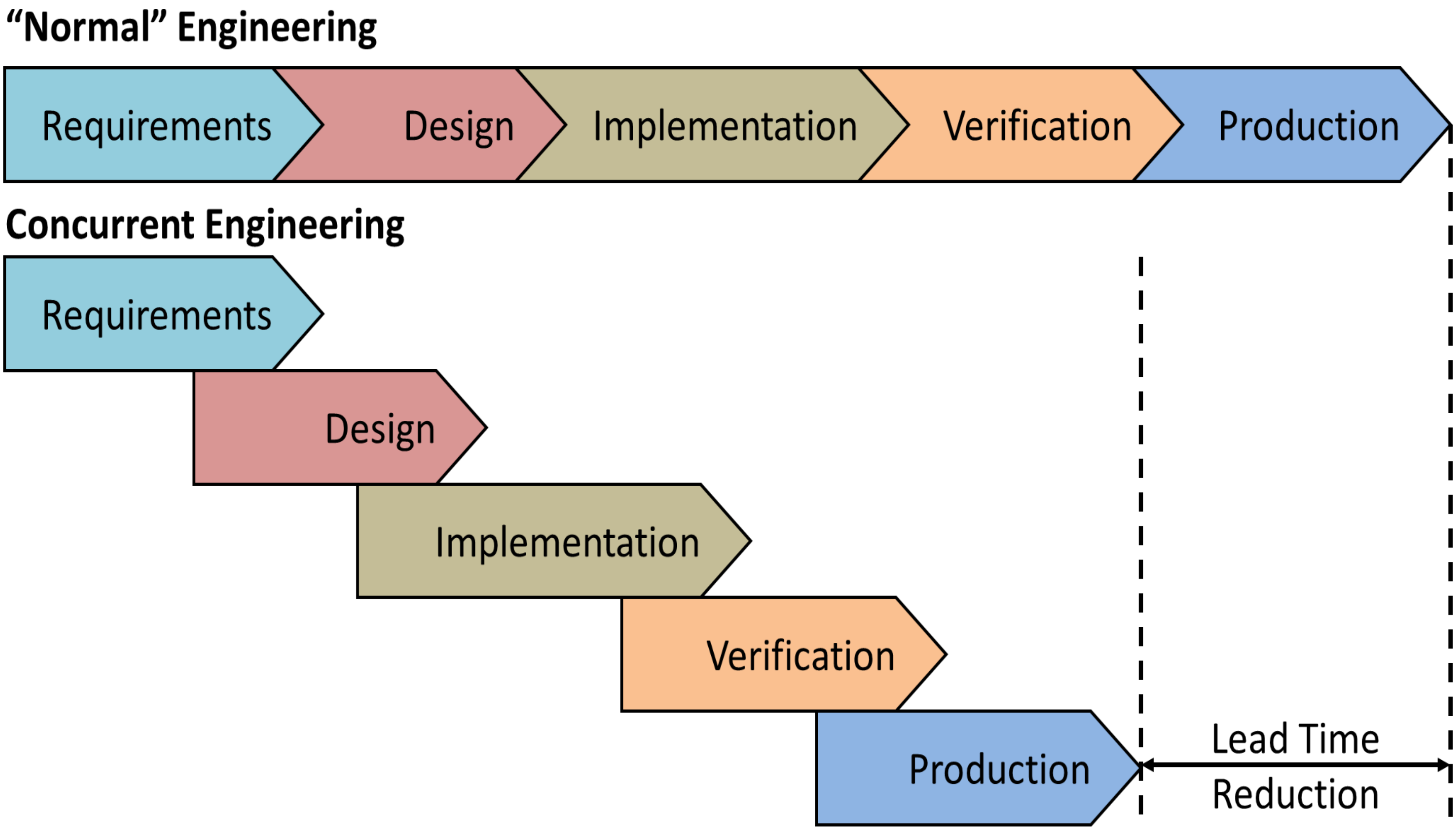
Concurrent Engineering

Is a strategy where all the tasks involved in product development are done in parallel.

Collaboration between all individuals, groups and departments within a company.

- Customer research
- Designers
- Marketing
- Accounting
- Engineering

QE in Production and Services

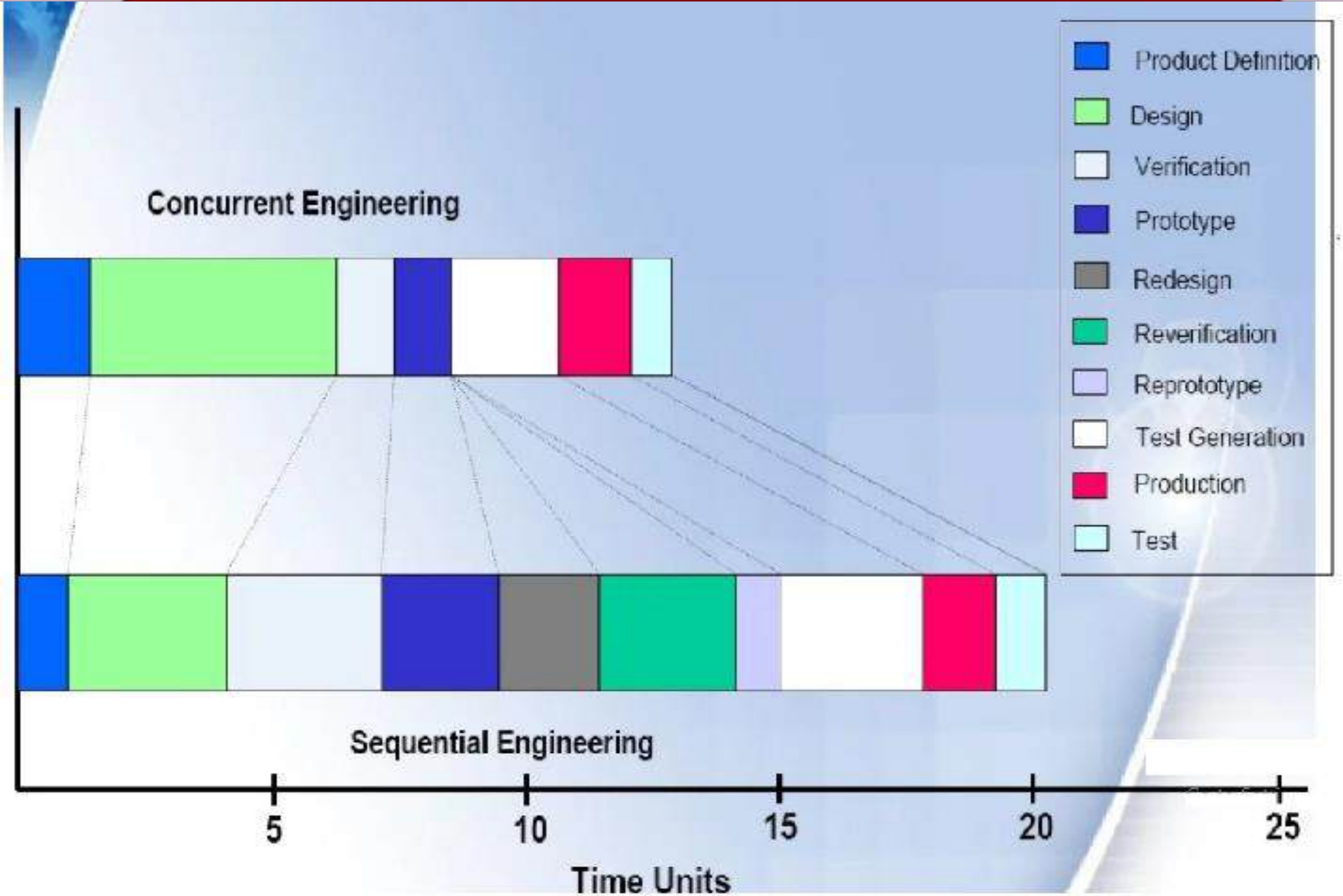


Concurrent Engineering

Involved People

- Customers
  - Users
  - Marketing and sales personnel
  - Operators
  - Maintenance personnel
- Product manager
- Project manager
- Requirement definition engineer
- Specification engineer
- Designer
- Implementation engineer
- Test engineer

QE in Production and Services



QE in Production and Services

Need of Concurrent Engineering

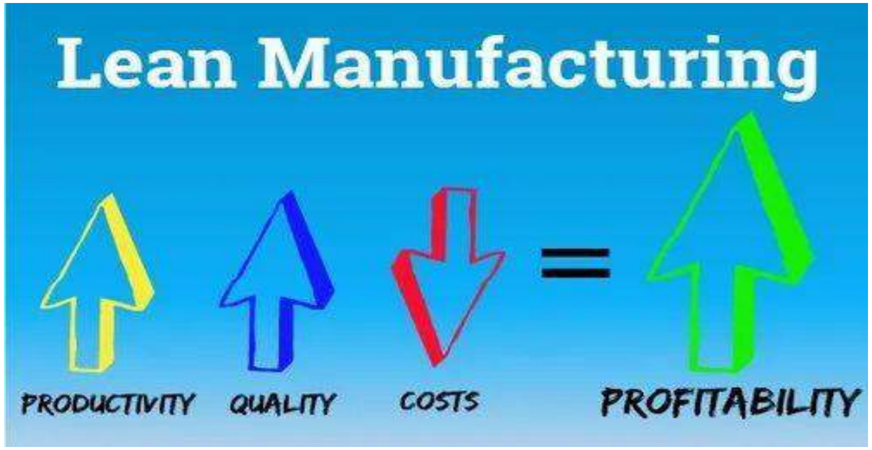
- Need to reduce product development lead time.
- Increased competition.
- New manufacturing processes developed.
- More demanding customers.

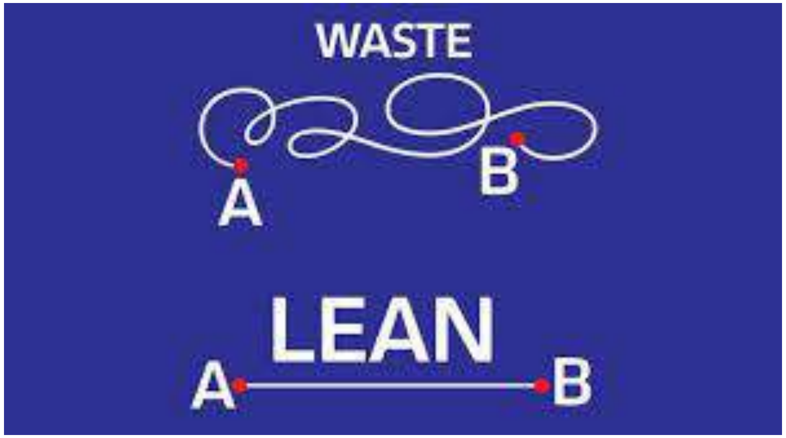
CE tools & Techniques:

- Design for manufacturing(DFM)
- Design for assemblability(DFA)
- Failure effects and modes analysis(FEMA)
- Cost driven design or target costing.
- Quality function deployment(QFD)
- Robust design through Taguchi method.
- Experimental design techniques
- Design stress analysis
- Benchmarking and competitive analysis
- Rapid prototyping
- Customer focused design
- Computer & it based tools like CAD tools (mechanical), CAD tools (electronic), CAM/CAE tools and electronic information or data network.

Lean Manufacturing

- It is a methodology that focuses on minimizing waste within manufacturing systems while simultaneously maximizing productivity.
- Waste is seen as anything that customers do not believe adds value and are not willing to pay for.





QE in Production and Services

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Advantage of Lean manufacturing

- Better Quality
- Low cost
- Less number of people
- Low inventory, inventory turn increase
- Less waste. Optimize men and materials
- Customer delivery performance better, reducing order to shipment time
- Enormous variety in products without the kind of change over costs that customized involves, flexible manufacturing.

Toyota's view is that the main method of lean is not the tools ,but the reduction of three types of waste:

1) **Muda**(" non-value adding work")
2) **Muri** (" overburden")
3) **Mura** ("unevenness")

Agile manufacturing

- It is a term applied to an organization that has created the processes, tools, and training to **enable it to respond quickly to customer needs and market changes** while still controlling costs and quality.
- Fast new product development
- Modular design
- Modular assembly
- Short/fast order processing
- Configure to order / Make-to-Order

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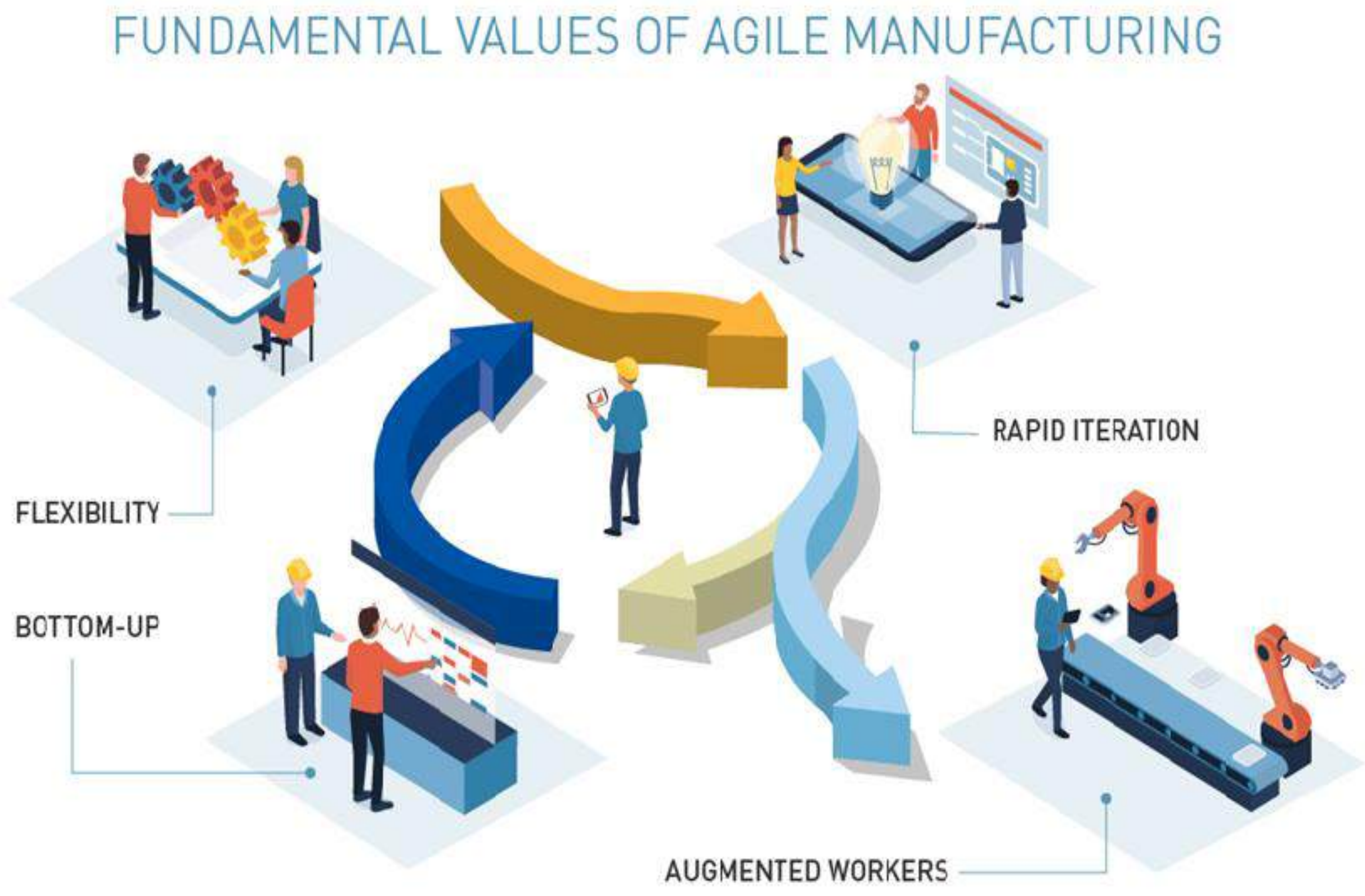

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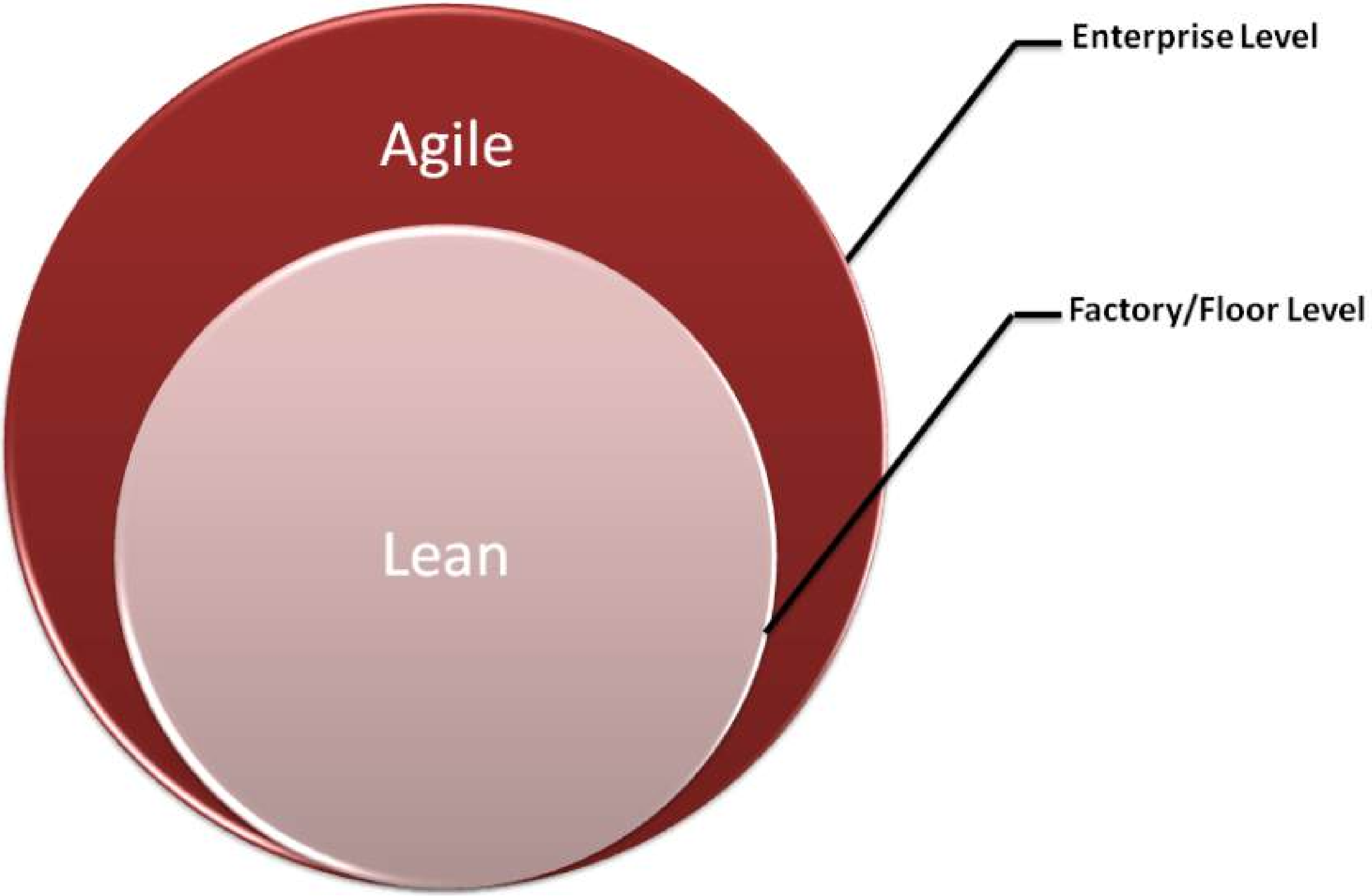

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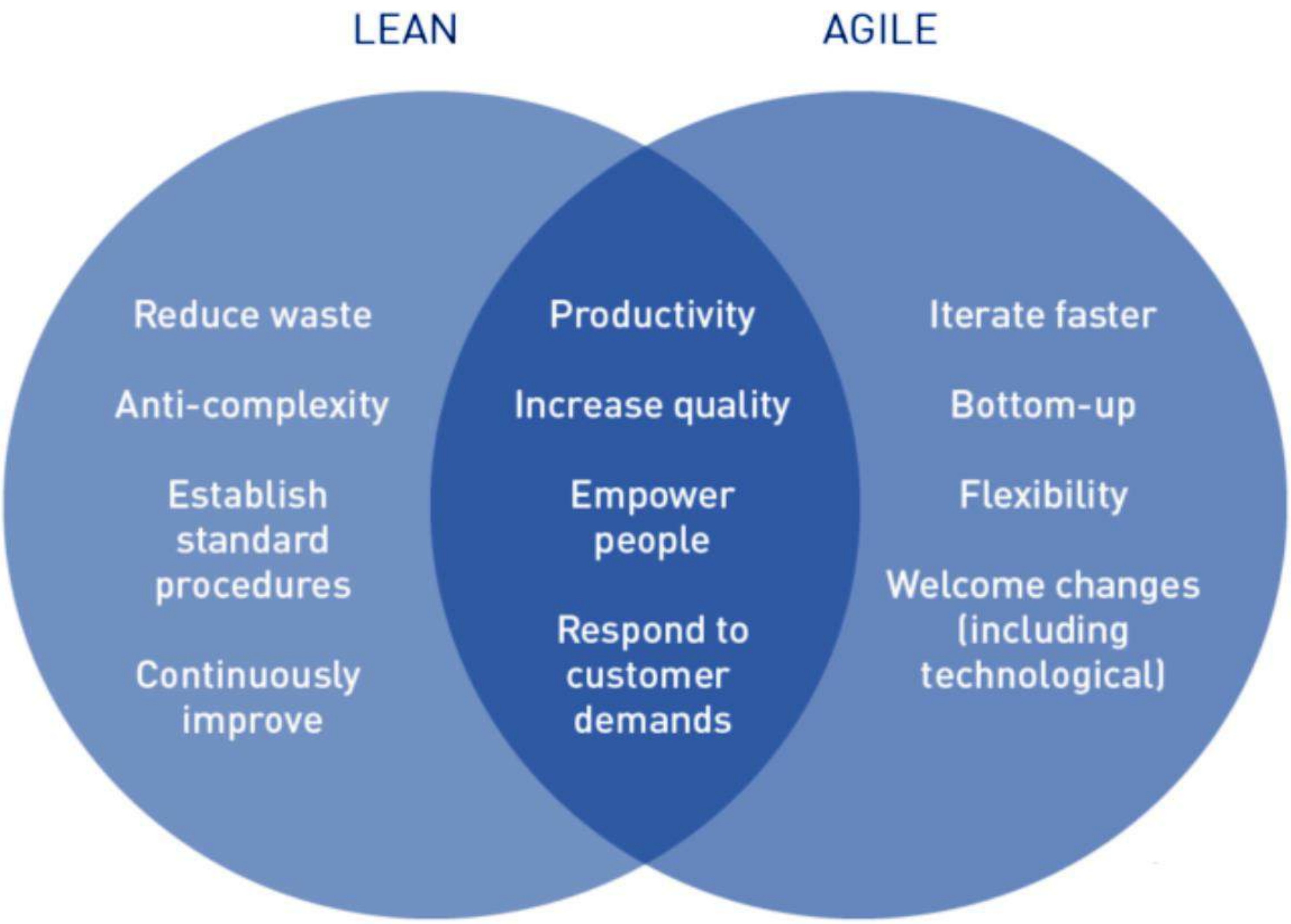

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Thankyou