GE6757

TOTAL QUALITY MANAGEMENT

"LECTURE NOTES"

Quality is first among equals

COURSE PLAN

UNIT - I - Introduction

TOPICS	NO. OF HOURS
• Introduction, Need for quality, Evolution of quality	1
• Definitions of quality, TQM framework	1
• Dimensions of quality, Basic concepts of TQM	1
• Contribution's of Deming, Juran & Crosby to TQM	2
• Barriers & Benefits of TQM	1
• Quality Statements	1
• Customer - Focus, Orientation, satisfaction, complaints & retention	1
• Quality Costs	2
TOTAL	10

NOTES OF LESSON

TOTAL QUALITY MANAGEMENT

UNIT - 1 - INTRODUCTION

What is quality?

* First thought about Quality occured to Sir Joseph Whitworth. → from England, (Manchester).
* Thought -? → Produce interchangeable parts
  → concepts of standardisation.
  → Practice TQM.
* Concept of TQM → First developed by an American statistician - Dr. W. Edwards Deming
  When? → After World War II
  Why? → To improve the production quality of goods & services.
* Who first introduced TQM in industry?
  - Sadly not Americans who overlooked Deming's concepts
  - Luckily, Japanese understood the importance of TQM and introduced the concepts in various industries.

  Why? → Japanese wanted to improve their post war business and industry.
  Simply "RESURRECTION".

* Thus Quality is "Degree of Goodness of a product or service as perceived by the customer".

* Quality → Degree of goodness
product or service
In the view of customer (needs).

* Business organisations have the following criteria to be met to maintain quality.

What? → Meet customer needs & expectations

How? → Doing it in an efficient manner.

* Quality can be defined in terms of ~~productivity~~ Ratio

$$Q = \frac{P}{E} = \frac{\text{Performance}}{\text{Expectations}}$$

If $Q > 1.0 \Rightarrow$ Customer has good feeling

$Q < 1.0 \Rightarrow$ Quality is not upto the mark.

What is TQM?

* Similar to Quality, TQM is also customer oriented.

* U.S dept. of philosophy defines TQM as

→ Both philosophy & a set of guiding principales that represent foundation of a continuosly improving organisation.

* Effects of using TQM concepts by Japanese
  → Dominate the world engineering and technology market in 1980's.
  → Japanese invested 30 years of
    * patience
    * hard work
    * continuous improvement
  to achieve the world dominance in 1980's

* Quality → In general, a broad term that may refer to various parameters on the usage basis like
  * Aesthetic - looking good
  * Performance - works well
  * Reliability - Reliable.
  * Safety - very safe in use.

* Definition can be → conventional
                    → strategic

* Most common meaning → "Meeting Customer Requirements well in a consistent manner".

* Misinterpretations of Quality:
  * Always good - Can be good or bad
  * Always reliable - Can have failures
  * Long lasting - Can be for short periods

* According to Webster's dictionary,

Quality → a physical or non physical characteristic
→ Basic nature of a thing or one of its distinguishing features.

* What is Quality according to experts?

- Deming → Quality is ~~doo~~something that is aimed at the needs of the consumer, present and future.
- Crosby (1979) → Quality is the conformance to requirements or specifications
- Juran (1974) → Quality is fitness for use.
- Feigenbaum → Total composite product and service characteristics of marketing, engineering manufacturing & maintenance through which the product and service will meet the customer demands (needs) expectations.

* Customer who expectations are to be met can be

→ Individuals → Employees
→ Institutions → Private & Public sector companies
→ Other (Own Countries) → Others, etc.,.

→ Application of quantitative methods & human resources to improve the materials and services supplied to an organisation, all the processes within an organisation and the degree to which needs of customers are met, now and in future.

→ Integrates fundamental management techniques, existing improvement efforts and technical tools under a disciplined approach focused on continuous improvement.

* TQM → How it can be achieved?

→ Only when each and every person and process in an organisation is organised or oriented towards quality.

Eg: Quality of a bike.

⇒ Can be achieved only if

- Right from raw materials through the entire supply chain the quality is maintained
- Continuous improvement.
- Implement processes accordingly right from top management bottom down.

* According to Dale Besterfield, TQM is defined as:

Total → made up of the whole

Quality → Degree of goodness / excellence of a product or service

Management → Act, art or manner of handling, controlling, directing, staffing an organisation.

Building Blocks of TQM:

* made up of several elements (or) aspects. like:

1.) Top management's commitments to quality in all aspects.
2.) Customer focus of the organization.
3.) Process focus and improvement
4.) Performance measurements
5.) Benchmarking
6.) Teams
7.) Supplier teaming
8.) Continuous Improvement.
9.) Employee involvement and empowerment
10.) Training of employees.
11.) Inventory Management
12.) Communication
13.) Quality Costs.

Basic Concepts of TQM:

* 6 basic Concepts are there as listed below:

1.) Commitment of top management to Quality (No compromise for quality motto)

2.) Focus on internal and external customers.

Internal → Employees

External → Suppliers & Customers (Consumer)

(X) → "Voice of the Customer"

3.) Effective involvement of the entire work force

4.) Continuous improvement of business and all other processes.

5.) Treating suppliers as partners.

6.) Establish performance measures for the process.

→ How to change an organisation to use TQM?

↓

Quality Elements	Prior to TQM	With TQM
Definition	Product Oriented	Customer Oriented
Priorities	second to service and cost.	First to service & cost.
Decisions	short term	Long term
Emphasis	Detection	Prevention

Quality Elements	Prior to TQM	With TQM
Errors	Operations	System
Responsibility	Quality Control	Everyone
Problem Solving	Managers	Teams
Procurement based on	Price	Life cycle costs, Partnership
Manager's role	Plan, Assign, Control & Enforce (PACE)	Delegate, Coach, Facilitate & Mentor (DCFM)

Dimensions of quality:

* David Garvin of Harvard Business identified
  - → 5 Approaches to quality
  - → 9 Dimensions of quality.

5 Approaches:

Garvin's 5 Approaches

- Transcendant Approach
- User Based Approach
- Value Based Approach
- Product Based Approach
- Manufacturing Based Approach

1.) Transcendant App:- Through Learning & experience.

2.) Product Based App:- Precise & Measurable; Ranked on various attributes and is an inherent part of product.

5) Durability → Measure of product life or useful life of a product.

→ Time span of life includes repairs & maintanence as well.

→ Eg: Useful life of a mobile phone

6) Serviceability → Resolution of problems & complaints on the product.

→ Speed, courtesy, competence of repair, ease of repair, etc.

General thought of customer → Rapid Repair ≡ Higher Quality

No Repair (or) Rare Repair ≡ Higher Quality

→ Eg: Good repair & service provided to Apple phones.

7) Aesthetics → Represents sensory characters like

→ Look, Feel, Exterior Finish

→ Eg: Interior dashboard & seat finishings of a Benz car.

8) Perceived Quality (or) Reputation → Represents indirect measure of quality

→ Brand image, Name, part performance, being ranked 1.

→ Eg: Car of the year.

9) Response → Represents human to human interface

→ courtesy of dealer, shop floor employees, etc.,.

→ Customer Responsiveness which means how fast organisations react to need of customers.

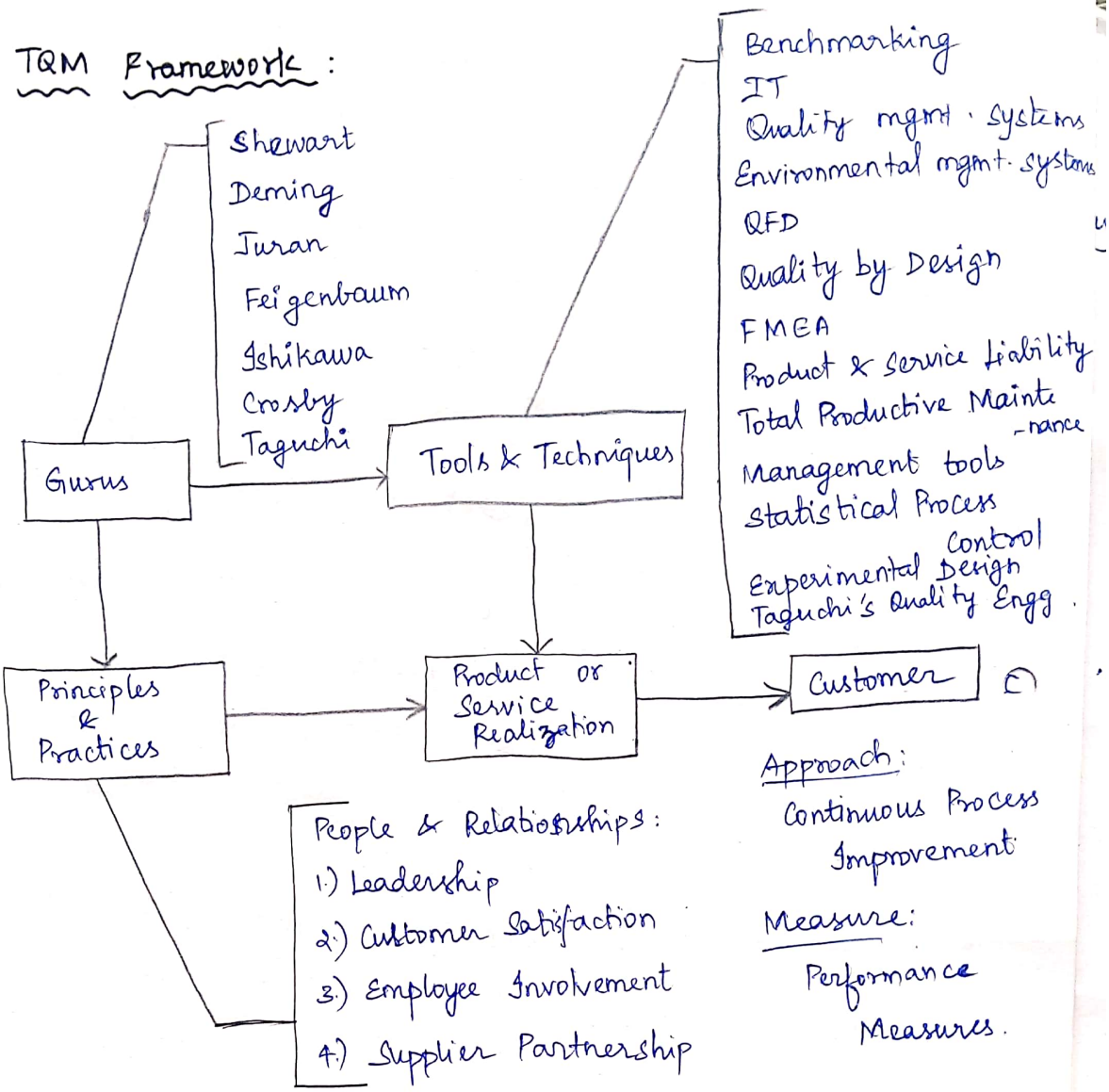
→ Eg: Huawei Honor was given 4G VOLTE after JIO introduced Sim through a hardware path upgrade.

* Garvin's 9 dimensions of qualities are Product quality dimensions.

Dimensions of Service Quality:

1.) Time
2.) Timelines
3.) Completeness
4.) Courtesy
5.) Consistency
6.) Accessibility & Convenience
7.) Accuracy
8.) Responsiveness.

TQM Framework :



Unit II ⇒ Explains about the various principles.

Units III & IV ⇒ Explains about the various tools & techniques in practise.

Contributions by Deming, Juran & Crosby:

a) Deming's Philosophy:

* Represented by 14 points
* Significance – Most of these points were developed and presented to all presidents of Japanese industries in 1950 post WW II

1) Create & publish the Aims and Purposes of the organisation.

→ Short term goals
→ Long term goals
→ Mission, Vision
→ Innovations
→ Modified policies, standards & statements overtin

2) Learn the new philosophy.

→ Everyone's desire to learn newer philosophies
→ Never ending improvement and refuse to accept non-conformance.
→ Customer satisfaction – Top Priority.
→ Improved processes & supplier relations.

3) Understand the purpose of inspection.

is to → Improve process
→ Reduce cost
→ Mass inspection not reliable & costly.
→ Use techniques to never ending improvemen
→ Stastictical evidence is required.
→ Spend efforts to eliminate & acceptance sampling.

4) Stop awarding business based on price alone

Stop → Giving contracts to low bidders as they may use less quality products.

Goal → To have single supplier for each item to conform loyalty & quality.

→ Follow through the entire life cycle of product with customer and get feedback.

→ Use feedback to fine tune supplier's part quality.

5) Improve constantly & forever the system.

→ Management to take serious steps in identifying problems in each & every step of the process.

→ Variations should not be sacrificed for the problems.

→ Continually improve the process.

6) Institute training

→ Orient employees on aims & purposes & develop the attitude of never ending trial among them

→ Use statistical methods for training

→ Monitor the training and plan for improvement

7) Teach & Institute Leadership

→ Provide special improved training to supervisors to delegate & extract quality work from sub-ordinates.

→ Avoid negative, fault finding atmosphere. instead Create positive, supportive atmosphere to get pride in workmanship.

8.) Drive out fear, create Trust and create a climax for innovation

→ Management must encourage open, effective communication & teamwork.

→ Fear is caused due to lack of power to control important aspects. Give power & drive out fear.

→ Also by lack of job security, possible physical harm, performance appraisals, ignorance of org. goals, poor supervision and knowing the job.

→ By providing adequate training, good supervision, proper tools, etc., can achieve this.

9.) Optimize the efforts of teams, groups & staff areas.

→ To achieve the aims & purposes of the org.

→ All internal and external barriers must be broken.

→ All to work together

→ By proper training, open communication channels, organized project teams & training in teamwork, the above is implemented.

→ Use Concurrent engineering.

10.) Eliminate Exhortations for the work force asking for

→ Improved productivity without providing specific improvement methods will fail an org.

→ Goals that are achievable and are contributing to the long term success of an organization needs to be put forth.

→ Improvements can't be made until tools & methods are available.

11.) a) Eliminate Numerical Quota for workforce

→ Quota focuses on quantity rather than quality.

→ Productivity improvement is not just an ↑ in number, but importantly Quality.

→ Use improved tools, methods & standards to achieve both quality & number.

b) Eliminate Mgmt. by Objective.

→ Mgmt. must learn the capabilities of the processes and how to improve them. Not by objective.

→ Use proper tools and methods to achieve this.

12.) Remove barriers that rob people of the pride of workmanship.

Barriers are → 1.) Workers don't know how to relate the org. mission
2.) They take blame for system problems
3.) Poor designs lead to Junk / Waste
4.) Inadequate training

5) Punitive supervision exists
6) Ineffective equipments provided to do work.

→ By eliminating the barriers, the workers can feel their pride.

13.) Encourage education & self improvement for everyone.

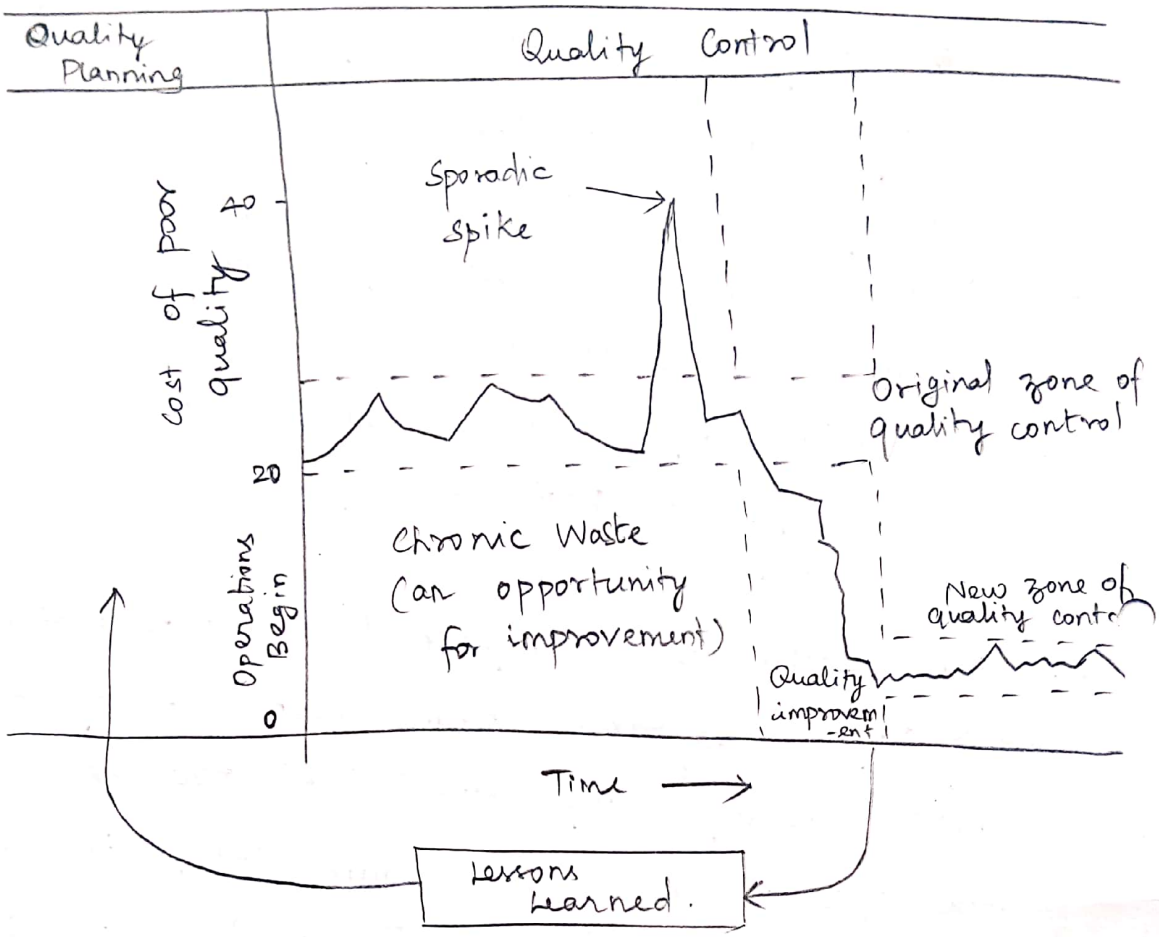
→ continuously train & educate people.
→ Deming's 14 points & Org. mission should be educated.

14.) Take action to accomplish the transformation.

→ Mgmt. to take prime responsibility for never ending improvement of process
→ Mgmt. should be committed, involved & accessible to implement new philosophy.

b.) Juran's philosophy:

* Devised by Joseph. M. Juran in 1954.
* Recommended Project improvements based on ROI to achieve breakthrough results.
* 3 components → Planning
  → Control
  → Improvement.
* This is a cycle aimed at continuous improvement of a process.



Juran's Quality Trilogy

c) Crosby's Philosophy :

* Devised by Phillip. B. Crosby
* statement - "Doing it right the first time" is less expensive than the costs of detecting and then correcting nonconformities.
* Has given 4 absolutes of Quality Mgmt.
  - → Quality is conformance to requirements
  - → Prevention to nonconformance is the objective and not appraisal.
  - → Performance stds. is "Zero Defects"
  - → Measurement of quality ⇒ Cost of nonconformance

Implementation of TQM:

* Stepwise process
* Starts with top management, ends with customers, low level employees and supplier partners.

* Steps are:

1) Educate CEO and senior leadership mgmt. team with concepts of TQM. To have practical experience, ask them to visit TQM org, read select articles and books, seminars from eminent personalities and conferences.

2) Check if the org. is ready to embark a TQM journey. Decide the time of implementation

3) Foreseeable problems like re-org., change in senior management personnel, interpersonal conflicts, a current crisis, time consuming activity, etc., should be encountered.

3) Form Quality council; Develop core values, vision, Mission & Quality policy statement.

4) Identify middle managers and first line supervisors who are ready to act as a link b/w senior mgmt & front line workers. Provide TQM training, Leadership skills & active involvement in the development.

(as, they are the pillars of comm.)

5.) Share TQM implementation plan to the union leaders and get their approval so as to work together during the transition phase.

6.) Communicate TQM to entire organisation to create awareness, interest, desire and action among all about TQM.

7.) Train everyone in quality awareness & problem solving

8.) Benchmark the attitudes of 3 stake-holders — Customer, Employee and supplier partner by taking surveys and proceed to further quality improvement projects.

TQM Implementation plan

Educate senior mgmt. on TQM concepts
↓
Decide Time of imp. considering foreseeable problems
↓
Form QC & develop vision, mission, core values & Quality Statements
↓
Identify & Train middle mgmt on TQM.
↓
Share TQM imp. plan to union and get approval for togetherness
↓
Communicate TQM to entire org. to create awarness.
↓
Train everyone for quality awareness & problem solving.
↓
Benchmark the attitudes of C, E, S thro. surveys and plan for cont. improv-ement.

Barriers of TQM (Obstacles):

* Obstacles for implementing TQM are:

→ Lack of mgmt commitment

⇒ Eg: Not considering failure costs, customer complaints & cycle time reduction.

→ Inability to change Org. Culture

- Most difficult part
- May take 5 years.
- Develop trust & avoid fear among people about change.

→ Improper planning

→ Lack of continuous training & Education.

- Ensure continual training to all personal.

→ Incompatible org. structure & Isolated individuals and departments.

- Adherence to 6 basic concepts of TQM will avoid this.

→ Ineffective measurement techniques & lack of access to data & results.

- Provide proper tools for measurement.
- Maintain records accessible thru. LAN if possible.

→ Paying inadequate attention to internal & external customers.

- Internal - Employees
- External - customer / Consumer, Supplier.
- Voice of the customer.

→ Inadequate use of empowerment & Teamwork.

→ Failure to continually improve.

Benefits of TQM:

* Growth in operating income
* Increase in sales
* Increase in total assets

→ Strong link b/w TQM & Financial performance.

other benefits include.

* Improved customer satisfaction
* Employees are happy with the share of org's profit as bonus
* Life of product increased
* Sustainability is better

Quality Statements :

Vision :

* A short declaration of what an org. aspires to be tomorrow.
* Probably an ideal state that might never be reached but which can be continually strived to be achieved to.
* Timeless, inspiral and deeply sheared within an organisation.
* Eg: Disney's vision → The happiest place on earth
  IBM's " → Service
  Polaroid's " → Instant Photography
* Realtime vision of Mercedes-Benz :
  → To be Number 1 in quality, image & profitability in the Automotive sector.

Mission :

* It is the statement which answers 4 (1.) who we are, (2.) who are the customers, (3.) what we do & (4.) How we do it.

* Mission statement elaborates the vision statement and might contain short term goals in it.

* Normally a paragraph (or) 3 to 4 bullet points.

* Real time mission statement of Mercedes-Benz

→ To delight our customers in everything we do

→ To continually improve the effectiveness of our QMS & our business processes.

→ To continually improve the quality of our products and services

→ To have a team oriented and open minded corporate culture involving employees through leadership and individual acceptance of delegated responsibility.

→ To be aware of our environment.

→ To have a professional relationship with our business partners.

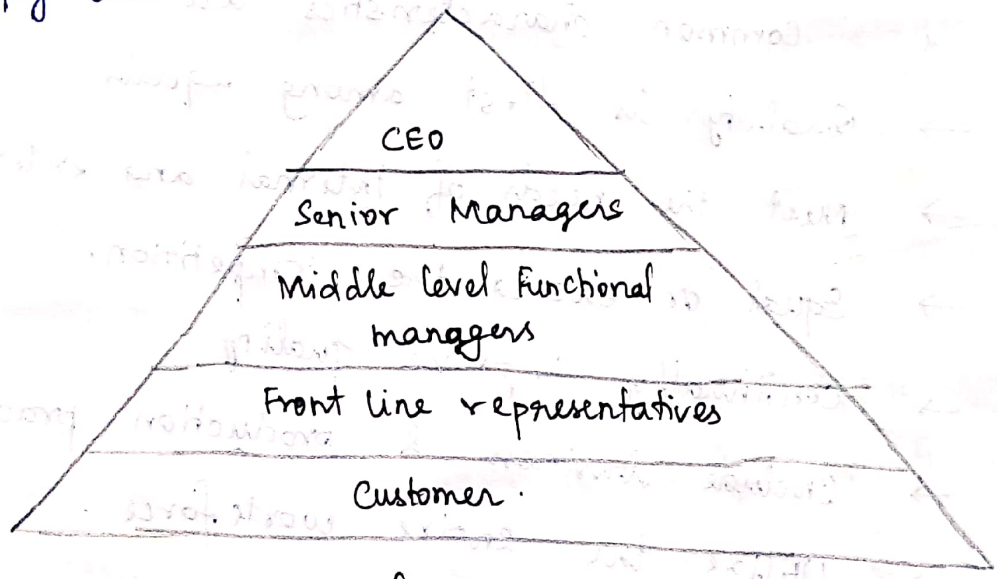
Quality Policy Statement:

* It is a guide to everyone in the org on how to provide products and service to customers.
* Usually written by CEO after getting feedback from the work force and be approved by the QC
* Common characteristics are:
  - → Quality is first among equals
  - → Meet the needs of internal and external customers
  - → Equal or exceed the competition.
  - → continually improve quality
  - → Include business & production practices
  - → Utilize the entire workforce.
* Requirement of a ISO|QS 9000.
* It simply says what does quality mean to a particular org.
* Eg: Xerox Corporation.

Xerox is a quality company. Quality is the basic business principle. Quality means providing our external & internal customers with innovative products & services that fully satisfy their requirements. Quality is the job of every employee.

Customer Focus:

* For any Org. customers are the prime focus.
* Customer's needs are to be met for any successful organisation.
* Customer is the base of any supply chain.



Pyramid of Customer Focus in Supply Chain

* Customer Types.

- External (All persons outside org.)
  - Current
  - Prospective
  - Lost
- Internal.
  - All employees within org. who work in diff. sections / dept.

* Example showing diff. customer types:

External Customer – External Supplier of Raw Materials

↓

Internal Customers –

- Purchase department
- ↓
- Stores dept.
- ↓
- Production department
- ↓
- Quality Inspection dept.
- ↓
- Logistics dept. (Delivery)

↓

External Customers. –

- Warehouse
- ↓
- Distributor
- ↓
- End User.

Customer Orientation | Perception:

* Customer thinks quality in the foll. 6 orientations:

1.) Performance → Availability in operation
→ Reliability
→ Maintainability.

2.) Features

3.) Service

4.) Warranty

5.) Price

6.) Reputation.

Customer Complaints :

* Getting feedback from both customer types will enable org. to :
  - → Discover cust. dissatisfaction
  - → Discover relative priorities of quality
  - → Compare performance with competition
  - → Identify customer needs
  - → Determine opportunities for improvement.

* Customer Complaints → Listening to the voice of the customer by various collecting tools like :
  1.) Comment card
  2.) Customer questionaire
  3.) Survey
  4.) Focus groups
  5.) Toll-free phone numbers.
  6.) Customer visit
  7.) Report card
  8.) Employee feedback.

* Kano Model is used to convert customer needs into requirements.

Customer Retention:

* More powerful & effective than cust. satisfaction
* Point where cust. satisfaction converts to cust. loyalty is cust. retention.
* All cust. complaints tools can be focused on to collect feedback. Rectify it, satisfy customers and make them stay loyal.
* Eg: Huawei Honor 5X was given hardware patch for 4G VOLTE after JIO was introduced.

Quality Costs:

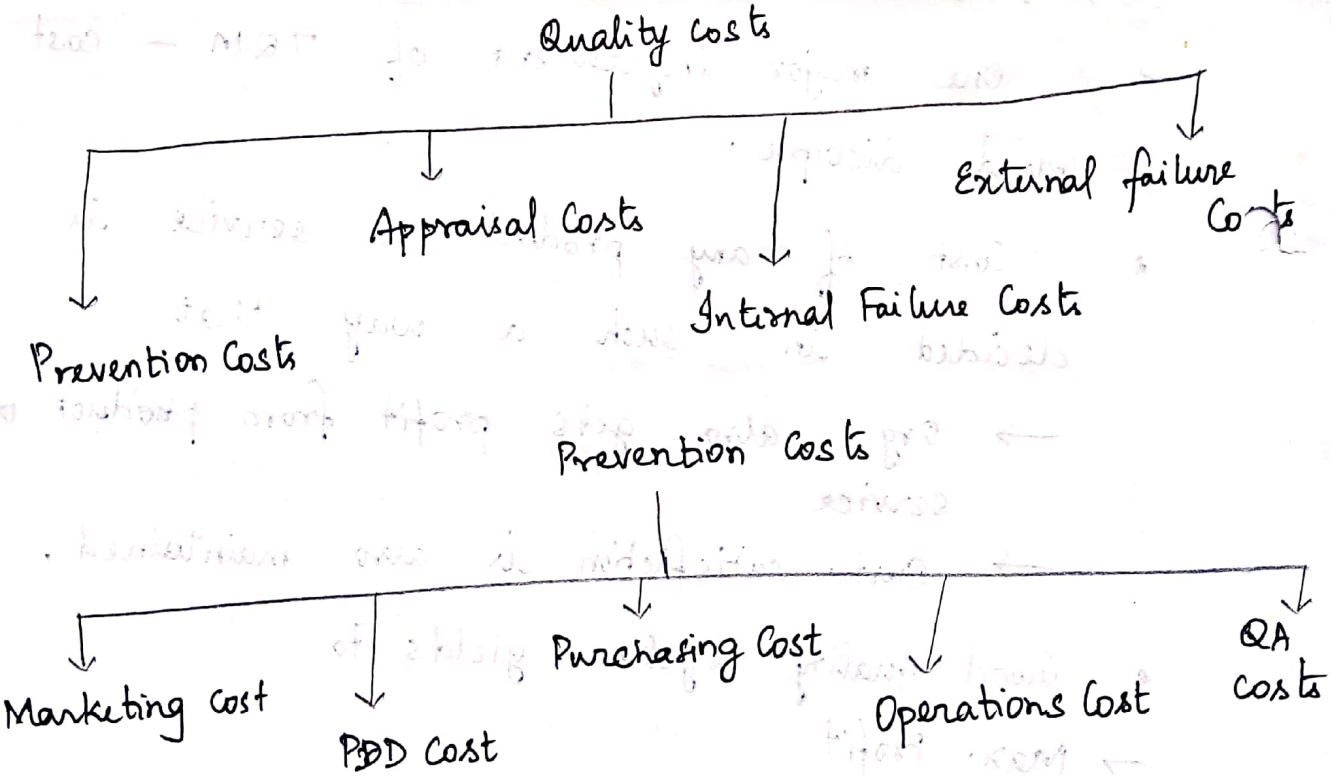
* One major ingredient of TQM – cost based disciple.
* Cost of any product or service is decided in such a way that
  → Org. also gets profit from product or service
  → Cust. satisfaction is also maintained.
* Good quality system yields to
  → Max. Profit
  → Cust. satisfaction
  → Market Share.

* By reducing costs in
  - Decision making
  - Maintenance
  - Production
  - Inspection
  - Sales

  etc., can result in yielding quality product (or) service at a lower cost.

* Quality Costs is a mgmt. tool for
  → Achieving quality improvement
  → Customer satisfaction
  → Increase market share
  → Profit Maximisation.

* Types:



* Marketing Costs

→ Marketing Research Cost
→ Customer Survey Cost
→ Consumer behaviour analysis cost
→ Contract & Doc. review cost.

* PDD Costs:

→ Design support activities cost
→ Design quality progress review cost.
→ product design qualification test cost
→ service design qualification & trial cost.

* Purchasing Costs:

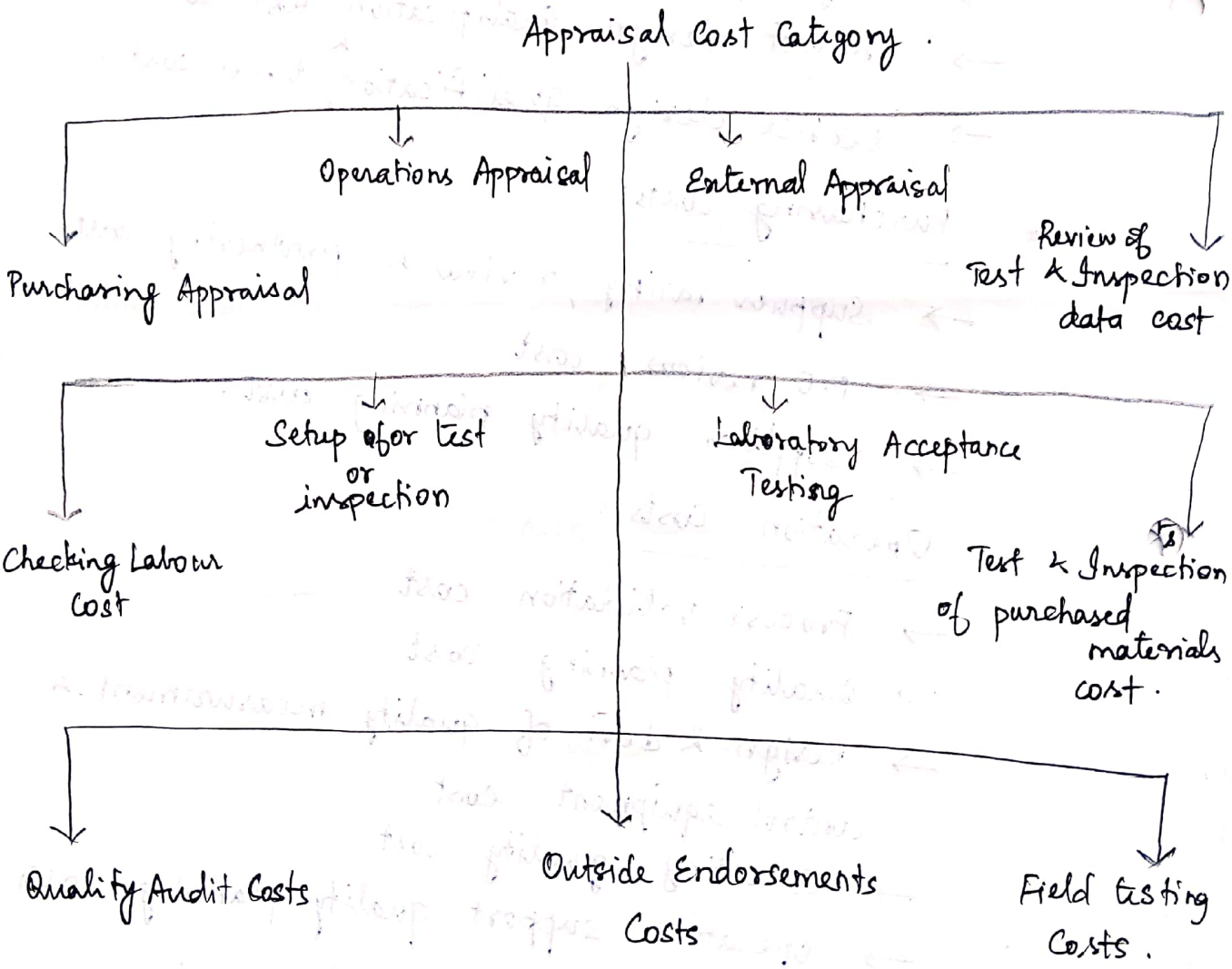
→ Supplier rating, review & partnering costs
→ P.O review cost
→ supplier quality planning cost.

* Operation Costs:

→ Process validation cost
→ Quality planning cost
→ Design & dev. of quality measurement & control equipment cost
→ Collecting quality cost
→ Operators support quality planning costs
→ Operator quality education costs.

* QA costs: (Q. Admin)

→ Program planning costs
→ Quality performance reporting cost
→ Quality education cost
→ Quality improvement cost
→ Documenting & Evaluating quality cost
→ Q. Audit cost
→ Admin salaries & expenses cost.



* Purchasing Appraisal Costs :

→ Incoming supplier's inspection & test cost

→ Testing & quality measurement equiptments cost

→ Source inspection & control program costs

* Operations Appraisal costs :

→ Inspection & test costs

→ Audit costs

→ Setup inspections & lab. support costs

* External Appraisal costs

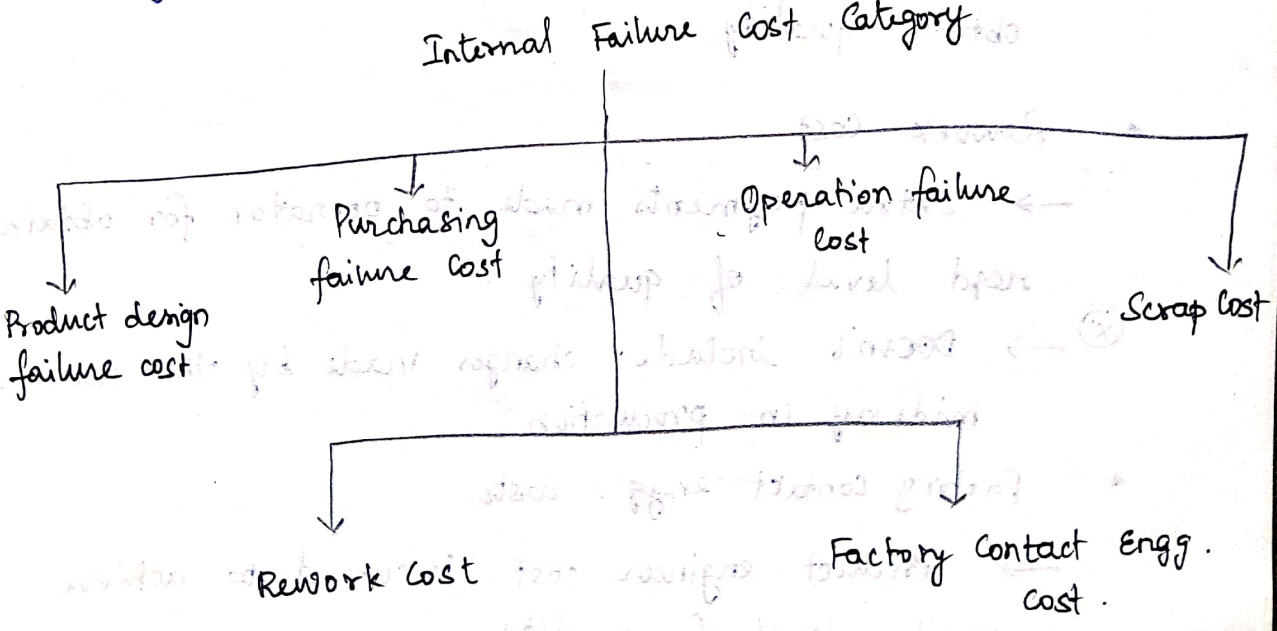
→ Field performance evaluations cost

→ Special product " "

→ Field stock & spare parts " "

Review of

All other sub categories don't have sub elements - They are directly incurred



Internal failure cost → Failure costs incurred with the org.

* Product Design failure cost :
  - → Design corrective action cost
  - → Rework due to design mistakes cost
  - → Product liasion cost

* Purchasing failure cost :
  - → Purchased Material replacement cost
  - → Supplier corrective action cost
  - → Rework of supplier rejects cost
  - → Uncontrolled material loss

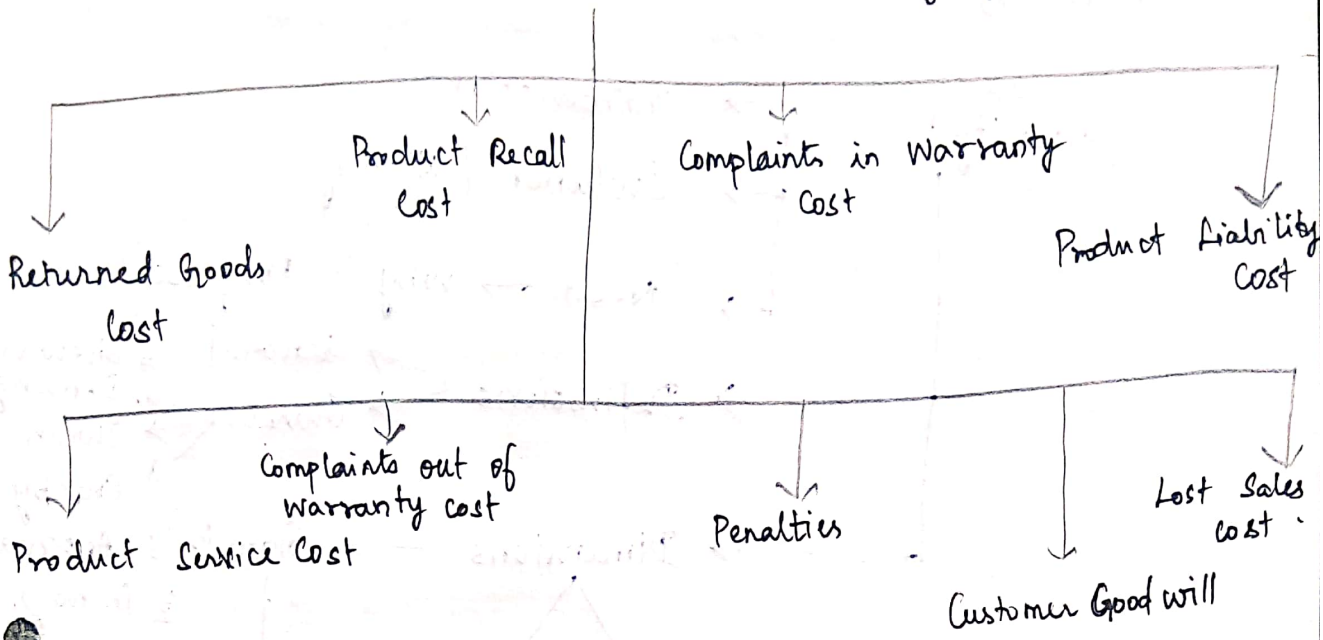
* Operation failure cost :
  - → Non conforming product production cost
  - → Operator mistakes cost.

* Scrap Cost :
  - → Material loss incurred during opetations to obtain quality.

* Rework Cost
  - → Extra payments made to operator for obtaining reqd. level of quality.
  - → Doesn't include changes made by the customer midway in production.

* Factory contact engg. costs
  - → Product engineer cost incurred to achieve reqd. level of quality
    Eg: Feasibility of product design.

External Failure cost Category :



External failure cost Category :→ Cost incurred by org. after product delivery to customer.

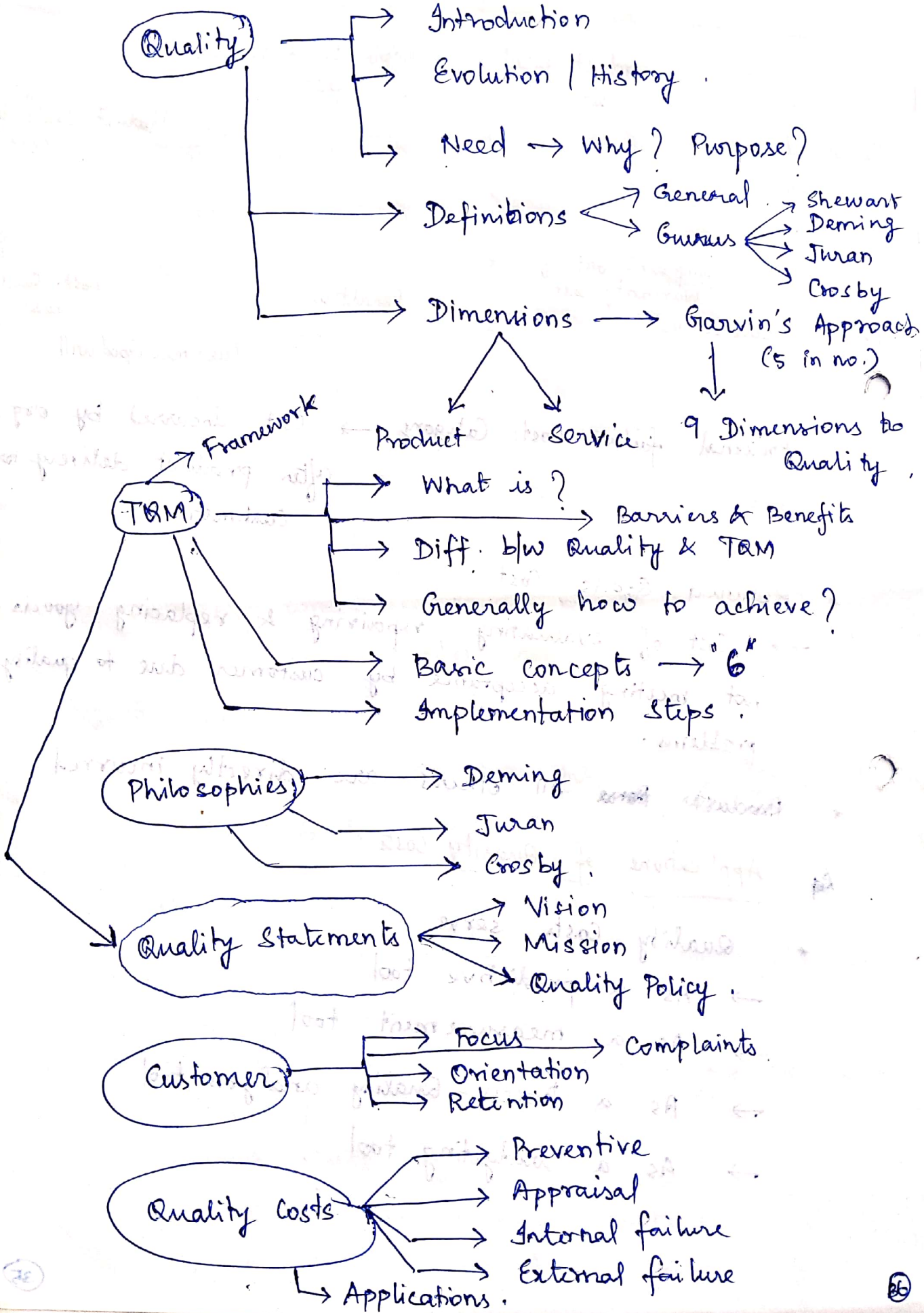
* Returned Goods Cost :
  → Cost of evaluating, repairing & replacing goods not meeting acceptance by customer due to quality problems.

* All others are directly incurred.

Applications of Quality Costs :

* Quality Costs serve
  → As a predictive tool
  → As a measurement tool
  → As a Process - Quality analysis tool
  → As a budgeting tool

Quick Recap of Unit 1 : (Mind Mapping)



COURSE PLAN

UNIT - II - TQM PRINCIPLES

TOPICS	NO. OF HOURS
Leadership - characteristics, strategy planning, quality councils and its duties	3
Employee Involvement - Motivation, Empowerment	1
Team & Teamwork - Types, Characteristics, roles, stages of team development, common problems, common barriers	3
R & R, Performance Appraisal	1
CPI - PDCA Cycle	1
kaizen, 5S	1
Supplier Partnering - Ten principles of customer - supplier relation, Partnering	1
Supplier Selection, Rating	1
TOTAL	12

UNIT- II - TQM PRINCIPLES

Leadership:

* Who is a Leader? - Is the one
  - → who instills purposes
  - → NOT one who controls by brutal force.
  - → who strengthens & inspires the followers to accomplish shared goals.
  - → Leader _____ the organisation's values
    - shapes
    - promotes
    - protects
    - exemplify

Leaders ⟷ (Mutually Motivates & Encourages to higher levels.) Followers

Characteristics of leaders:

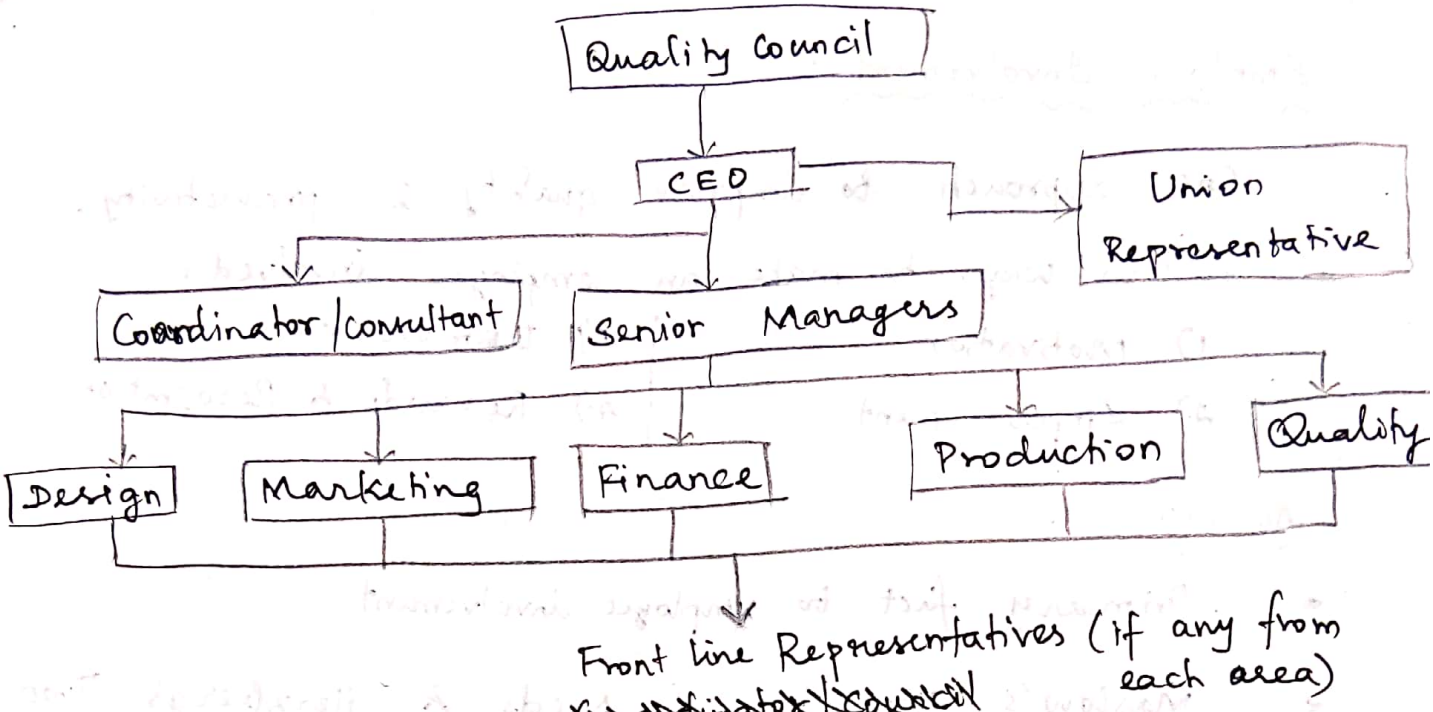
* Priority Attention to customers
* Empower rather than control subordinates
* Emphasize prevention rather than maintenance.
* Emphasize improvement
* Encourage collaboration than competition
* Train & coach rather than direct & supervise.
* Learns from problems.
* Continually try to improve communications b/w subordinates
* Continually demonstrate their committment to quality
* Choose suppliers on the basis of quality not price
* Establish org. systems to support quality effort.
* Encourage & recognise team effort.

Strategic Planning :

* Goals & Objectives are the strategy to be followed
  - Goals → Long term planning
  - Objectives → short term planning
* Seven steps to strategic Planning
  1.) Customer Needs → Discover future needs
  2.) Customer Positioning → Determine where the org. wants to be in relation to customers
  3.) Predict the Future → Predict future conditions of product or services by Demographic, forecast of economy, technical assessments
  4.) Gap Analysis → Identify the gap b/w the current state & future state.
  5.) Closing the Gap → Establish goals & responsibilities to close the gap.
  6.) Alignment → Align. the plan with mission, vision, core values and concepts of org.
  7.) Implementation → Allocate resources to collect data, designing changes & overcoming resistance to change. Finally implement

Quality Council :

* To build quality into culture, a quality council is established to provide overall direction
* Driver of TQM engine.



Duties of Quality Council:

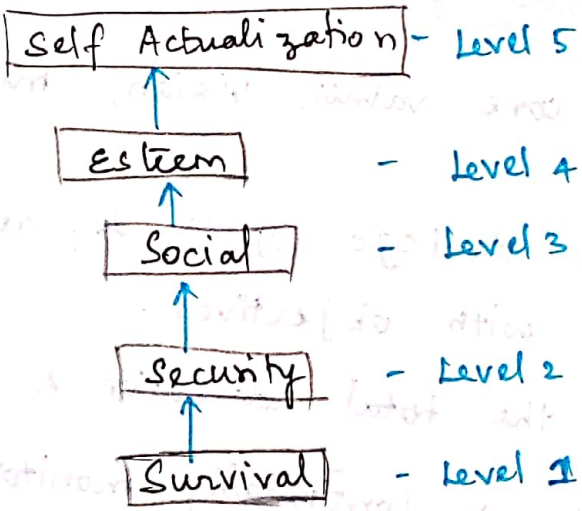
* Develop core values, vision, mission & quality policy statement
* Develop strategic goals & annual quality improvement program with objectives.
* Create the total education & training plan
* Determine & Continually monitor cost of poor quality
* Determine performance measures for the organisation, approve those for functional areas and monitor them
* Continually determine those projects that need improvement, especially in terms of external & internal cust. satisfaction
* Establish multifunctional project & departmental teams and monitor their progress
* Establish the reward & recog. system to account for the new way of business.

Employee Involvement :

* One approach to improve quality & productivity.
* Various ways to make an employee involved :
  1.) Motivation
  2.) Empowerment
  3.) Teamwork
  4.) Rewards & Recognition

Motivation :

* Primary fact to employee involvement.
* Maslow's Hierarchy of Needs & Herzberg's Two factor theory are the ways to motivate.



Maslow's Hierarchy of Needs

* Herzberg's 2 Factor Theory :

Two Factors

- Motivators → compared to Maslow's Lower levels
  Eg: Recognition, Responsibility, Achievement, Advancement, Work itself
  ↓
  Intrinsic in nature

- Dissatisfiers (or) Hygiene factors ← compared to Maslow's higher levels
  Eg: Low salary, minimal fringe benefits, poor working conditions, ill-defined org. policies, mediocre technical supervision
  ↓
  Extrinsic in nature.

How to achieve Motivated Force?

1.) Know thyself
2.) Know your employees
3.) Establish a positive attitude
4.) Share the goals
5.) Monitor progress
6.) Develop interesting work
7.) Communicate effectively
8.) Celebrate success

Empowerment:

* It is an environment where people have the ability, the confidence, the ~~commitment~~ to take responsibility & ownership to improve the process & initiate the necessary steps to satisfy customer requirements well within well-defined boundaries in order to achieve org. values & goals.

* 3 conditions to achieve empowerment:
  1.) Everyone must understand the need for change
  2.) The system needs to change to the new paradigm
  3.) The org. must enable its employees

Team & Teamwork:

* TEAM → A group of members working together towards a common set of objectives (or) goals.

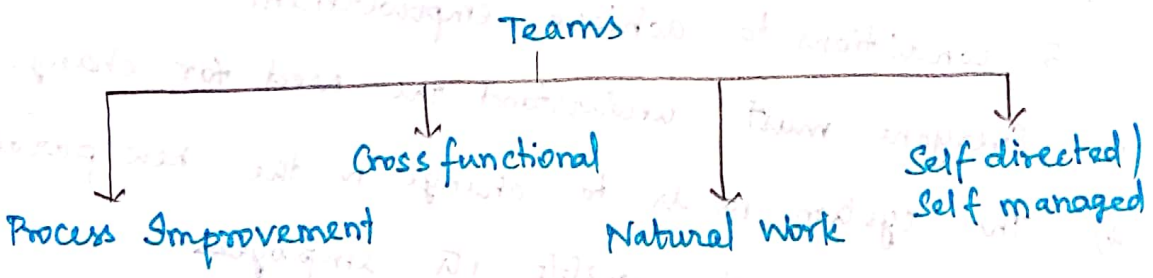
"TOGETHER EVERYONE ACHIEVES MORE"

* TEAM-WORK - Cumulative actions of the team during which each and every member of the team subordinates his individual interests and opinions to fullfill the objectives (or) goals of the group.

Why Team ?

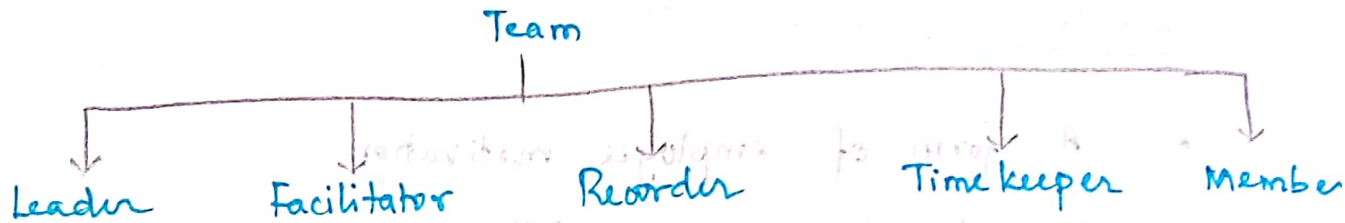
* Each members has special abilities to solve a problem
* Processes are so complex that one person cannot be completing
* Interactions among team members improves efficiency of work.
* Improves communication thereby multiple solutions for the same problem can be achieved.

Types of Teams:



Characteristics of successfull teams:

1.) Sponsor
2.) Team Charter
3.) Team Composition
4.) Training
5.) Ground rules
6.) Clear Objectives
7.) Accountability
8.) Well-defined decision procedures
9.) Resources
10.) Trust
11.) Effective Problem solving
12.) Open Communication
13.) Appropriate Leadership
14.) Balanced Participation
15.) Coherveness



Roles of a Team

Stages of Team Development :

1.) Forming
2.) Storming
3) Norming
4) Performing
5.) Adjourning

Ten Common Problems & Solutions of a Team :

1.) Floundering
2.) Overbearing participants
3.) Dominating participants
4) Reluctant participants
5.) Unquestioned acceptances of opinions as facts
6.) Rush to accomplish
7.) Attribution
8) Discounts & plops
9.) Wanderlust
10.) Feuding team members

Common Barriers to Team's Progress :

1.) Insufficient training
2.) Incompatible rewards & compensation
3.) First line supervisor resistance
4) Lack of planning
5.) Lack of management support
6.) Access to information systems
7.) Lack of union support
8.) Project scope too large
9.) No significant project objectives.
10.) No clear measures of success
11) Team is too large
12.) Trapped in groupthink

R & R :

* A form of employee motivation
* To acknowledge tve contributions of an individual
* Types :
  1.) Individual R&R
  2.) Group R & R
  3.) Cash R & Gainsharing
* An effective R & R system

→ Serves as a continual reminder that org. regard quality & productivity as important

→ offers e.g. a visible technique to thank achievers & motivate them

→ Boosts morale in the work environment causing healthy sense of competition.

Performance Appraisal :

* To let employees know how they work
* Set a basis for promotion, salary increment
* Counsel employees for their future.
* Good relation b/w Employee & Appraiser is Imp.

App. Formats:

1.) Ranking
2.) Narrative
3.) Graphic
4.) Forced Choice

* Improvement ways for PA :

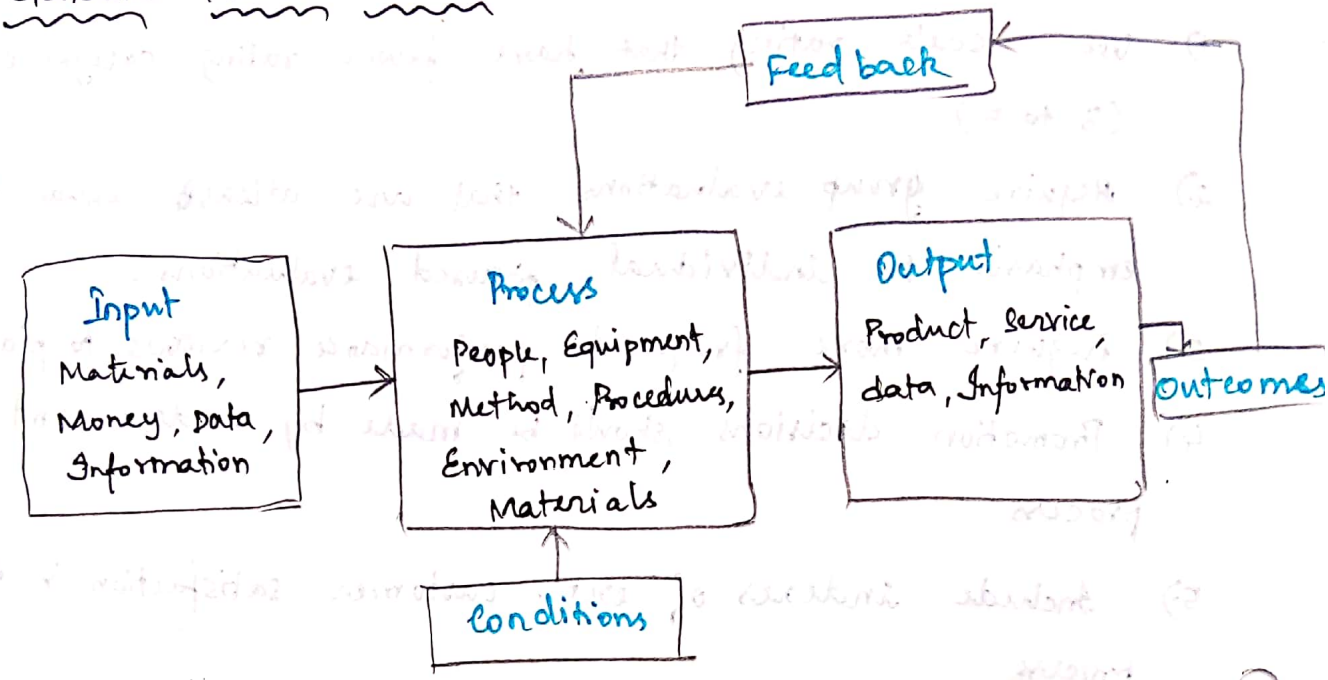
1) Use scale rating that have fewer rating categories (3 to 5)
2) Require group evaluations that are atleast equal in emphasis to individual focused evaluations.
3) Require more frequent performance reviews to plan future
4) Promotion decisions should be made by independant admin process
5) Include indexes of ext. customer satisfaction in the App process.
6) Use peer & subordinate feedback as an internal cust. satisfaction
7) Include evaluation for process improvement in addition to results.

Continuous Process Improvement :

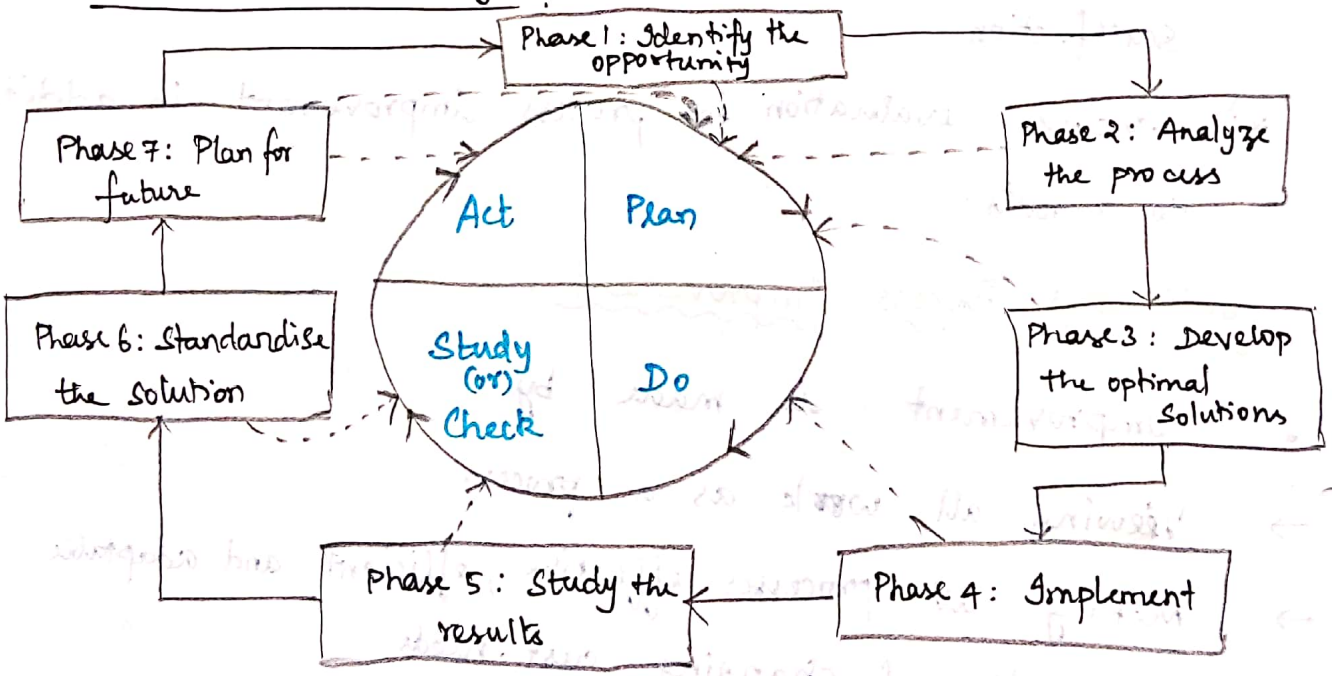
* Improvement is made by

→ Viewing all work as a process
→ Making all processes effective, efficient and adaptable
→ Anticipation of changing cust. needs
→ Controlling in-process performance
→ Eliminate waste & rework
→ Investigate activities that don't add value to product
→ Eliminate nonconformities
→ Benchmarking
→ Innovating to achieve breakthroughs
→ [illegible] future activities

Generic Process Model :



PDSA (or) PDCA Cycle :



Continuous Process Improvement Cycle using PDSA (or) PDCA Cycle.

→ Phase 1 : Identify the opportunity :

* Identified using tools like

- Pareto Analysis
- Proposals from key insiders, suggestion schemes
- Field Study of cust. needs
- Performance data of competitors
- Comments / Feedback from external customers
- Cust. & Employee surveys
- Brainstorming

* Create problem statements which should specify
  - Authority
  - Objective
  - Composition
  - Direction & Control
  - General.

→ Phase 2 : Analyse the current process :

* Establish performance Measures
* Determine data needed to manage processes
* Establish regular feedback with cust. & suppliers.
* Establish measures for quality / cost / timelines of inputs & outputs
* Ask questions like What, Why, How, Who to analyze current process.

→ Phase 3 : Develop optimal solutions :

* Brainstorming used to identify possible solutions
* Creativity → Create New
  → Combine 2 diff. processes
  → Modify existing

→ Phase 4 : Implement changes :

* Plan & then implement the optimal solution identified.

→ other phases are directly explained with the name

Kaizen :

* It's a Japanese word for philosophy.
* It means → Management's role in continuously encouraging and implementing small improvements involving everyone.
* Process of continuous improvements in small increments that make the process more - efficient, effective, under control & adaptability.
* Focuses on

Complex Process
Breakdown | Simplification
↓
Simple processes
↓
Improve

* Focuses on the use of :

1) Value added & non-value added work activities
2) Muda - Seven classes of waste
   a) Overproduction
   b) Delay
   c) Transportation
   d) Processing
   e) Inventory
   f) Wasted motion
   g) Defective parts

3) Principles of motion study and use of cell technology

4) " " materials handling and use of one-piece flow.

5) Documentation of SOP.

6) Five S's of workplaces & organization

→ 5 words from Japanese.

- Seiko — Proper Arrangement
- Seiton — Orderliness
- Personal cleanliness — Seiketso
- Seiso → cleanup
- Shitsuke → Discipline.

7) Visual mgnt. by means of visual displays that everyone in the plant uses for better communication.

8) JIT principles to be followed

- Right Quantity
- Riaght @ Time
- Riaght Resources

9) Poka-yoke — Prevent or detect errors

10) Team dynamics

- Problem Solving
- Communication skills
- Conflict resolution

Supplier Partnership:

* Supplier quality can affect overall cost of quality
* By means of partnering, can attain the same level of quality in the supplier environment as in our org.
* Supplier Partnership had a round of change
  - → When Deming insisted that the suppliers should not be chosen due to low bidding
  - → Introduction of JIT.
  - → Continuous process improvement
  - → Adversely changed the Customer-Supplier relationship and turned into a mutually beneficial partnership.
* Thus joint efforts
  - → Improve quality
  - → Reduce costs
  - → Increase market share for both parties.

Ten Principles of Customer-Supplier Relation:

* Dr. Kaoru Ishikawa introduced 10 principles to ensure quality products/services and eliminate unsatisfied conditio b/w customer & supplier.

1) Both are fully responsible for the control of quality
2) Both should be independent & respect each other's independence.

3.) Cust. should provide clear & sufficient requirements to supplier, so that supp. knows what to do precisely

4.) Both should have a nonadversarial contract with respect to quality, quantity, price, delivery methods & terms of payment.

5) Supp. is responsible for providing quality that will satisfy the cust. & submitting necessary data upon customer's request.

6.) Both should decide method of quality evaluation to honour both parties satisfaction.

7.) Both should mention methods of resolving amicable conflicts if any arises b/w the two in the contract

8.) Both should continually exchange information

9.) Both should perform business activities like procurement, production, inventory planning, clerical work, systems to maintain satisfied relationship

10.) When dealing with business transactions, both should always have the best interest of the end user in mind.

Partnering:

* A long term committment b/w two or more org. for the purpose of achieving specific business goals & objectives by maximizing each participant's resources.

* 3 key elements of partnering are:
  1) Long term commitment
  2) Trust
  3) Shared vision.

Supplier Selection:

* Before going into selection, an effort is to be made to decide if an item can be produced inhouse or to be purchased. This strategic decision is made on the answers to following questions:
  - → How critical is the item to the design of product/service?
  - → Does org. has tech. knowledge to produce items internally? If not, should that knowledge be developed?
  - → Are there suppliers who are specialised in producing the item? If not, if the org is willing to develop one such specialized supplier?
  - → Answer these q's in terms of cost, delivery, quality, safety & acquisition of technical knowledge.
* If the decision is to outsource, then SUPPLIER SELECTION comes into the picture. Have the following 10 pts. as the evaluation & selection criteria.

1) Supp. should understand and appreciate the management philosophy of the org.

2) Supp. should have stable management system.

3) Supp. maintains high technical standards and has the capability of dealing with future techno. innovation

4) Supp. should meet quality specifications.

5) Supp. has the capability to produce the amount of production needed based on demand.

6) Supp. shouldn't breach corporate secrets

7) Price is right & delivery dates are met.

8) Supp. should sincerely implement contract provisions

9) Supp. should have an effective quality program such as ISO 9000 (or) ISO/TS - 16949.

10) Supp. has a track record of cust. satisfaction & org. credibility.

Supplier Rating:

* Rating Criteria

→ Obtain an overall rating of Supp. performance.

→ Ensure complete communication of Supp. " in the areas of quality, service, delivery & any other measure the cust. desires.

→ Provide Supp. a detailed & factual report of problems for corrective action.

→ Enhance the relationship b/w cust. & supplier.

* 3 key factors of successful supp. rating system are:

1.) An internal structure to implement & sustain rating pgm.

2.) A regular & formal review process

3.) A standard measurement system for all the suppliers.

A sample Supplier Rating Score Card:

Item Name : Engine Assembly

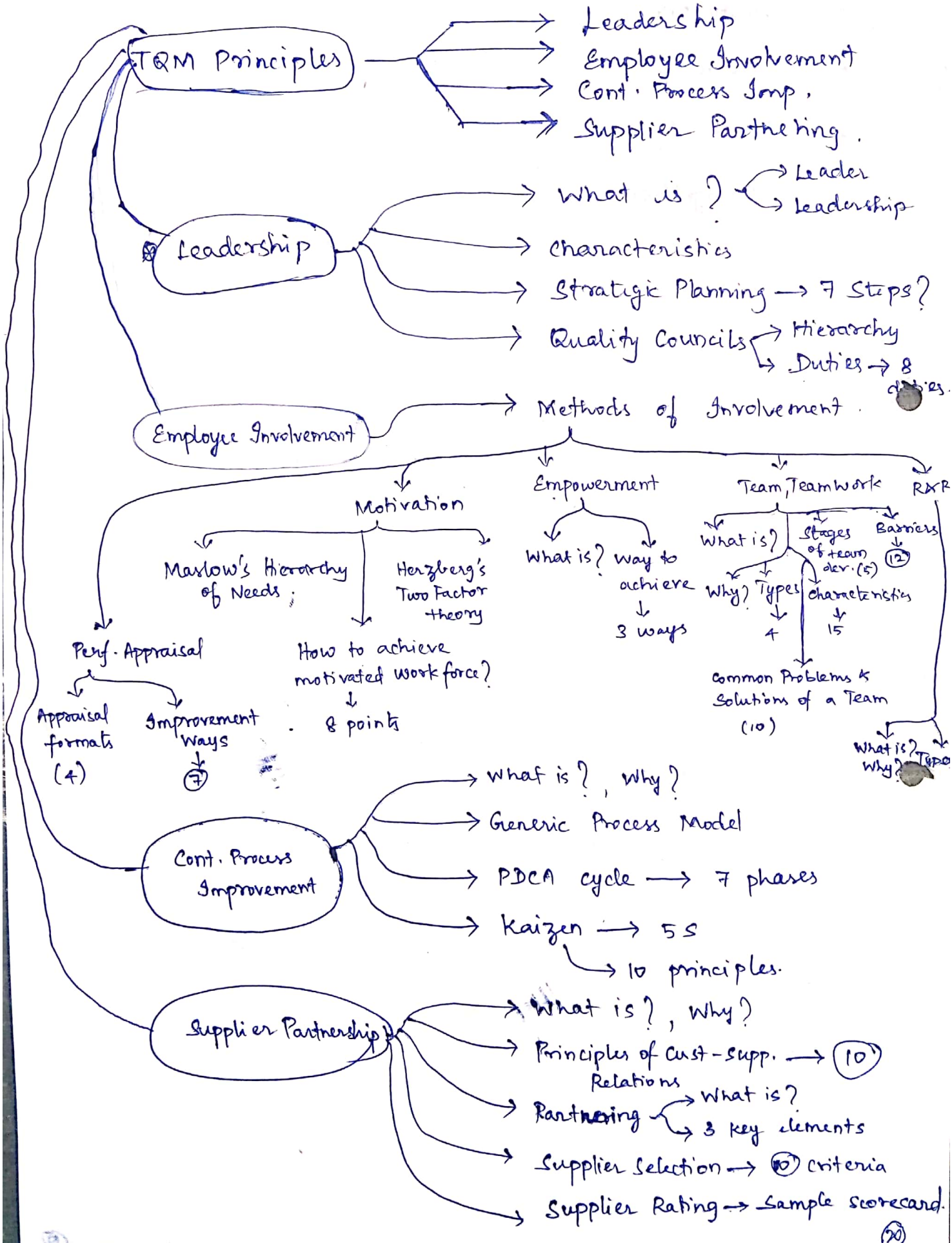
Period 3Q16		Supplier A	Supplier B	Supplier C
Quality Performance Parameters	Maximum Points	Actual points	Actual points	Actual points
Line Returns	30	27.66	29.61	28.11
PPM Deduction (Max - 10)		-10	-10	-10
Certified yield Multiplier		0.9	0.94	0.87
Penalty: Field Issues (Max -15)				
Stop Shipment (Max-15)				
Line Purge (-5 each time)				
Subtotal (0-30)	30	15.984	18.433	15.756
Process Control	8	6.5	6.5	5.5
Process Technology	6	5.2	4	5.2
Sustaining technical support	6	2.3	1.6	3.5
On time delivery	20	20	18	19
Product technology	10	9.7	6.7	9.1
Lead time	15	13	13	13
Purchasing & Material Support	5	5	3	2
Performance Matrix (P.M) Total (100)	100	77.594	71.233	73.056
Price Index (P.I) = Target P. / Act. Price	1	0.878	0.947	1
Score = P.M × P.I	100	68.127	67.457	73.056
Total cost of supply = $\left(\frac{(100-\text{Score})}{100}\right)+1$	1	1.3187	1.3254	1.2694

1 → Perfect

How to develop supplier relationship:

- Inspection
- Training
- Team Approach
- Recognition.

Quick Recap of Unit 2 : (Mind Mapping)



UNIT - 3 - TQM Tools & Techniques - 1

* Seven Traditional Tools of Quality:

* Problem solving tools
* Also called Q-7 tools
* Japanese Quality Guru - Ishikawa proposed Q-7.
* List of tools are:

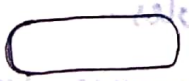
Statistical Tools	Purpose
1.) Flow Chart	Depicts the essential steps of a process by using standard symbols
2.) Check sheet	Systematic Data gathering by tabulating the frequency of occurrence
3.) Histogram	Graphical display of the frequency distribution of the numerical data.
4.) Pareto Diagram	for identifying the vital few causes that account for a dominant share of quality loss.
5.) Cause & Effect diagram.	Identifying and analysing the potential causes of a given problem.
6.) Scatter diagram	Helps in depicting the relationship b/w two variables.
7.) Control Chart	Identifying process variations and signalling corrective action to be taken.

* Relationship b/w 7 QC tools & PDCA cycle :

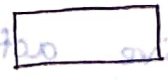
Q-7	P	D	C	A
Flow chart	✓	✓	✓	✓
Checksheet		✓	✓	
Histogram	✓	✓	✓	
Pareto diagram		✓	✓	✓
Cause & Effects diagram		✓	✓	✓
Scatter diagram		✓	✓	
Control Chart		✓	✓	

1) Flow Chart :

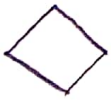
* Also called process flow chart/diagram, flow diagram (or) process deployment flow.
* It is a diagrammatic representation of the various steps in a sequential order that form an overall process in an organisation.
* Used to analyze the connection & sequence of events in a process
* Symbols used :



→ Terminator — Start (or) Stop



→ Action (Rectangle) — Activity (or) task



→ Decision (Diamond) - Decision Making

→ Arrows - Dir. of flow

→ Link (connector) - Link b/w one pg. to another.

2.) Check Sheet (Data Collection Sheet):

* Also known as tally sheet
* It is a form of systematic data gathering and registering to get a clear view of the facts.
* To keep track of how often something occurs.
(or) know the frequency of occurrences.
* How to use it?

I	II	III	IIII	𝍸
1	2	3	4	5

* Types:
1.) Process distribution - process variability
2.) Defective Item - variety of defects + freq
3.) Defect location - where does defect occur?
4.) Defect factor - monitor the input parameters that may cause defect.

* Eg: Check sheet of customer complaint on a day.

Problems	Tally	Frequency
Delivery	IIII	4
Packaging	𝍸 𝍸 II	12
Quality / Performance	𝍸	5
Personnel	II	2
Invoice	III	3
Customer Support	𝍸 II	7

3.) Histogram:

* It is a bar chart / diagram showing a distribution of a variable's quantities or characteristics.
* Otherwise, graphical display of freq. distribution.
* Displayed as rectangles of equal width, but varying heights.

* Used for determing max. results / quickly visualise the features of a complete set of data.

* Construction method:

(1.) Collect data → (2) Det. Range = Highest Value − Lowest Value

(3.) Divide the values into classes & count the number of values in each class. (4.) Det. width of class = (Range / No. of classes selected)

(5.) Draw freq. table for all values (6) Construct histogram by marking class limits ↔ & frequency ↕ (7.) Write title & no. of values on the diagram.

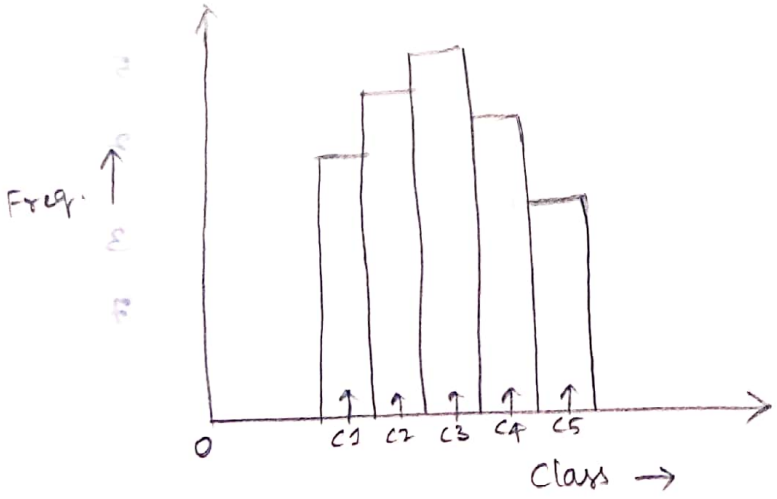
* Types of Histograms:

1.) Bell shaped
2.) Double Peak
3.) Plateau
4.) Comb
5.) Isolated Peak
6.) Edged Peak
7.) Skewed
8.) Truncated.

* Guidelines to form class:

No. of Values	No. of classes
< 50	5 − 7
50 − 100	6 − 10
100 − 250	7 − 12
> 250	10 − 20

* Use Tally to construct Frequency table (Pt. # 5)



4) Pareto Diagram:

* Diagnostic tool commonly used for seperating the vital few causes that account for a dominant share of quality loss

* Designed by Alfredo Pareto → Italian economist
* Simply → Tool to single out "vital few" from "trivial many"
* Based on Pareto's principle → states that a few of the defects accounts for most of the effects.
* Pareto Analysis is also called 80/20 rule (or) ABC analysis.
* Method of classifying items according to their relative importance
* Used to prioritise problems. Also can be used as a Risk Assessment technique from activity level to system level.
* Procedure :

1.) Obtain data using check sheet (or) Brainstorming
2.) Arrange data in descending order ↓
3.) Calculate the total & % total that each category represents
4.) Compute cumulative %.
5.) Draw a histogram with two ↕ (vertical) axis
Left vertical axis → Mark from '0', measured value of each cause
Right vertical axis → % → 0% to 100%, Same ht. as Left.
↓
cumulative

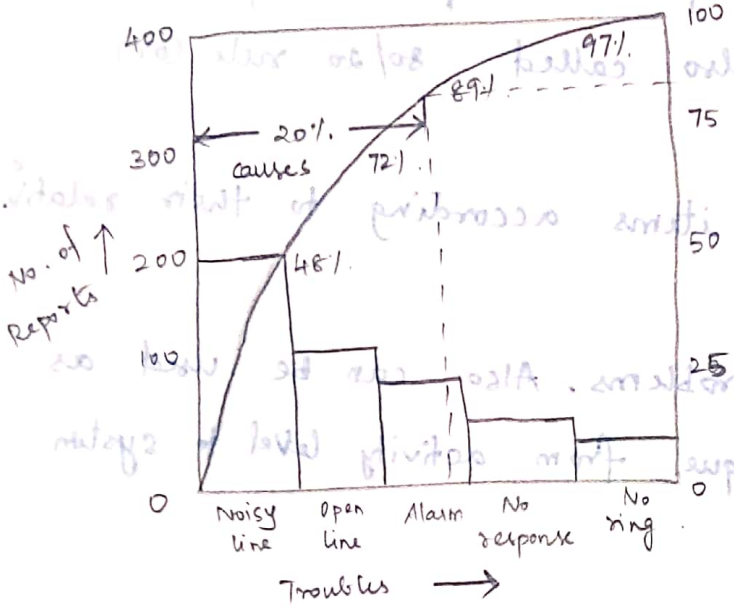
Horizontal axis → Diff. kinds of causes.
L to R → Descending order of freq. (or) costs.

6.) Draw a bar above each item whose ht. represents no. for that cause.
7.) Plot a cumulative % line
8.) Draw a horizontal line from a right V. axis to the left till it coincides with cumulative %. line.

9.) Draw a vertical line from pt. of intersection down to meet H.axis

10.) Left of intersection pt are the 20%. causes (most essential bottlenecks) causing 80% of damages/effects.

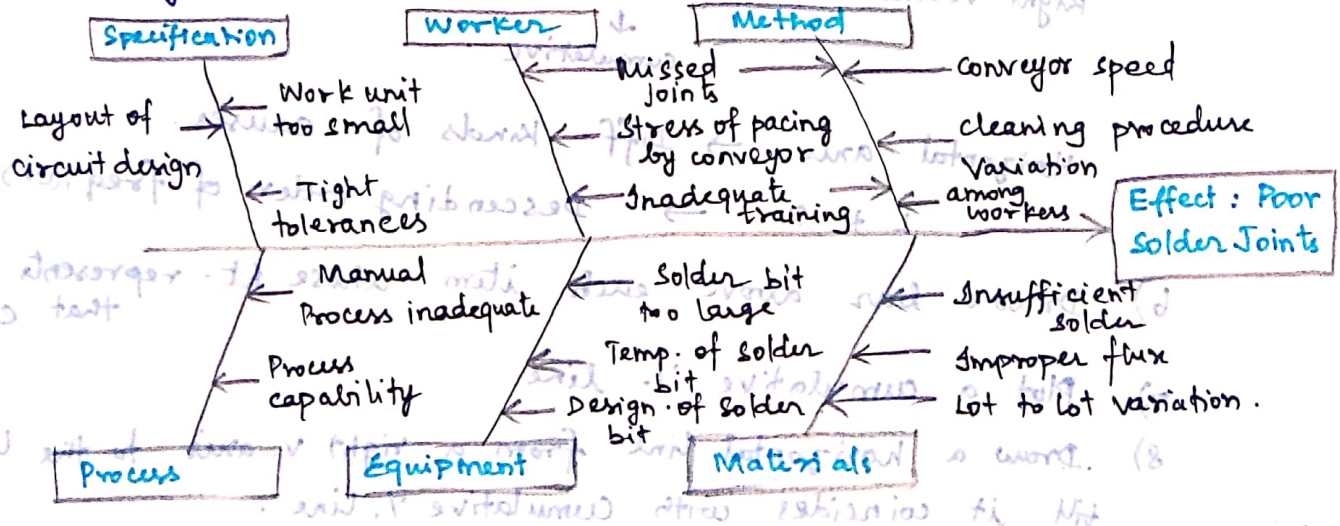
* Eg: Pump Maintanence Pareto dia:



Pareto Diagram

5.) Cause and Effects Diagram :

* Graphical - tabular chart to list and analyse the potential causes of a given problem.
* Fish-bone dia, Ishikawa diagram. → Developed it.
* Untimited applications.
* Eg: C & E Dia. of a manual soldering operation.



Fish-Bone diagram

6.) Scatter Diagram :

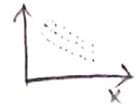
* Simple graphical method to depict the relationship b/w two variables.

→ Independant variable | ↑ dependant variable.

* Represents paired data as cloud points

* Types.

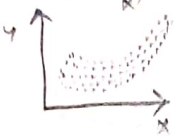
1.) Positive correlation 

2.) Negative correlation 

3.) No correlation 

4.) Negative correlation may exist 

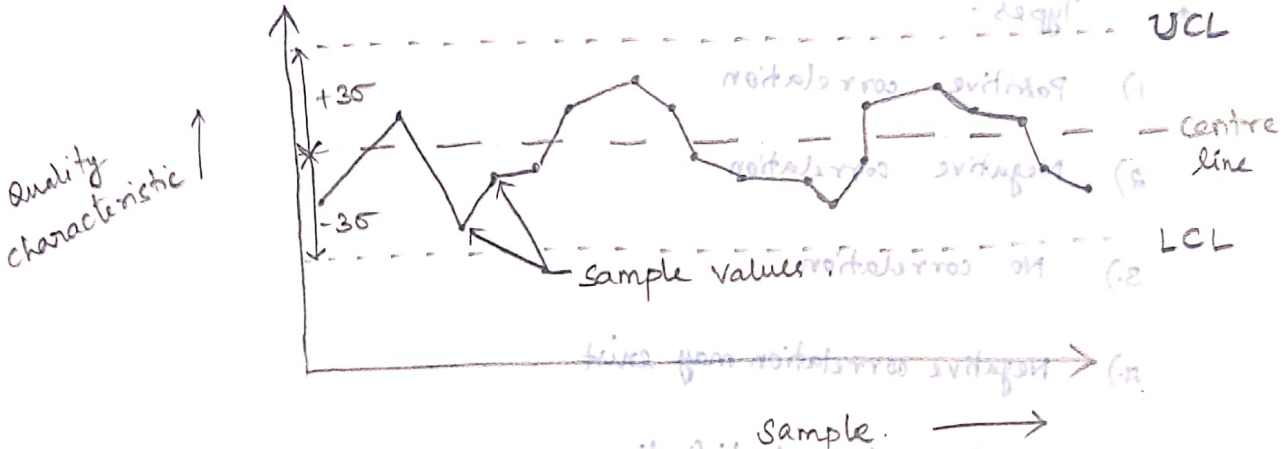
5.) Correlation by stratification 

6.) Curvilinear Relationship 

7.) Control Chart :

* Designed / Invention by Walter. A. Schewart. (X) DYNAMIC
* Most widely used tool in SPC.
* It is a graph that displays data taken over the time and the variations of this data.
* To check whether process is in control (or) not
* Histogram Vs control chart
  ↓ static pic of process variability
  ↳ dynamic pic of the process.
* Chart has 3 lines
  1.) LCL → Lowercontrol limit } -3σ
  2.) Centre line
  3.) UCL → Upper control limit } +3σ

* If the sample drawn falls b/w UCL & LCL, then process is in control; else out of control
* UCL & LCL are generally set as ±3 SD
* Types:
  1.) For variables → Eg: Time, Length, Temp, Pr, Vol., etc.,.
  2.) For characteristics → Eg: No. of defects, typing errors in a report, etc.,



Control Chart

* New 7 Management tools:
  * 7 traditional QC tools are used for Quantitative problems.

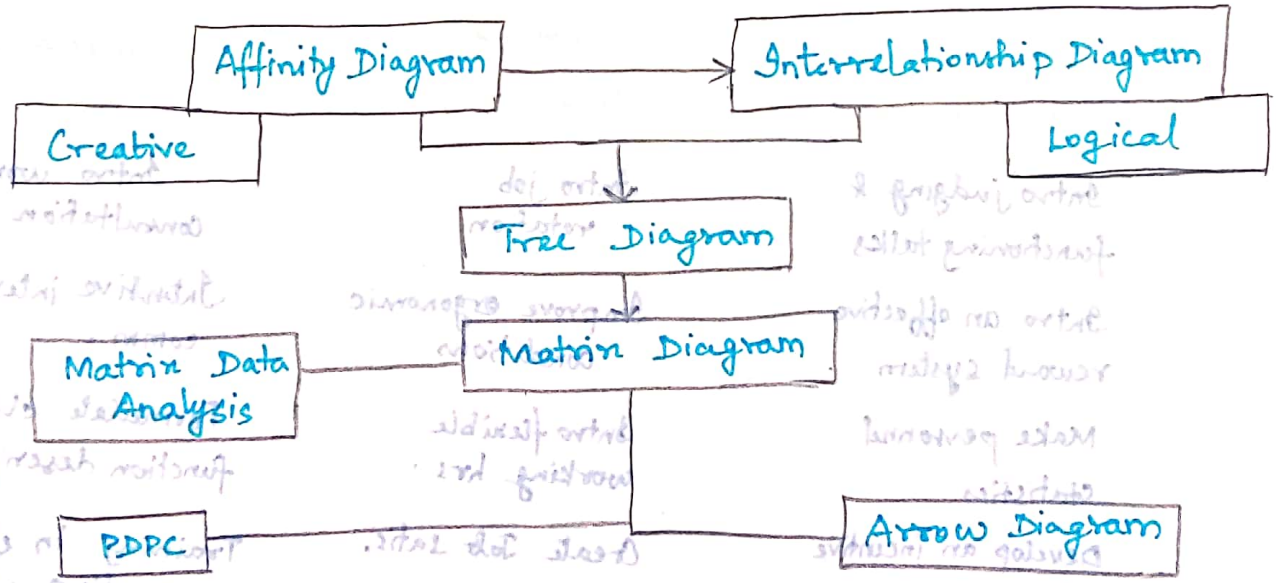
  (whereas)

  7 management QC tools are used for Qualitative problems.
  * Otherwise called "7 Mgmt. & planning tools".
  * Helpful for managers
    i.) To organise large data of non-quantitative type
    ii.) To create hypotheses.
    iii.) To clarify inter-relationships
    iv.) To establish priorities.

* New 7 QM tools are :

Management tool	Purpose
1.) Affinity Diagram (KJ dia.)	To synthesize, classify, organize indefinite ideas.
2.) Relationship Diagram	To isolate Cause & Effect relationships
3.) Tree Diagram	To deploy general concepts into details
4.) Matrix Diagram	To correlate in a logical form, in order to evaluate, select & decide.
5.) Matrix Data Analysis	To quantify relationships.
6.) Decision tree (PDPC)	To identify alternatives
7.) Arrow diagram (PERT)	To plan tasks, activities, etc.,.

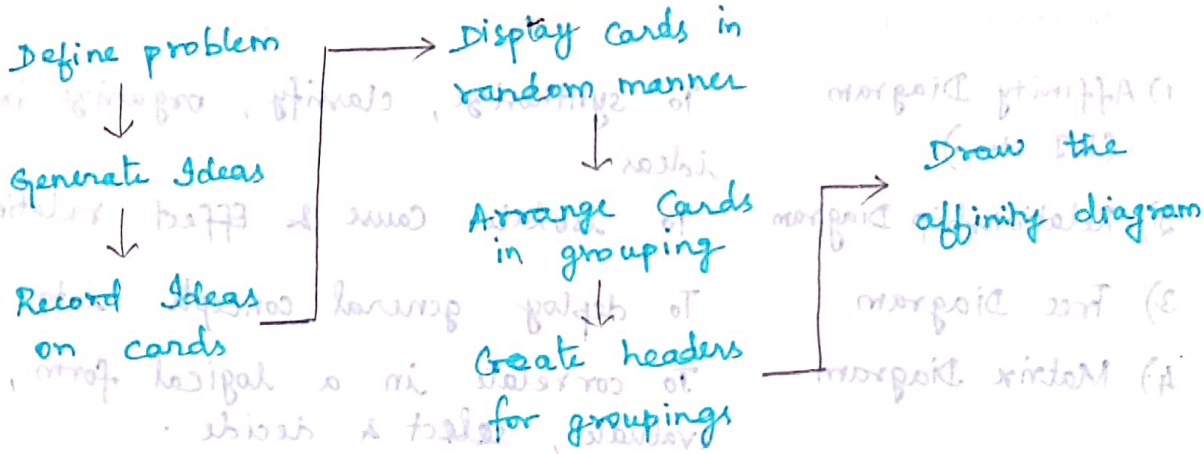
Interrelationship b/w New QT tools :



1.) Affinity Diagram :

* Tool to collect a large amount of verbal expressions like ideas, opinions, etc., and organize them in groups according to natural relationships b/w individual items.
* Also called KJ diagram. → Inventor - Jiro Kawakita
* AD → Brainstorming tool.

Construction of AD :



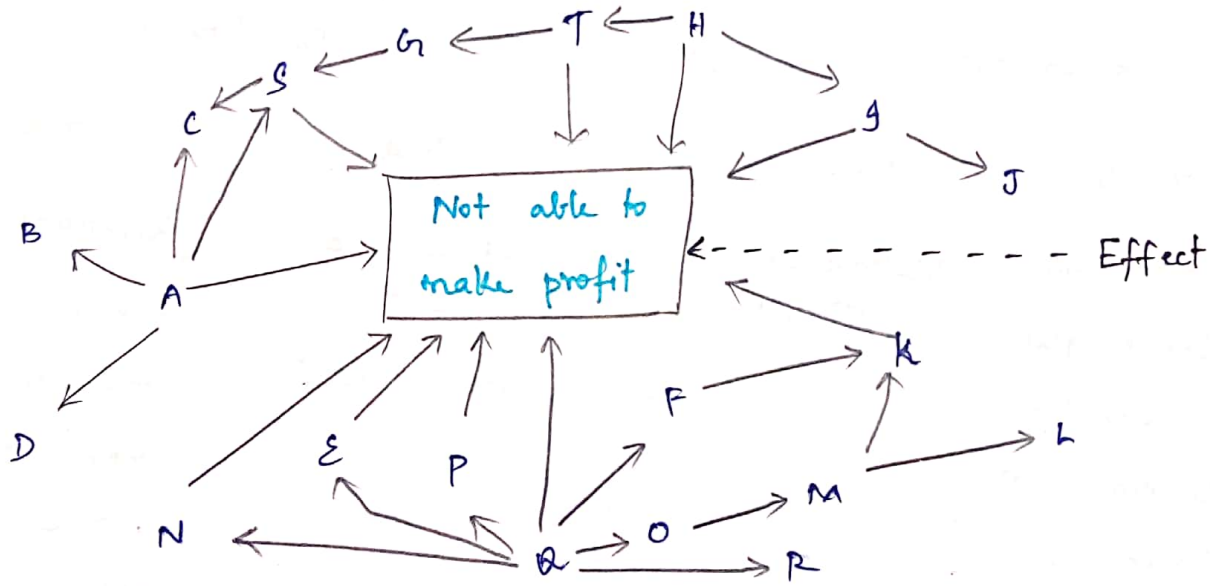
Eg: Motivating & improving labour productivity of employees:

How can a work climate be created within the organisation in which there are active participation from everyone, open communication & a high labour productivity?

Judging / Remuneration	Working Conditions	Communication.
Intro judging & functioning talks	Intro job rotation	Intro work consultation
Intro an effective reward system	Improve ergonomic conditions	Intuitive internal comm.
Make personnel statistics	Intro flexible working hrs.	Formulate clear function descriptions
Develop an incentive policy	Create Job satis.	Training in eff. meeting
Introduce a career plan	Job & function oriented training	Org. excursion & sport activities
Introduce a time clock	Purchase air-conditioners.	Build a common canteen
Handle Sanctions		Description of admin. processes.

2) Relationship Diagram :

* Tool to find causes of problems.
* Logic is same as Cause & Effect diagram.
* Not only clarifies the relationship b/w causes & effects but also b/w various causes.
* Tool to
  - → find key problem causes.
  - → det. root causes.
  - → Provides key factors to make a decision.



All alphabets are causes

* The one with much arrows contributing to effects are the Root Causes. In the fig. above → Q & A are RCs.

3) Tree diagram :

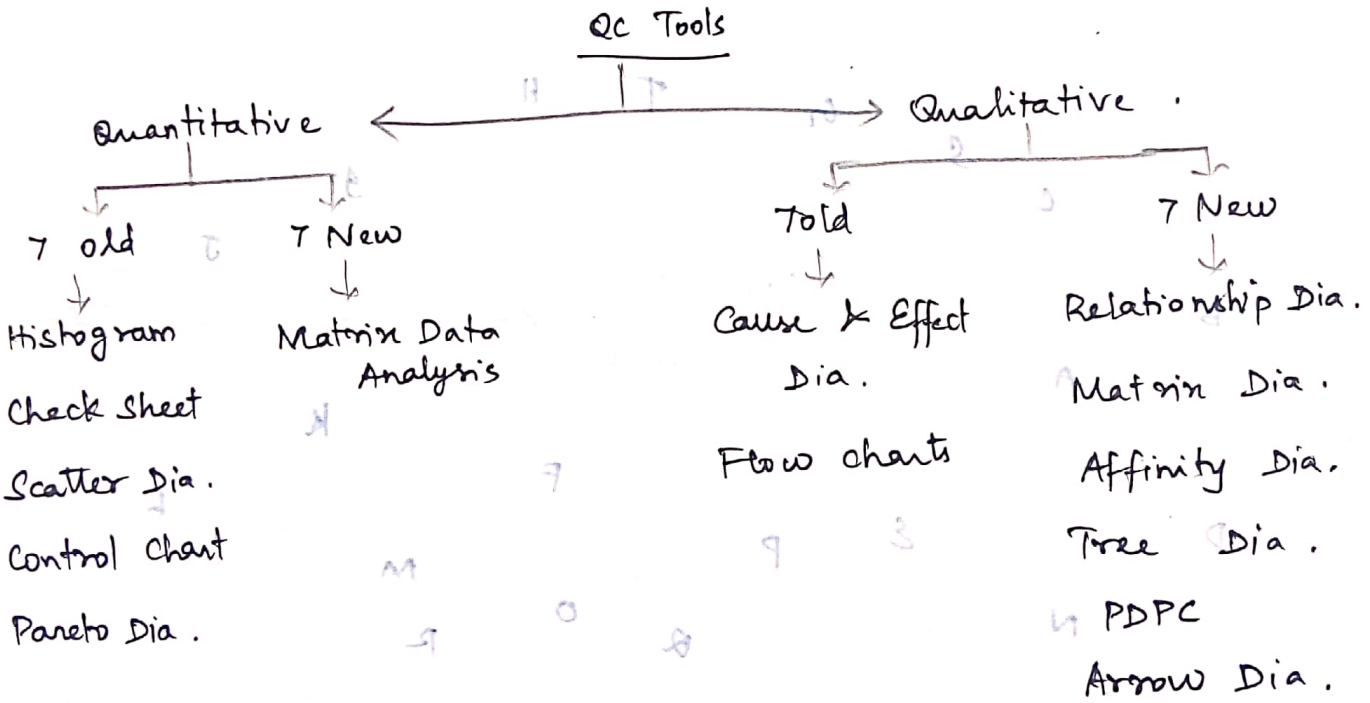
* Systematically breaks down a topic into component elements and shows the logical & sequential links b/w elements.

* Tool to know the ways & means to achieve the objective.

Construction:

State the problem
↓
Brainstorm causes
↓
Identify & List 1°, 2° & 3° causes
→ Arrange & rearrange the elements in proper order.

* Eg: Tree dia. for QC tools.



4) Matrix Diagram:

* Tool to systematically org. info. & compare a variety of characteristics in order to make a comparision, selection or choice
* Depicts relation b/w 2, 3 (or) 4 sets of factors in the form of table (or) Matrix.
* Quality Table. → starting pt. to build HoQ
↓
House of Quality.

* Types

→ L Shaped
→ T Shaped
→ Y shaped
→ X Shaped
→ C Shaped
→ Roof shaped.

S.No.	Type	No. of groups	Meaning.
1.	L	2	A ↔ B (or) A ↔ A
2.	T	3	B ↔ A ↔ C but not B ↔ C
3.	Y	3	A ↔ B ↔ C ↔ A
4.	C	3	3D form of representation.
5.	X	4	A ↔ B ↔ C ↔ D ↕ A but not A ↔ C (or) B ↔ D
6.	Roof-Shaped	1	A ↔ A also in A ↔ in L or T

* Eg:

Customer Req. (WHAT's)	Primary	Secondary	Technical Descriptors (HOW's)						
			Material selection			Manu. processes			
			Steel	Aluminium	Titanium	Welding	Die Casting	Sand Casting	Forging
	Aesthetics	Reasonable Cost	●	●	△	●	○	●	○
		Aerodynamic Look		△	△	△	●	○	●
		Nice Finish	○	●	●	△	●	△	○
		Corrosion Resistant	△	●	●	△	○	○	○
	Performance	Light weight	△	●	●				
		Strength	●	○	●	△	○	○	●
		Durable.	●	○	○	△	●	○	●

● → Strong
△ → Medium
○ → Weak

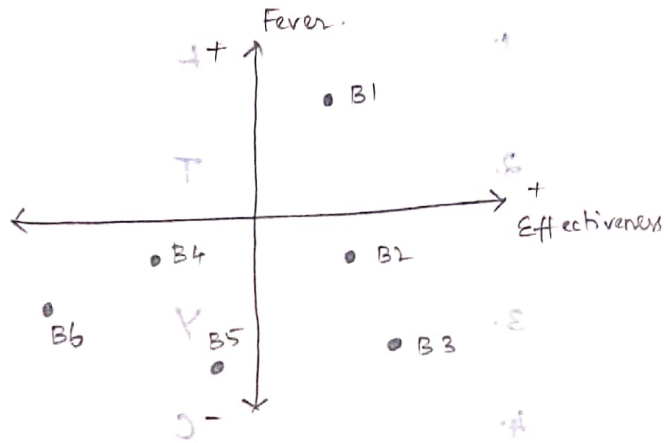
→ Relation b/w Cust. Req. & Tech. Desc.
WHATs Vs HOWs

5) Matrix Data Analysis Diagram:

* Same as Matrix Diagram. But only diff. is, instead of symbols as used in matrix diagram, we use numbers here. to indicate existence & relationship's strength.

Construction:

Decide 2 factors whose relations are to be analysed
↓
Check no. of individual items in the 2 factors.
↓
Prepare a matrix to accomodate all items of the 2 factors
↓
Enter Numerical data in the matrix
↓
Analyse the final results.

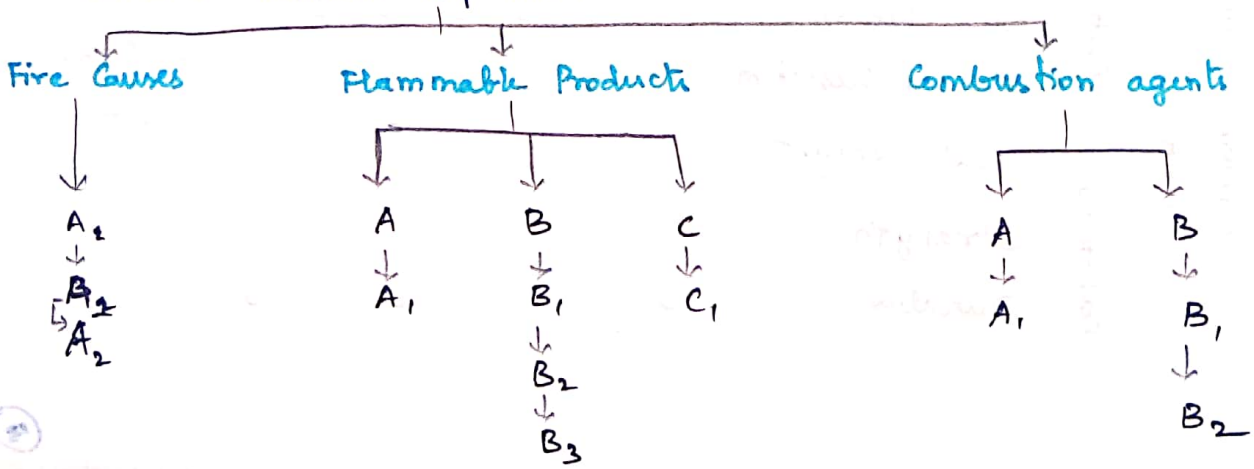


Eg: MDAC for fever control drugs.

6) Process Decision Programme Chart (PDPC) (or) Decision Tree:

* Planning tool to outline every conceivable and likely occurrence in any planning
* Forces proactive thinking on what can go wrong in one's plan.

Eg: Prevention policies for a nuclear reactor explosion

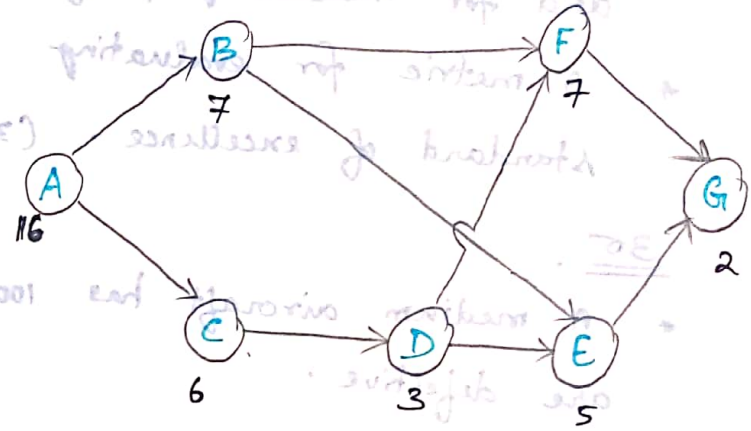


7.) Arrow Diagram :

* Graphic representation of the sequential steps that must be completed for a project to be completed.
* Also called Activity Network.
* Eg: PERT → Program Evaluation & Review Technique
  CPM → Critical Path Method.

Construction:

Identify & list activities
↓
Det. sequence of activities
↓
Construct a network with relationships
↓
Write the activity time under arrow leading from it.



Eg: Arrow diagram for a set of activities in a project planning & imp. phase.

Six Sigma :

* Six Sigma ⟶ 6 S.D (Std. Deviation) from Mean. (i.e) $\pm 6\sigma$
* Similar to "Zero Defects" → 6σ is a philosophical benchmark (or) standard of excellence proposed by Philip Crosby.
* Process capability Tool.
* Started by Motorola in 1987 in Manufacturing division. & GE used it in 1995 for products (ppm).

- Strives for perfection.
- Allows 3.4 defects per million (99.999666 % accuracy)
- As per GE "Six Sigma means "a vision of quality which equates with only 3.4 defects per million opportunities (DPMO) for each product (or) service transaction & strives for perfection"
- It's a systematic method for process & product improvement and for measuring performance variation.
- A metric for evaluating performance quality & a standard of excellence. (3.4 DPMO)

3σ.

- A medium aircraft has 10000 parts. At 3σ, 27 parts are defective.

$\bar{x}$ → Mean.

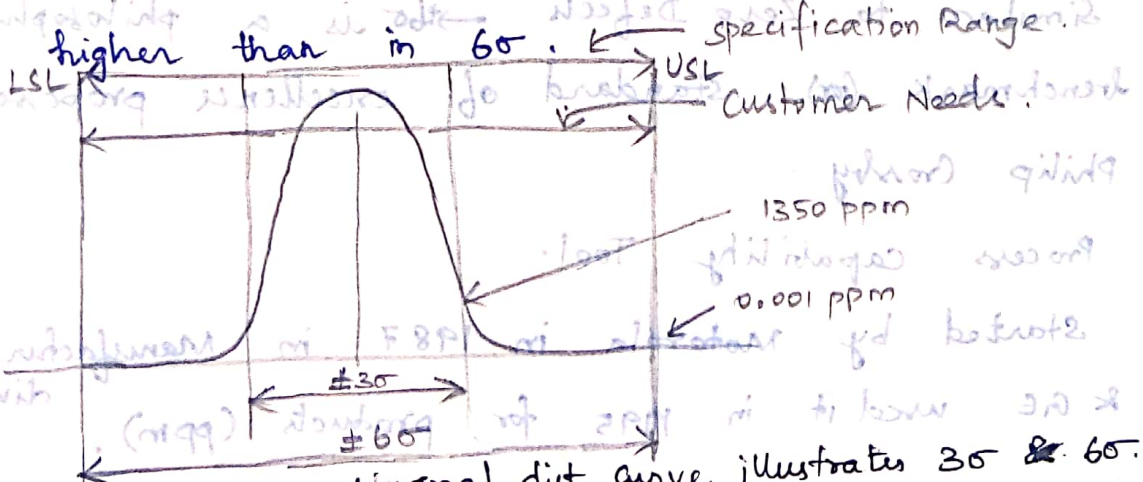
3σ → SD.

$(\bar{x} \pm 3\sigma)$ = Natural Variability

↳ Tolerance = USL − LSL

- 3σ → 27 parts in 10,000
- 6σ → 3.4 parts in 10,00,000 (Million)

↳ Means probability of parts failing in 3σ is higher than in 6σ.



Normal dist curve illustrates 3σ & 6σ.

(16)

(17)

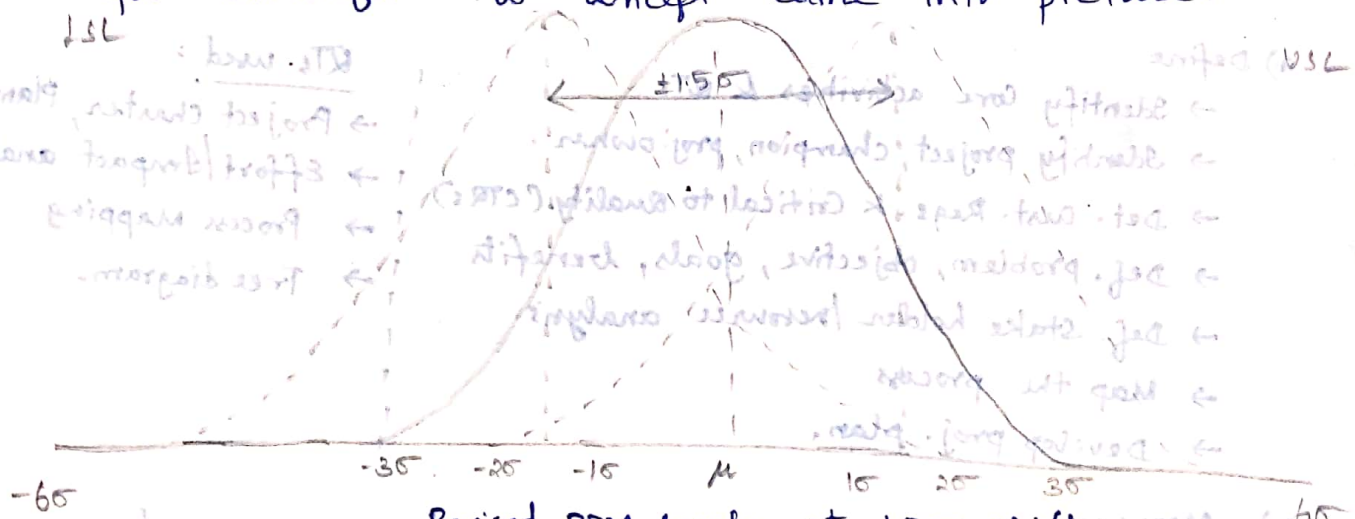
...unknown variations in process by achieving Cp of 2.

Concept of 6σ:

* To know concept of 6σ, we must first know the Process Capability Ratio, C_p.

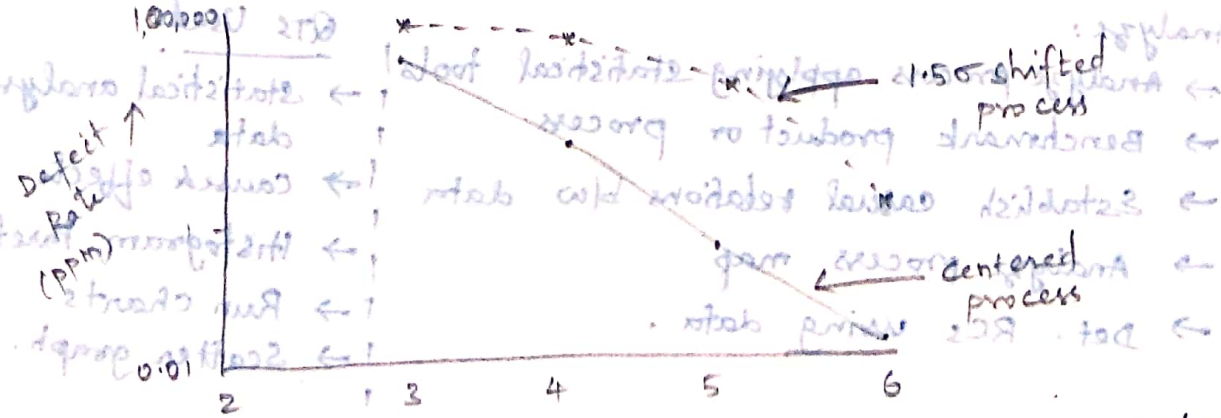
$$C_p = \frac{\text{Design Width}}{\text{Process Width}} = \frac{USL - LSL}{UCL - LCL}.$$

* ∴ 3σ (or) 4σ (or) even 5σ is not suited for aircrafts 6σ concept came into picture.



Revised PPM levels at 1.5σ shift

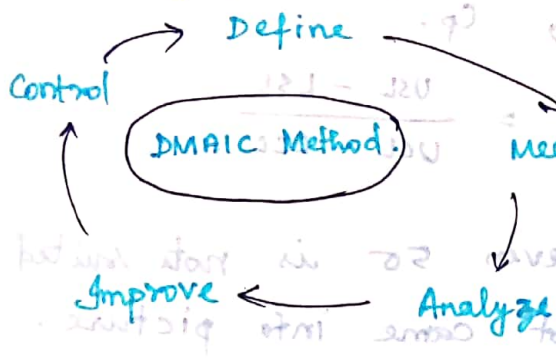
Spec. Limit	C_p	%	Defective PPM	
~~6σ~~ ±1σ		30.23	697700	
±2σ	0.67	69.13	308700	← Non competitive
±3σ	1.00	93.32	66810	← Non competitive
±4σ	1.33	99.3790	6210	← Industry Avg.
±5σ	1.67	99.9767	233	← Industry Avg.
±6σ	2.00	99.999666	3.4	← World class



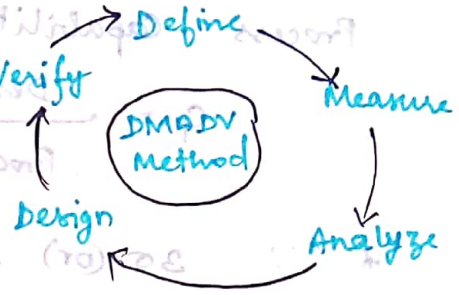
→ 6σ is essentially a tightening of the process performance so as to reduce the random variations in process by achieving C_p of 2.

Six Sigma Methodology:

* DMAIC Methodology for improving 6σ for existing products / processes.



* DMADV methodology for New product/process 6σ implementation.



a.) Define

- → Identify Core activities & QTs
- → Identify project, champion, proj. owner.
- → Det. Cust. Reqs. & Critical to Quality (CTQs)
- → Def. problem, objective, goals, benefits
- → Def. stake holder / resource analysis
- → Map the process
- → Develop proj. plan.

QTs used:

- → Project charter, Planner
- → Effort / Impact analysis
- → Process Mapping
- → Tree diagram.

b.) Measure

- → Quantify & Benchmark the process using actual data.
- → Det. proj. critical Xs & Ys.
- → Det. operational definitions.
- → Establish performance standards
- → Develop. data collection & sampling plan
- → Validate measurements
- → Measurement systems analysis
- → Det. process capability & baseline.

QTs Used:

- → QFD
- → Measurement system Analysis (MSA)
- → Check sheet
- → Process Capability

c.) Analyze:

- → Analyze process applying statistical tools
- → Benchmark product or process
- → Establish casual relations b/w data
- → Analyze process map
- → Det. RCs using data.

QTs Used:

- → Statistical analysis of data
- → cause & effects. dia.
- → Histogram, Pareto dia.
- → Run charts
- → Scatter graph.

d.) Improve

→ Fixing & preventing problems by designing creative solutions.
→ Develop alternate solutions.
→ Assess risks & benefits of solution alternatives
→ Validate solution using a pilot
→ Implement soln. completely.
→ Det. soln. effectiveness using data.

QTs used:
→ Design of Exp. (DoE)
→ Brainstorming
→ FMEA
→ Risk assessment.

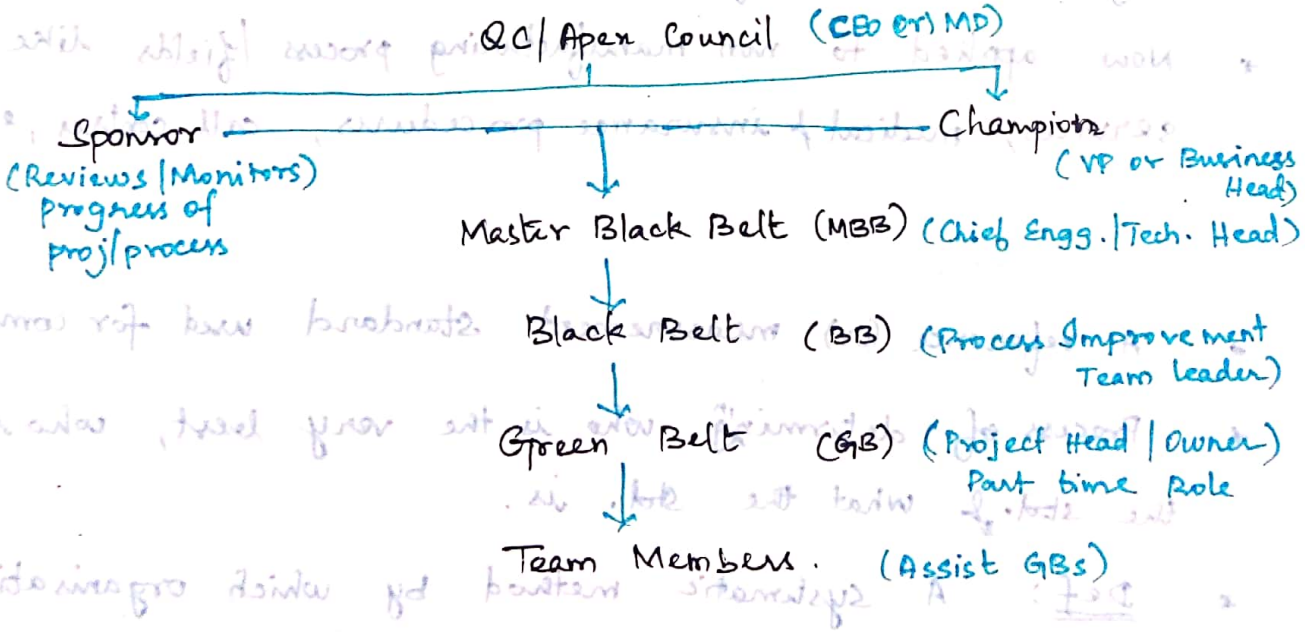
e.) control

→ Det. needed controls
→ Implement & Validate controls
→ Develop transfer plan
→ Realize benefits of implementing soln.
→ Close proj. & communicate results

QTs Used:
→ SPC
→ Out of control Action plan (OCAP)
→ Design changes to eliminate defect.

Six Sigma Organization:

* Involvement & participation from all employees necessary.
* Typical 6σ structure of organization:



Advantages of 6σ:

* Improved Cust. Satisfaction
* Improved quality, efficiency & cost of products sold
  - → Reduction of wastes & defects
  - → Financial saving through reduced prod. cost.
* Creation of self sustaining infrastructure.
  - → Well defined Roles & Responsibilities
  - → Empowering all employees
  - → Improved communication.
* Standardization
  - → Commonalized lang. training material, tools & software
  - → Standardized methodology
  - → Creating commonality in expectations, solutions, financial tracking of the process

Scope of 6σ:

* Originated for manufacturing process.
* Now applied to non manufacturing process / fields like services, medical & insurance procedures, call centres, etc.

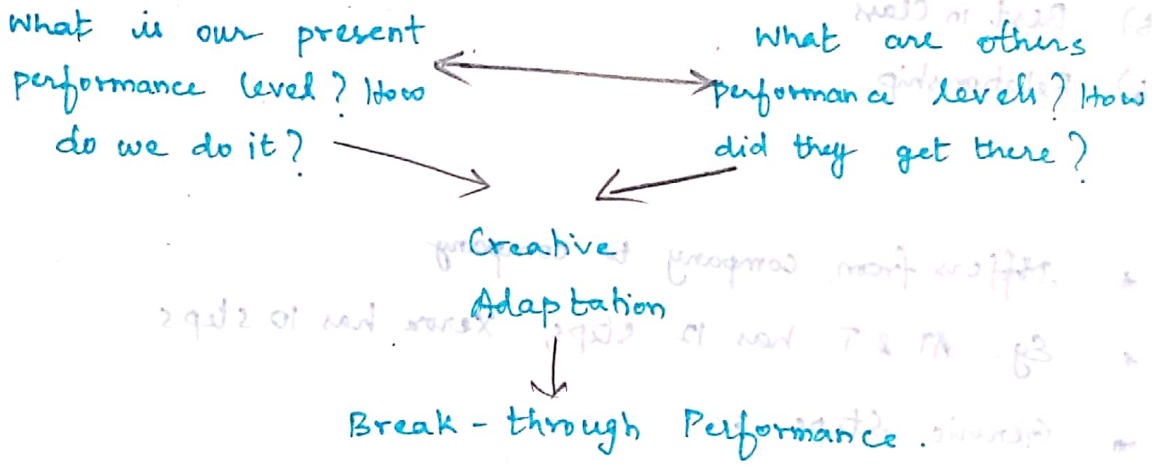
Benchmarking:

* A reference (or) measurement standard used for comparision
* Process of determining who is the very best, who sets the std. & what the std. is.
* Def: A systematic method by which organisations can measure themselves against the best industry practices.

* American Productivity & Quality Centre (APQC) defines benchmarking as "the process of identifying, understanding, and adapting outstanding practices and processes from organizations anywhere in the world to an organization to improve its performance.

* Continuous process of measuring products, services & practices against the toughest competitors or those companies recognised as industry leaders.

* Benchmarking concept:



Reasons to Benchmark:

* Aims at a goal setting process to facilitate comparision with the best.
* Aims at motivating & stimulating company employees towards the goal of continuous quality improvement
* Aims at external orientation of the company
* Aims at identifying technological break-through.
* Aims at searching for industry best practices.

Benchmarking types:

1.) Product Benchmarking
2.) Performance Benchmarking
3.) Process Benchmarking
4.) Strategic Benchmarking
5.) Generic Benchmarking.

} Based on object to be Benchmarked.

1.) Internal
2.) External
3.) Industry
4.) Competitive
5.) Best in Class
6.) Relationship

} Based on organizations against whom one is benchmarking

Benchmarking Process:

* Differs from company to company
* Eg: AT & T has 12 steps, Xerox has 10 steps.
* Generic Steps :

Phase	Steps
Planning	1.) Earmark what is to be benchmarked? 2.) Identify the best competitor 3.) Determine the data collection method and start collecting data.
Analysis	4) Determine the current performance gap. 5.) Project future performance levels.
Integration	6) Communicate benchmark findings & gain acceptance. 7.) Establish functional goals: ↓ Communicate data for analysis ↓ Gain acceptance for analysis

Phase	steps
Action	8.) Develop action plans 9.) Implement specific actions & monitor progress 10.) Recalibrate benchmarks.
Maturity	11.) Attain the leadership position 12.) Integrate practices into the process.

Benefits of Benchmarking:

* Creates a culture for continuous improvement.
* Sharing best practices b/w benchmarking partners.
* Prioritizing the areas that need improvement
* Enhancing creativity by devaluing the "not invented here" syndrome.
* ↑ sensitivity to changes in external environment.
* Shifting the corporate mindset from relative complacency to a strong sense of urgency for ongoing improvement.
* Focusing resources through performance target set with employee unit.

→ Benchmarking shouldn't be the primary strategy for Improvement.

→ shouldn't be a substitute for innvation.

FMEA - Failure Mode & Effect Analysis

* Also called risk analysis
* It is a process of preventive measure to systematically display the causes, effects & possible actions regarding observed failures.
* OBJECTIVE: Anticipate failures & prevent them from occuring
* It is a "before the event" action

Types of FMEA:

1.) System FMEA
2.) Design FMEA
3.) Process FMEA
4.) Service FMEA
5.) Equipment FMEA
6.) Maintenance FMEA
7.) Concept FMEA
8.) Environment FMEA

→ However in practices, only 2 types are there:
a.) Design FMEA → In design stages
b.) Process FMEA → In manufacturing stages.

Benefits of FMEA:

* Improve product/process reliability & quality
* Increase customer satisfaction
* Early identification & elimination of potential pdt/process failure modes.
* Prioritize pdt/process deficiencies.
* Capture engineering/organization knowledge.
* Document & track the actions taken to reduce risk.

* Provide focus for improved testing & development
* Minimize late changes & associated cost
* Act as catalyst for teamwork & idea exchange b/w fns.

Inputs for preparation of FMEA:

* People Inputs → People from all departments
* Data Inputs → All relevant data

FMEA Methodology (or) Stages of FMEA:

* Stage 1 - Specifying possibilities
  (a.) Functions, (b.) Possible failure modes, (c.) Root Causes,
  (d.) Effects, (e.) Detection / Prevention

* Stage 2 - Quantifying risk
  (a.) Probability of cause, (b.) severity of effect,
  (c.) Effectiveness of control to prevent cause, (d.) Check points on completion

* Stage 3 - Correcting High risk causes
  (a.) Prioritizing work, (b.) Detailing action, (c.) Assigning action responsibility, (d.) check points on completion

* Stage 4 - Re-evaluation of risk
  (a.) Re-calculation of risk priority number.

FMEA Form: (otherwise called FMEA chart (or) document)

FMEA Number _____
Page _____ of _____
Item _____ Design/process responsibility _____ Prepared By _____
Model Number/Year _____ Key Date _____ FMEA Date (Orig) _____ (Rev) _____
Core Team _____

Product / Process Function Requirements	Potential Failure Mode	Potential Effects of failure	S	CLASS	Potential Causes/ Mechanisms of Failure	O	Current Design / Process Controls	D	RPN	Recommended Actions	Responsibility & Target completion Dates	Action Results				
												Action Taken	SEV	OCC	DET	RPN

FMEA Procedure :

1.) Describe the product/process and its function

2.) Create a block diagram of the product/process

3.) Complete the header of the FMEA form worksheet

4.) List product/process functions

5) Identify failure modes

↓

→ It is the manner in which a component, sub-system, system (or) process could potentially fail to meet the design purpose.

6) Describe the potential failure effects:

↓

→ It is defined as the result of a failure mode on the function of the product/process as perceived by the customer.

7.) Establish a numerical ranking for the severity (S) of the effect (S → severity)

8.) The CLASS column → classify components that req. additional process controls.

9.) Identify the potential causes/mechanisms of failure

10) Enter the probability factor (O → Occurrence)

11.) Identify current controls (design or process)

12.) Determine the likelihood of detection (D)

13.) Review Risk Priority Number (RPN)

→ RPN ⇒ Product of Severity (S), Occurrence (O) & Detection (D)

$$RPN = S \times O \times D$$

14.) Determine recommended actions

15.) Assign responsibility and a target completion date

16.) Indicate actions taken

17.) Update the FMEA

UNIT-IV - TQM TOOLS AND TECHNIQUES - II

Control Charts :

* One of the traditional QC tools.
* Sources of variations (process variations)
  - → Processes
  - → Materials
  - → Operators
  - → Miscellaneous factors like heat, light, radiation, humidity, etc.
* Types of variations :

Variations

Assignable (Special) — Chance (Random / common)

* Control Chart - Purpose:
  - → Is Process stable (or) in control ?
  - → Extent of process variability

Assignable Causes of Variations :

* Larger in magnitude and can be easily detected.
* Reasons are "Differences in"
  - → Machines
  - → Materials
  - → Processes
  - → Each of the 3 over time
  - → Relationship with one another.
* Prime objective of control chart is detecting assignable causes of variables by analyzing data.
* ↓ Once detected & eliminated thru. remedial actions Process becomes statistically controlled

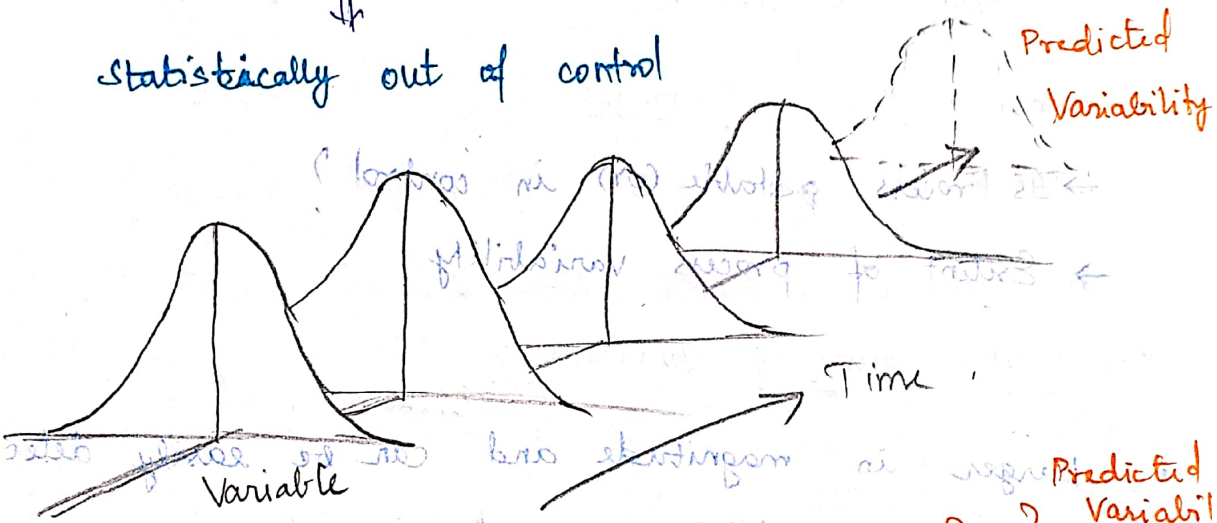
Chance causes of variations :

* Inevitable in any process. Difficult to identify even under best conditions of production.
* All occur @ random.

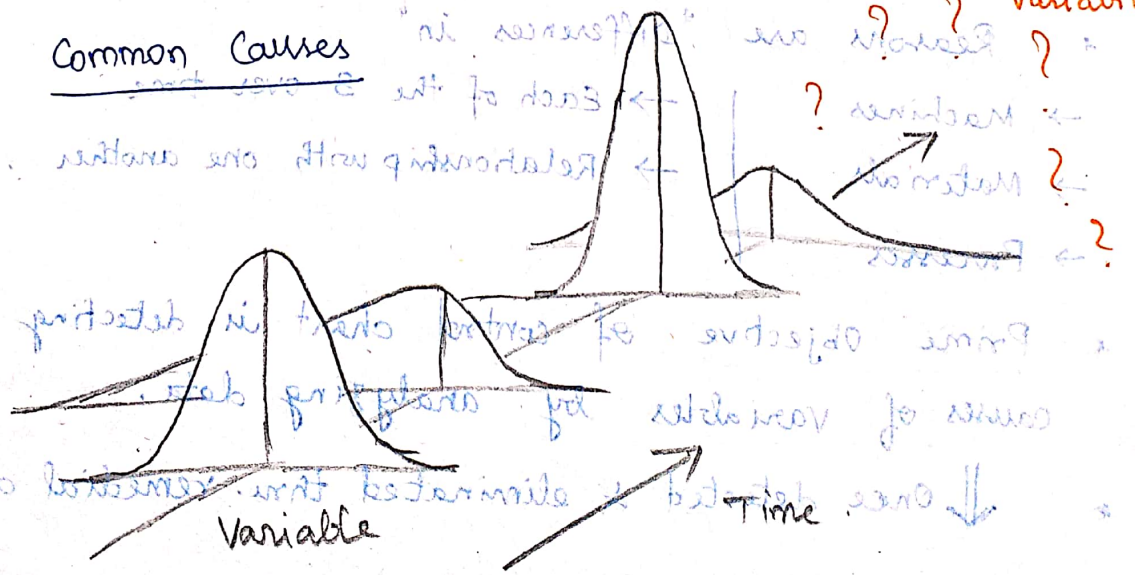
* Caused by
  - → Human variability from one operation cycle to next
  - → Minor variations in raw materials
  - → Fluctuations in working conditions
  - → Lack of adequate supervision skills.

* Process with common causes
  ⇩
  Statistically under control

* Process also with assignable causes
  ⇩
  Statistically out of control



Common Causes



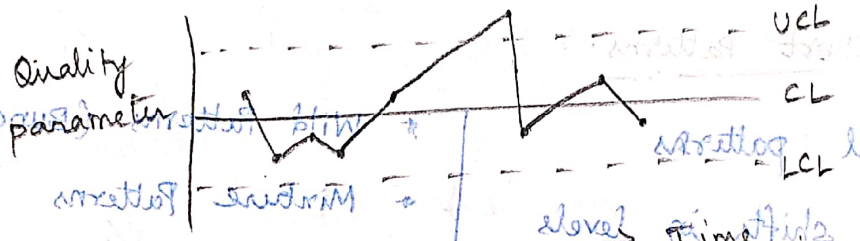
Assignable Causes

Why Stable Process is reqd?

* To know process capability & predict performance, cost, quality, etc.
* Productivity ↑, costs ↓
* To measure effects of changes in system at greater speeds & reliability
* To have decision backups, can alter specification limits

Control Chart:

* A graph to display data taken over time & the variations of this data.
* Can be used to differentiate chance & assignable causes of variations.



* Types of control chart:
  - → For variables – Measurement of quality characteristic
  - → For attributes – Determination of whether a part is defective (or) how many defects in the sample
* Patterns in CC:
  - → Plot patterns.
  - → Difficult to analyze.
  - → Rules for analysis – "Process is out of control if"

1.) Single pt falls outside 3σ limit

2) 2/3 consecutive points falls outside the 2σ warning limit on the same side of CL

3) 4/5 consecutive points fall beyond the 1σ limit on the same side of CL.

4) 9 or >9 (≥9) consecutive points fall to one side of CL

5) A run of ≥6 consecutive points steadily increasing (or) decreasing

Control Chart for variables:

* Quality characteristics ⇒ variables
  ↓ When measured using CC
  CC for variables.
* Types:

CC for variables

- $\bar{X}$ (or) Avg. Charts
- R (or) Range Charts
- S (or) S.D Charts

Control Chart Patterns:

* Natural patterns
* Sudden shifts in levels
* Gradual shifts in levels
* Trending pattern
* Cyclic pattern
* Wild Patterns (Bunching)
* Mixture Patterns
* Stratification patterns.

Applications: ⇒ Wide Range of applications.

* Hospitals
* Bank
* Insurance companies
* Post Office
* Ambulance.
* Police department
* Hotel
* Transportation
* Auto service

Control chart Pattern details:

* Natural Patterns:
  → Stable / in-control process
* Sudden shifts in level:
  → changes in process settings causes this. Eg: Temp, depth of cut, new equipments, tools, instruments, etc.
* Gradual shifts in level:
  → Incoming quality of raw materials decreases over time
  → Also due to new operator, labour fatigue, etc.
* Trending Patterns:
  → Tool wear, Die wear, gradual deterioration of equipments, build up of debris in jigs & fixtures.
* Cyclic Patterns:
  → Repetitive Periodic behaviour
  → Rotation of operators, periodic changes in temp, humidi etc.
* Wild Patterns:
  → Use of new vendor for short interval of time, a diff. m/c for short time, new operator for short time.
* Mixture Patterns:
  → One set of values too high & other set too low
  → Due to diff. quality of raw materials from two sets of suppliers, etc
* Stratification Patterns:
  → Mixed from two (or) more shifts.

Control Chart Construction :

Construction of $\bar{X}$ & R charts :

* 11 steps.
* Step by step procedure :

1.) Select characteristics for applying a CC
2.) Select the appropriate type of CC
3.) Collect data
4.) Choose the "Rational Sub-group" (i.e) Sample
5.) Calculate Average ($\bar{x}$) & Range (R) for each sample

$$\bar{X} = \frac{x_1 + x_2 + x_3 + x_4 + \dots + x_n}{n \Rightarrow \text{Sample size}}$$

$$R = \text{Max. Value} - \text{Min. Value}$$

6.) Calculate Average of averages of each sample & ranges of each sample.

$$\bar{\bar{X}} = \frac{\Sigma \bar{X}}{N} \Rightarrow \text{Total no. of samples / sub-groups}$$

$$\bar{R} = \frac{\Sigma R}{N}$$

7.) (a.) Control limits of $\bar{X}$ - chart :

$$CL_{\bar{X}} = \bar{\bar{X}}, \quad UCL_{\bar{X}} = \bar{\bar{X}} + A_2\bar{R}, \quad LCL_{\bar{X}} = \bar{\bar{X}} - A_2\bar{R}$$

A_2 ⇓ Factor (or) Constant taken from the table "Areas under the standard Normal Curve"

(b.) Control limits of R - chart :

$$CL_R = \bar{R}, \quad UCL_R = D_4\bar{R}, \quad LCL_R = D_3\bar{R}$$

D_4 ⇓ , D_3 ⇓ Statistical factors taken from the table "Areas under the standard Normal Curve"

8.) Plot CL, UCL & LCL on the chart

9.) Plot individual $\bar{x}$ & R values on the chart

10.) Check if process is in control or not

11.) Revise the control limits by removing out-of-control points.

Estimation of Process S.D:

a.) If $\bar{R}$ is known, $\hat{\sigma} = \frac{\bar{R}}{d_2}$

b.) If S.D is known, $\hat{\sigma} = \frac{\bar{\sigma}}{c_4}$

$d_2, c_4 \Rightarrow$ Statistical factors.

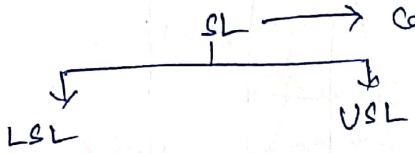
Process Capability:

Control limits Vs Specifications limits:

- CL $\Rightarrow$ Derived from actual process performance. (to check if process is in control or not)

  SL $\Rightarrow$ Derived from customer requirements (to ensure adequate functioning of a pdt).

SL $\longrightarrow$ Can be called as specs or Tolerances of a product.



Control limits	Specification limits
1.) Voice of the process	1.) Voice of the customer
2.) Calculated from data	2.) Defined by customer
3.) Appear on CCs	3.) Appear on histograms
4.) Apply to samples / sub-groups	4.) Apply to items
5.) Guide for process actions	5.) Separate good items from bad.
6.) What the process is doing	6.) What we want the process to do.

Natural Tolerance Limits :

* Also called Process Capability Limits

If μ → Process Mean

σ → Process S.D

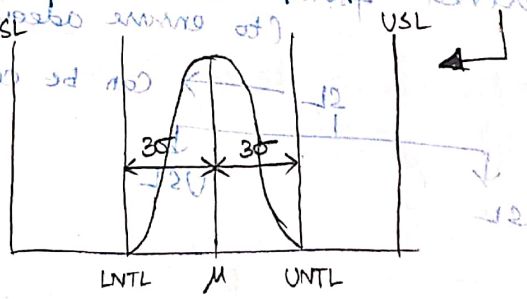
Then,

* Upper Natural Tolerance Limits (UNTL) (or) Upper Process Capability Limits (UPCL) $= \mu + 3\sigma$
* Lower Natural Tolerance Limits (LNTL) (or) Lower Process Capability Limits (LPCL) $= \mu - 3\sigma$

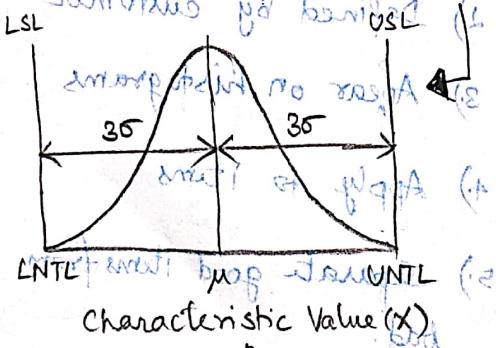
Relationship b/w Tolerance Limits & Specification Limits :

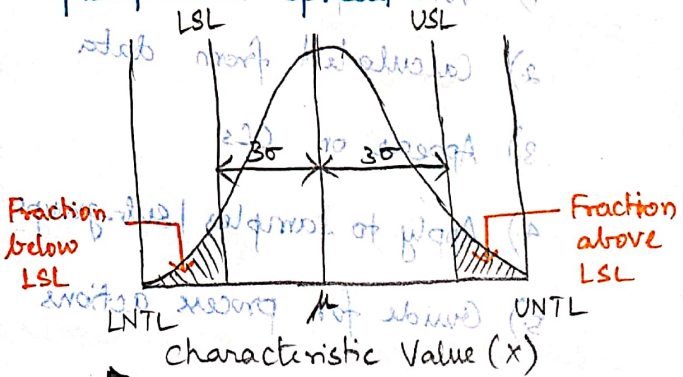
* 3 cases of relationships possible

Case 1 : Process spread < Specification Spread



Case 2 : Process Spread = Specification Spread





Case 3 : Process Spread > Specification Spread

Process Capability Analysis: (PCA)

* PC analysis estimates process capability.
* Involves estimating Process Mean, Process S.D, & Relative frequency distribution of the quality characteristic.
* If SL are known, PCA will also estimate the proportion of Non-conformity product.
* PCA can be carried out only when following criteria is met:
  - → Process is statistically in control
  - → Distribution of the process is "Normal".
* PC ⇒ Minimum spread of a specific measurement variation which will include 99.7% of the measurements from the given process.
* PC = 6σ ⇒ Natural Tolerance
  ⇒ Range of (-3σ to 3σ)

Process Capability Indices:

* PCI (or) C_p
  - → Used to relate Process spread with specification spread
  - → Used in product design phase & pilot production phase.

$$C_p = \frac{\text{Total Specification Tolerance}}{\text{Process Capability}}$$

$$C_p = \frac{(USL - LSL)}{6\sigma} \Rightarrow \text{Tolerance} \rightarrow \text{Process Capability.}$$

Interpretation of C_p :

If $C_p \geq 1$ ⇒ Process meets specifications

$C_p < 1$ ⇒ Process not meeting specifications

$C_p = 1$ ⇒ Process just meets specifications.

Drawbacks :

* Doesn't measure process performance in terms of the nominal (or) target value.

* PCI (or) C_{pk} :

→ Not only measures the process variation with respect to allowable specifications, but also considers the location of the process average.

→ Used in pilot production phase & routine production phase.

$$C_{pk} = \min \left\{ \frac{USL - Mean}{3\sigma} , \frac{Mean - LSL}{3\sigma} \right\}$$

Interpretation of C_{pk} :

↔ $C_{pk} \leq C_p$. (Always)

If

$C_{pk} \geq 1$ ⇒ Process conforms specifications

$C_{pk} < 1$ ⇒ Process doesn't confirm specifications

$C_{pk} = 1$ ⇒ Process just conforms to specifications

$C_{pk} = C_p$ ⇒ Process is centered.

Control Chart for Attributes :

→ CC for variables like $\bar{X}$ & R charts cannot be used for quality characteristics like incorrect colour, blow holes, cracks because these are not measurable.

* $\bar{x}$ & R charts can be used for only one measurable characteristic at a time.

Eg: An automatic turning having 50 dimensions requires 50 $\bar{x}$ & R charts ⇒ Too expensive & time consuming.

* Attribute ?

→ Refers to the quality characteristics that conform to specifications (or) donot conform to specifications.

* Types of Attributes :

Attributes

Measurement NOT possible.
Eg: Colour, Missing parts, Scratches, damages

Measurement Possible but are not made due to economy of time, cost (or) need.
Eg: Instead of using linear measurement instruments, can use GO-NO GO gauges

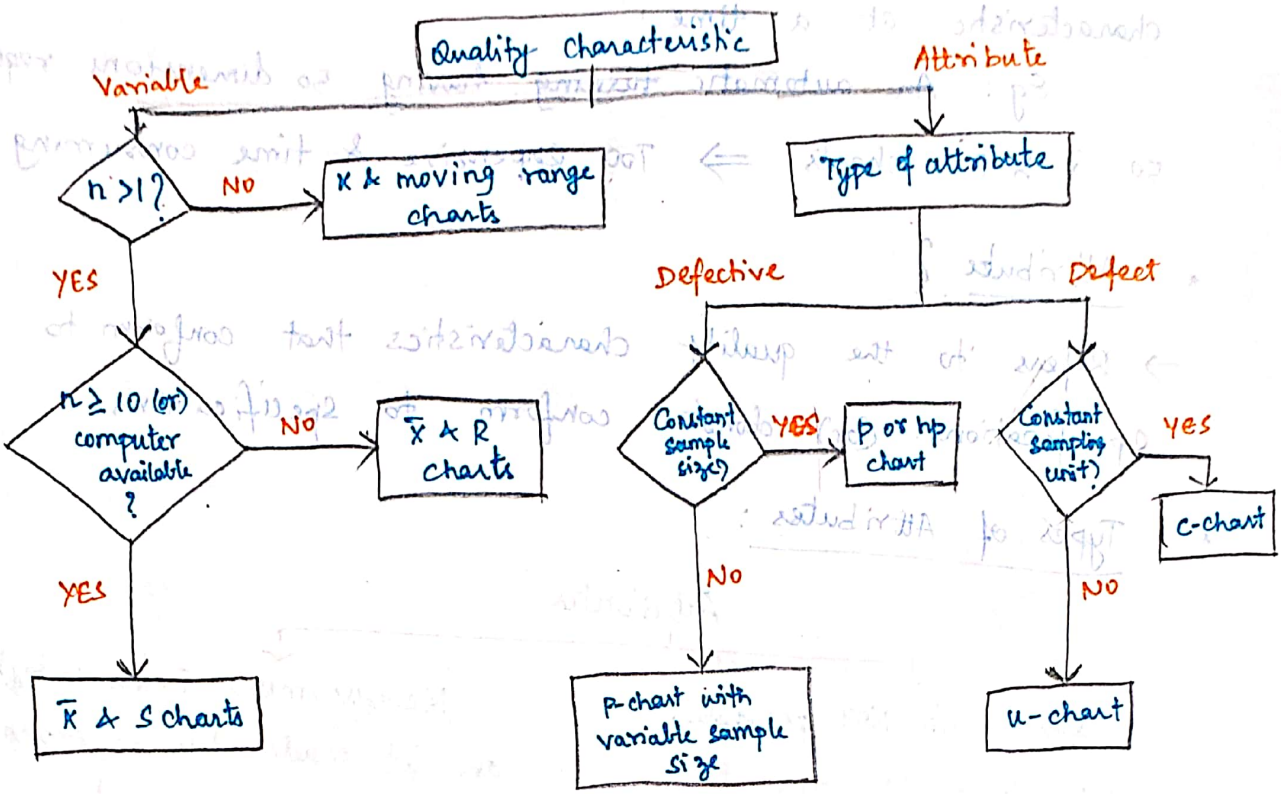
Defect Vs Defective :

* Otherwise called Non-conformity Vs Non-conforming item
* Defective ⇒ Item not conforming to specifications.
* Defect ⇒ Each characteristic that doesn't conform to specifications.

Types of Attribute CCs :

1) p - chart for → fraction rejected as non conforming
2) np - chart for → number of non-conforming items
3) c - chart for → number of non-conformities
4) u - chart for → number of non-conformities per unit

Guidelines for choosing the right control chart :



p- chart :

* Fraction defective, p ⇒ Ratio of number of defectives in any inspection to total number of articles actually inspected.

$$p = \frac{np}{n}$$

np ⟹ Number of defectives

n ⟹ Number of items inspected in sample

Percent defective ⇒ $100p$

* Control limits for p- chart :

$$\bar{p} = \frac{\Sigma np}{\Sigma n}$$

$$CL_p = \bar{p}$$

$$UCL_p = \bar{p} + 3\sigma = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$LCL_p = \bar{p} - 3\sigma = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

np chart :

- np & p charts are same / similar.
- Only diff : Sub-group size varies ⇒ p-chart
  Sub-group size constant ⇒ np-chart.
  ↓
  Under this condition, go for np-chart.

- Control limits for np-chart :

$$CL_{np} = n\bar{p}$$

$$UCL_{np} = n\bar{p} + 3\sqrt{n\bar{p}(1-\bar{p})}$$

$$LCL_{np} = n\bar{p} - 3\sqrt{n\bar{p}(1-\bar{p})}$$

- Basic for both p- & np- charts are BINOMIAL DISTRIBUTION

c-chart :

- c for count ⇒ No. of defects in sample plotted over time
- c-chart ⇒ Applies to no. of defects in constant sized subgroup.
- p & np charts ⇒ Controls fraction defective in product
- c-chart ⇒ Controls no. of defects in product

Average no. of defects, $\bar{c} = \frac{\text{Total no. of defects in all samples}}{\text{Total no. of samples.}}$

(i.e.), $\bar{c} = \frac{\Sigma c}{n}$

$$CL_c = \bar{c}, \quad UCL_c = \bar{c} + 3\sqrt{\bar{c}}, \quad LCL_c = \bar{c} - 3\sqrt{\bar{c}}$$

u - chart :

- u- charts ⇒ Controls no. of defects.
  ⇒ Used when sub-group size varies from sample to sample.

$$\bar{u} = \frac{\text{No. of defects in a sample}}{\text{No. of units in a sample}} = \frac{c}{n}$$

$$CL_u = \bar{u}$$

$$UCL_u = \bar{u} + 3\sqrt{\bar{u}/n}$$

$$LCL_u = \bar{u} - 3\sqrt{\bar{u}/n}$$

Quality Function Deployment (QFD):

- QFD is the latest approach to product design.
- Focuses on "Voice of the Customer" → Hears Customer requirements
- QFD otherwise called "Customer Driven Engineering"
- QFD ⇒ A system for translating consumer requirements into appropriate requirements at every stage, from research through product design & development, to manufacture, distribution, installation & marketing, sales & service.
- 1st Application of QFD :- Mitsubishi, Heavy Industries Ltd. in the Kobe Shipyard, Japan, in 1972.

QFD Team :

→ Members of various functional departments that work together for product development.

1. Marketing
2. Design
3. Quality Assurance
4. Manufacturing
5. Testing
6. Finance
7. Support & Maintenance.

Objectives of QFD:

* To identify "voice of the customer" (VOC)
* To analyse "pertinent information associated with project"

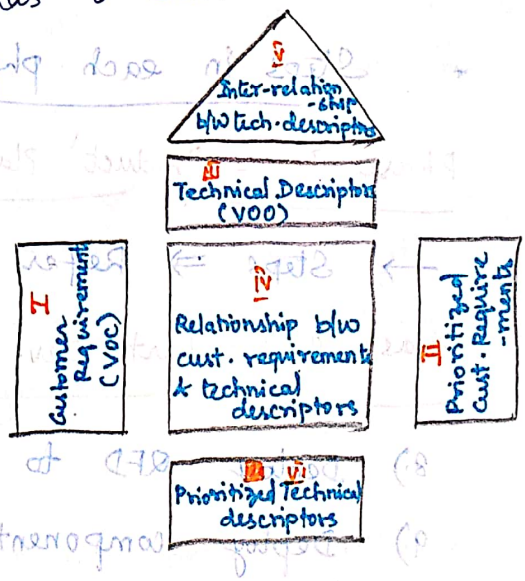
How to capture VOC?

* Interviews
* Cust. Surveys
* Market Surveys
* Trade trials
* Focus groups
* Cust. Visits
* Standards
* Consultants
* Observation
* Warranty data
* Cust. Audits
* Cust. Complaints
* Field reports
* Government regulations.

House of Quality (HOQ):

* Primary tool used in QFD
* Basic structure of HOQ has 6 sections

1.) Customer Requirements (Whats?)
2.) Prioritized Cust. Requirements
3.) Technical Descriptors (Hows?)
4.) Relationship Matrix
5.) Trade-off Matrix
6.) Prioritized Technical descriptors



House of Quality

QFD Methodology:

1.) List Cust. Requirements (Whats)
2.) List tech. descriptors (Hows)
3.) Develop a Relationship matrix b/w WHATS & HOWS
4.) Develop an inter-relatiaship matrix b/w Hows
5.) Competitive Assessments
6.) Develop prioritised Cust. Requirements
7.) Develop prioritised tech. descriptors.

QFD Process:

* 4 phases
  - → Product Planning
  - → Part Development
  - → Process Planning
  - → Production Planning

* Steps in each phase:

Phase I :- Product Planning:

→ Steps ⇒ Refer 7 steps of QFD Methodology.

Phase II :- Part Development:

8.) Deploy QFD to sub-components level
9.) Deploy component deployment chart & relate critical sub component control characteristics.

Phase III :- Process Planning:

10.) Develop relationship b/w the critical characteristics & proces used to create characteristics
11.) Develop control plan relating critical control to critical proces

Phase IV :- Production Planning :

12.) Tabulate operating instructions characteristics from process requirements

13.) Develop prototype & do testing

14.) Launch the final product to the market.

Benefits of QFD :

Tangible Benefits	Intangible Benefits
⊛ Significant reduction in start-up & engineering cost by 30%.	⊛ Improves customer satisfaction
⊛ Elimination of most late engineering changes.	⊛ Facilitates multidisciplinary teamwork.
⊛ Early identification of high risk areas.	⊛ Provides a basis for improvement planning.
⊛ Up-front determination of product-process requirements	⊛ Establishes & maintains documentation.
⊛ Significant ↓ in development time by upto 50%.	⊛ Creates a transferable store-house of engg. knowledge.
⊛ More efficient allocation of resources	⊛ Encourages transfer of training to other projects via all team members.
⊛ Application in both service & manufacturing industries	⊛ Strengthens good relationships b/w customers and company.

Taguchi's Quality Loss Function (QLF) :

Taguchi Methods :

* Statistical Methods developed by Genichi Taguchi to improve quality of manufactured goods.
* Controversial with western statisticians.
* Taguchi's principles → (3)

Taguchi's Principles:

1.) Taguchi Loss Function
2.) Philosophy of off-line quality control and
3.) Innovations in the design of experiments (DoE)

Taguchi's Loss Function:

* Taguchi defines quality as "the loss imparted by the product to society from the time, the product is shipped"

* Loss includes:
  - → costs to operate
  - → failure to function, maintenance & repair costs
  - → customer dissatisfaction
  - → injuries caused due to poor design

* Defective products that are detected, repaired, reworked or scrapped before shipment are not considered part of this loss.

* Essence of the loss function concept is that whenever a product deviates from its target performance, it generates loss to society.

Loss Minimum when Performance is right on target

∴, the best strategy is to produce products as close to the target as possible, rather than aiming at "being within specifications"

Taguchi's Approach Vs Traditional approach :

* **Traditional Approach :**

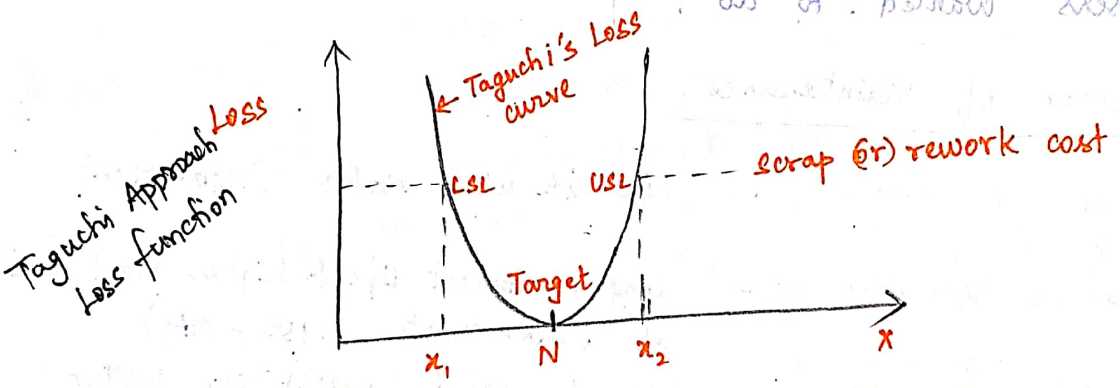
→ Product within specified limit is good
outside bad

* **Taguchi Approach :**

→ Product deviates away from target is loss no matter if the deviation is within (or) outside specified limits

Taguchi's Quadratic QLF :

* Deviation small, loss is less
grows, increasing



* Uses a quadratic equation to determine this curve.

* QLF ⇒ Represented as L(x)

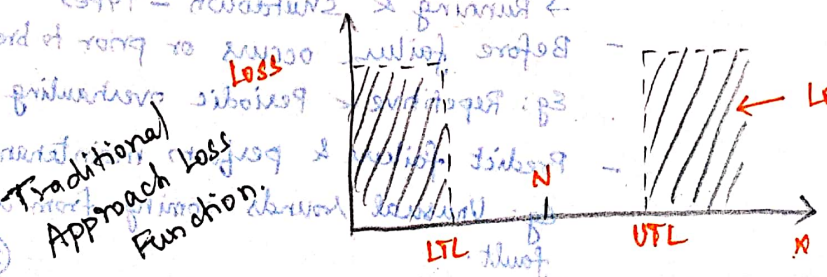
→ Nominal Value of the chosen product

QLF, $L(x) = k(x - N)^2$

↓ → Quality characteristic of selected product

Proportionality Constant

Here $x - N \Rightarrow$ Tolerance



Taguchi's Proportionality Constant : (k)

$k = \frac{C}{d^2}$ ⇒ Loss associated within spec. limits

⇒ Deviation of the specification from the target value.

Represents the slope of the Loss Function

Total Productive Maintenance : (TPM)

* Maintenance → Defined as the management, control, execution & quality assurance of activities which ensure the achievement of optimum availability & performance of a plant in order to meet business objectives.
* To ensure physical assets continue to do what their users wanted to do.

Evolution of Maintenance :

First Generation - Fix it when broke (1940 - 1956)

Second Generation - Long equipment life & higher plant availability at lower costs (1950 - 1970)

Third Generation - Greater safety, reliability, Better productivity, lesser damage to environment (1970 - 2000)

Types of Maintenance :

1.) Corrective (or) Breakdown — Repairs made after failure
Eg: Replacing gears in a machinery

2.) Scheduled (or) Routine - Stitch in time procedure to avoid breakdown.
Eg: Periodic inspection, cleaning, lubrication
→ Running & shutdown - Types

3.) Preventive - Before failure occurs or prior to breakdown
Eg: Repetitive & Periodic overhauling.

4.) Predictive - Predict failure & perform maintenance.
Eg: Unusual sounds coming from any fault.

Layer - The - Both.

Steps for TPM Development :

* 12 steps in 4 phases/stages :

Stages	Steps
(1.) Preparation Stage	1.) Announce top management about decision to implement TPM 2.) Launch education & campaign to introduce TPM 3.) Create organization to promote teams. 4.) Establish basic TPM policies & goals. 5.) Formulate basic TPM policies & goals
(2) Preliminary Implementation Stage.	6.) Hold TPM kick-off.
TPM (3.) Implementation Stage	7.) Improve effectiveness of each piece of equipment 8.) Develop an autonomous maintenance program 9.) Develop a scheduled maintenance program for the maintenance department. 10.) Conduct training to improve operation and maintenance skills 11.) Develop early equipment management program.
(4) Stabilization Stage	12.) Perfect TPM implementation ; Raise TPM levels and continually improve.

Overall Equiptment Effectiveness: (OEE)

* A measure of TPM efforts.
* Otherwise called "OEE"

Calculation of OEE :

Six Big Losses	Calculation
1.) Breakdown 2.) Setup & change over	→ Availability = $\frac{\text{Loading time - Down time}}{\text{Loading time}} \times 100$
3.) Idling & Minor Stoppages 4.) Reduced Speed	→ Performance Efficiency = $\frac{\text{Theoretical Cycle time per unit} \times \text{Number of units}}{\text{Operating time}} \times 100$
5.) Defects & Rework 6.) Startup losses	→ Rate of Quality Products = $\frac{\text{Produced Quantity - Defect Quantity}}{\text{Produced Quantity}} \times 100$

Overall Equipment Effectiveness,

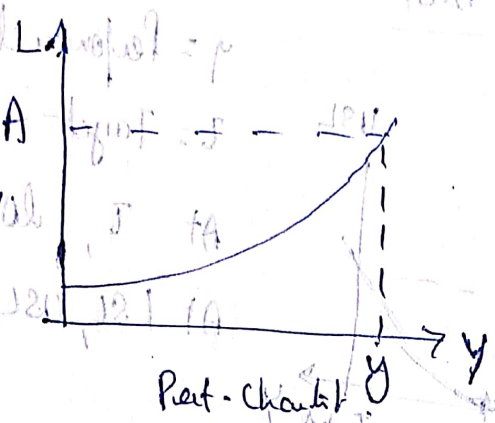
OEE = Availability × Performance Efficiency × Rate of Quality Products

Benefits of TPM :

* ↑ equipment productivity
* ↑ equipment reliability
* ↓ equipment downtime
* ↑ plant capacity
* Extended Machine Line
* Lower maintenance & production costs
* Approaching zero equipment-caused defects
* ↑ teamwork b/w operators & maintenance people
* Enhanced job satisfaction
* ↑ ROI
* ↑ safety.

LEGEND: ↑ - Improved / Increased
↓ - Reduced / Decreased

Layer - the - Bell



Total Productive Maintenance:

Total: All inclusive in the org. working together

Productive = Production of goods that meet or exceed customer expectations

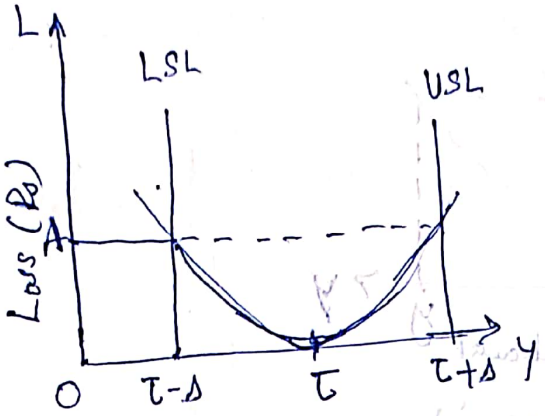
Maintenance - keeping Equipment & plant in good condition at all times

Why TPM? Avoid wastage
Producing goods without reducing quality
Reduce cost for production
Producing non defective goods.

Principles of TPM:

⇒ Use Overall Equipment Effectiveness (OEE) as a company success.
⇒ Improve existing planned maintenance system.
⇒ Work toward zero loss.
⇒ Providing training to upgrade operation & Maintenance skills.
⇒ Involve everyone & utilize cross-functional teamwork

Nominal - the - Best



y = Performance characteristic
τ = Target
At τ, loss is Rs. 0
At LSL, USL, loss is Rs. A.

Quadratic loss function, $L = k(y-\tau)^2$

L = Cost incurred as quality deviate from target
y = performance characteristic
τ = target
k = Quality loss co-efficient
Quality loss co-efficient is determined by, $\Delta = (y-\tau)^m$
∴ When Δ is USL or LSL, Then $L = A$.

$$A = k(\Delta)^2$$
$$k = A/\Delta^2$$

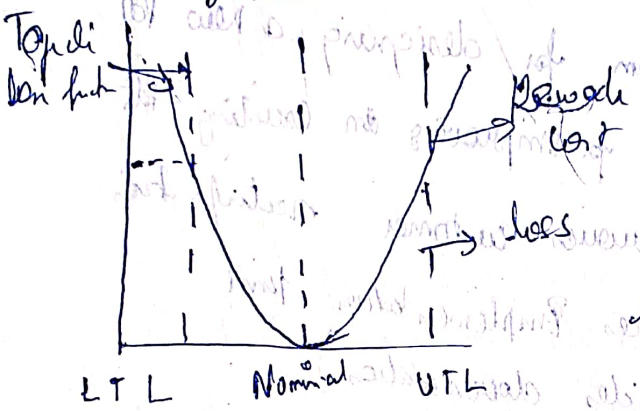
Smaller - the - better

- target value for Smaller-the-better is 0.
- No negative values for pef. Characteristic
- e.g. pollution from an automobile, response time for a computer

Quality loss concept:

- Deviation from target results in loss
  - lower than target
  - Greater than target
- Quality loss occurs when a P/d deviates from target (or) nominal value.
  Deviation grows, then loss increases.

Taguchi's V-shaped loss function curve:



To determine loss curve,

$$L(x) = k(x-N)^2$$

where, $L(x)$ = Loss Function

$k = \frac{C}{d^2}$ = constant of Proportionality

C = Loss amounted with Sp. limit from target value

d = Deviation of Specification

x = Quality feature of selected P/d

N = Nominal value of P/d.

$(x-N)$ = Tolerance

Quality loss fnctn II

$$L(y) = k(y-m)^2$$

$L(y)$ = loss

k = constant

y = response value

m = mean value (avg)

Types of quality loss functions:

1) Nominal - the - best
2) Smaller - the - better
3) Larger - the - better

Unit - IV

TQM Tools & Techniques II

Control Charts - process Capability - Concept of Six Sigma - Quality Function development (QFD) - Taguchi quality loss function - Total Productive Maintenance (TPM) - Concept, improvement and - Performance Measures.

QFD - Quality Function development is a planning tool used to fulfill customer expectations. It is referred as Voice of the customer.

QFD Team: 1) Team for designing a new Pdt
2) Team for improving an existing Pdt

Benefits of QFD: 1) Improves customer satisfaction
2) Reduces Implementation time
3) Provides documentation

TAGUCHI's Quality Loss Function:

* Taguchi methods is a statistical methods developed by Genichi Taguchi to improve quality of mfr. goods.
* philosophy of off-line quality control
* innovations in the design of experiments (DoE)

Taguchi loss function definition:

Taguchi defines Quality as "The loss imparted by the product to society from the time the product is shipped"

Loss = Cost to operate, Failure to function, maintenance & repair cost, customer satisfaction,