

SCAD ENGINEERING COLLEGE

TOTAL QUALITY MANAGEMENT

Mechanical Engineering

GE2022 TOTAL QUALITY MANAGEMENT

UNIT I INTRODUCTION

Introduction - Need for quality - Evolution of quality - Definition of quality - Dimensions of manufacturing and service quality - Basic concepts of TQM - Definition of TQM – TQM Framework - Contributions of Deming, Juran and Crosby – Barriers to TQM.

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

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Quality circles – Quality Function Deployment (QFD) – Taguchi quality loss function – TPM – Concepts, improvement needs – Cost of Quality – Performance measures.

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Need for ISO 9000- ISO 9000:2000 Quality System – Elements, Documentation, Quality auditing- QS 9000 – ISO 14000 – Concepts, Requirements and Benefits – Case studies of TQM implementation in manufacturing and service sectors including IT.

TEXT BOOK:

1. Dale H. Besterfield, et al., “Total Quality Management”, Pearson Education Asia, Third Edition, Indian Reprint (2006)

REFERENCES:

1. James R. Evans and William M. Lindsay, “The Management and Control of Quality”, 6th Edition, South-Western (Thomson Learning), 2005.
2. Oakland, J.S. “TQM – Text with Cases”, Butterworth – Heinemann Ltd., Oxford, 3rd Edition, 2003.
3. Suganthi, L and Anand Samuel, “Total Quality Management”, Prentice Hall (India) Pvt. Ltd., 2006.
4. Janakiraman, B and Gopal, R.K, “Total Quality Management – Text and Cases”, Prentice Hall (India) Pvt. Ltd., 2006.

UNIT I – INTRODUCTION

TQM is defined as both philosophy and a set of guiding principles that represent the foundation of continuously improving organisation. It is the application of quantitative methods and human resources to improve all the process within the organisation and exceed customer needs now and in the future.

Definition of quality

Total Quality Management (TQM) refers to management methods used to enhance quality and productivity in business organizations. TQM is a comprehensive management approach that works horizontally across an organization, involving all departments and employees and extending backward and forward to include both suppliers and clients/customers. Total Quality Management (TQM) refers to management methods used to enhance quality and productivity in business organizations. TQM is a comprehensive management approach that works horizontally across an organization, involving all departments and employees and extending backward and forward to include both suppliers and clients/customers. Total Quality Management (TQM) refers to management methods used to enhance quality and productivity in business organizations. TQM is a comprehensive management approach that works horizontally across an organization, involving all departments and employees and extending backward and forward to include both suppliers and clients/customers.

One of the important issues that business has focused on in the last two decades is —quality. The other issues are cost and delivery. Quality has been widely considered as a key element for success in business in the present competitive market. Quality refers to meeting the needs and expectations of customers. It is important to understand that quality is about more than a product simply working properly.

Quality refers to certain standards and the ways and means by which those standards are achieved, maintained and improved. Quality is not just confined to products and services. It is a homogeneous element of any aspect of doing things with high degree of perfection. For example Business success depends on the quality decision making.

EVOLUTION OF QUALITY

Time Until 1960s	Events
Prior to the 20th century	Quality is an art Demands overcome potential production An era of workmanship
F.Taylor 1900s	The scientific approach to management resulting in rationalization of work and its break down leads to greater need for standardization, inspection and supervision
Shewart 1930s	Statistical beginnings and study of quality control. In parallel, studies by R A Fisher on experimental design; the beginning of control charts at western Electric in USA

Late 1930s	Quality standards and approaches are introduced in France and Japan. Beginning of SQC, reliability and maintenance engineering
1942	Seminal work by Deming at the ministry of war in USA on quality control and sampling Working group setup by Juran and Dodge on SQC in US army Concepts of acceptance sampling devised
1944	Daodge and Deming carried out seminal research on acceptance sampling
1945	Founding of the Japan standard association
1946	Founding of the ASQC
1950	Visit of Deming in Japan at the invitation of K Ishikawa
1951	Quality assurance increasingly accepted
1954	TQC in Japan ; Book published 1956
1957	Founding of European organization for the control of quality
After 1960s	
1961	The Martin Co in USA introduces the zero defects approach while developing and producing Pershing Missiles. Quality motivation is starting in the US and integrated programmes begun
1962	Quality circles are started in Japan

Define Quality .

- . Predictable degree of uniformity and dependability at low cost and suited to the market -Deming
- . Fitness for use-Juran
- . Conformance to requirements - Crosby
- . Minimum loss imparted by a product to society from the time the product is shipped - Taguchi
- . A way of managing tile organization -Feigenbaum
- . Correcting and preventing loss, not living with loss - Hosffin .
- . The totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs – ISO

QUANITIFICATION OF QUALITY

$$Q = P / E$$

P = Performance

E = Expectations

Q = Quality

DIMENSION OF QUALITY

Quality has 2 dimensions. These dimensions are product and service quality.

Dimensions of product quality:

1. Performance: primary product characteristics, e.g. picture brightness in TV.
2. Features: secondary characteristics, added features, e.g. remote control, picture-in-picture.
3. Usability: ease of use with minimum training.
4. Conformance: meeting specifications, industry standards,. (E.g. ISI specs., emission norms).
5. Reliability: consistency of performance over a specified time period under specified conditions.
6. Durability: extent of useful life, sturdiness.
7. Maintainability/Serviceability: ease of attending to maintenance, repairs.
8. Efficiency: ratio of output to input. E.g. mileage, braking distance, processing time.
9. Aesthetics: sensory characteristics, e.g. appearance, exterior finish, texture, color, shape, etc.
10. Reputation: subjective assessment based of past performance, brand image, industry ranking.
11. Safety: in items like pressure cookers, electrical items, toys, cranes, etc.

Dimensions of service quality:

1. Time: how much time a customer must wait / undergo service.
2. Timeliness: whether service will be performed when promised.
3. Completeness: whether all items in the order are included.
4. Consistency: consistent service every time, and for every customer. Reliability of service.
5. Accessibility/Convenience: ease of obtaining the service.
6. Accuracy: absence of mistakes.
7. Responsiveness: quick response, resolution of unexpected problems.
8. Courtesy: cheerful, friendly service.
9. Competency/Expertise: In professions like doctors, lawyers, mechanics, etc.

DIMENSION OF QUALITY	
product quality	Service quality
Performance	Time
Features	Timeliness
Usability	Completeness
Conformance	Consistency
Reliability	Accessibility/Convenience
Durability	Accuracy
Maintainability/Serviceability	Responsiveness
Efficiency	Courtesy
Aesthetics	Competency/Expertise
Reputation	
Safety	

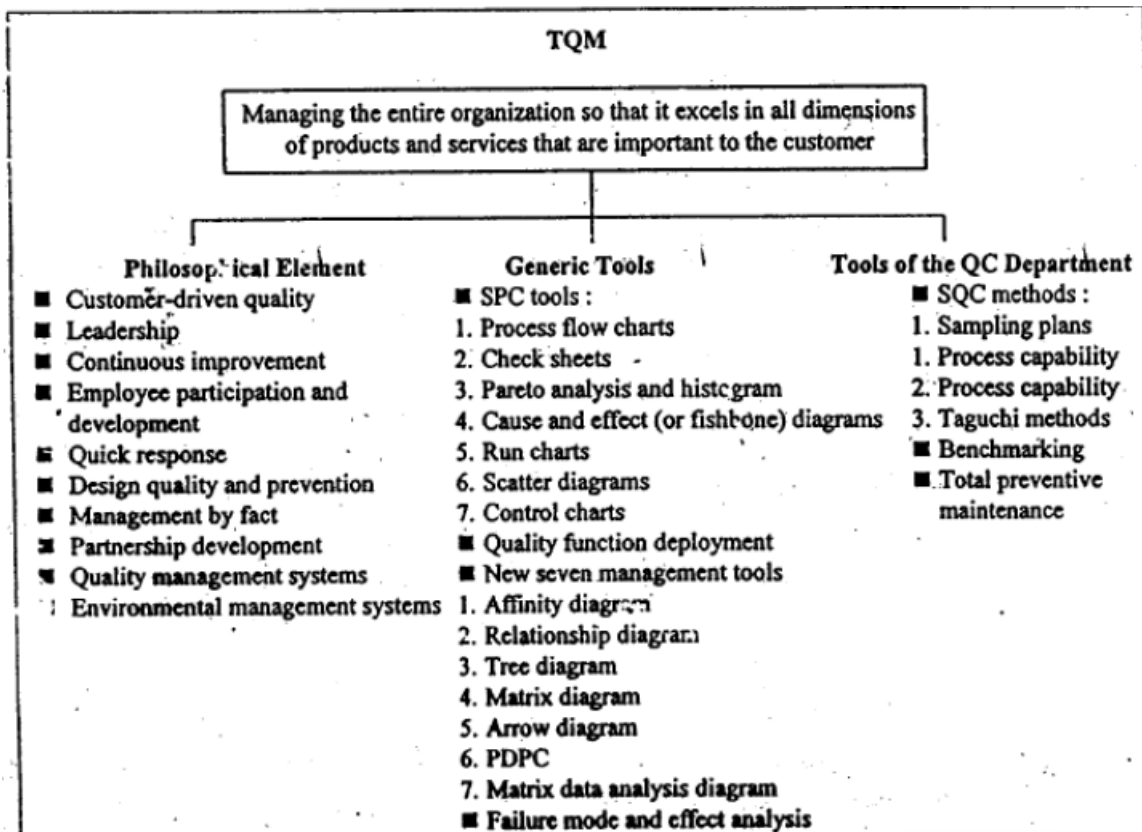
TQM BASIC CONCEPTS

- 1. Management Involvement** – Participate in quality program, develop quality council, direct participation
- 2. Focus on customer** – who is the customer – internal and external, voice of the customer, do it right first time and every time.
- 3. Involvement and utilisation of entire work force** – All levels of management
- 4. Continuous improvement** – Quality never stops, placing orders, bill errors, delivery, minimise wastage and scrap etc.
- 5. Treating suppliers as partners** – no business exists without suppliers.
- 6. Performance measures** – creating accountability in all levels

TQM DEFINITION

1. TQM is the management approach of an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction. and benefits to all members of the organization and to society.- **ISO**
2. TQM is an integrated organizational approach in delighting customers (both internal and external) by meeting their expectations on a continuous basis through every one involved with the organization working on continuous improvement in all products, services, and processes along with proper problem solving methodology - **INDIAN STATISTICAL INSTITUTE (ISI)**
3. TQM is people - focused management system that aims at continual increase in customer satisfaction at continually lower cost. TQM is a total system approach (not a separate area of program), and an integral part of high level strategy. It works horizontally across functions and departments, involving all employees, top to bottom, and extends backwards and forward to include the supply chain and the customer chain – **TOTAL QUALITY FORUM OF USA**

TQM Framework



Contributions of Deming, Juran and Crosby

Deming's 14 points for Management:

1. Create and publicize to all employees the aims and purposes of the organization.
2. Adopt the new philosophy (of customer satisfaction, continuous improvement, defect prevention, management-labour cooperation, etc.).
3. Stop dependence on inspection to achieve quality. (Managers must understand how variation affects their processes and take steps to reduce the causes of variation. Workers must take responsibility for their own work).
4. End the practice of awarding business on the basis of price tag alone. (Costs due to inferior materials/components increase costs in the later stages of production. Suppliers themselves are part of the whole system and hence should be treated as long-term partners).
5. Improve constantly and forever the system of production and service. (Aim for small, incremental, continuous improvements – not merely in the area of production but also covering transportation, maintenance, sales, service, administration, etc. – all areas of the organization).
6. Institute training. (Employees need the proper tools and knowledge to do a good job, and it is management's responsibility to provide these. Training not only improves quality and productivity, but also enhances workers' morale).
7. Adopt modern methods of supervision and leadership. (Managers, Supervisors should act as coaches, facilitators and not as policemen).

8. Drive out fear. (Fear in work manifests as fear of reprisal, fear of failure, fear of change, fear of the unknown. Fear encourages short-term, selfish thinking, not long-term improvement for the benefit of all).
9. Break down barriers between departments and individuals. (Promote teamwork).
10. Eliminate the use of slogans and exhortations. (Workers cannot improve solely through motivational methods when the system in which they work constrains their performance. On the contrary, they will become frustrated, and their performance will decrease further).
11. Eliminate work standards, numerical quotas, and MBO. (Numerical quotas reflect short-term perspectives and do not encourage long-term improvement. Workers may shortcut quality to reach the goal. The typical MBO system focuses on results, not processes, and encourages short-term behavior).
12. Remove barriers to pride in workmanship. (Treating workers as commodities; giving them monotonous jobs, inferior tools; performance appraisals, management assuming it is smarter than workers and not using the workers' knowledge and experience to the fullest extent).
13. Encourage education and self-improvement for everyone.
14. Take action to achieve the transformation. (The TQ philosophy is a major cultural change, and many firms find it difficult. Top management must take the initiative and include everyone in it).

Contributions of Juran to TQM.

Biographical:

- + Joseph M. Juran, Ph.D. (1904-). Born in Romania. His parents migrated to the USA.
- + Worked at Western Electric Co. from 1924 to 1941. There he got exposed to the concepts of Shewhart.

Contributions:

- + In 1951, he published 'Quality Control Handbook' which is still a standard reference for quality control departments in organizations.
- + Traveled to Japan in 1954 to teach quality management to the Japanese at the invitation of the Japanese Union of Scientists and Engineers (JUSE). Juran and Deming introduced the concept of SQC to the Japanese. Helped the Japanese to improve quality to unprecedented levels.
- + Developed, published in 1986, the **Juran Trilogy (Quality Trilogy)** of three inter-related processes
 - quality planning, quality control, and quality improvement – for managing quality.
- + He popularized the concept of **Fitness for Quality** – comprising of Quality of Design, Quality of Conformance, Availability (reliability), Safety and Field Service.
- + Along with Deming, he introduced the concept of 'Quality Assurance'.
- + He formulated a Quality Planning Roadmap.

Quality Planning Roadmap.

1. Identify your customers,
2. Find out their needs,
3. Translate them into technical requirements,
4. Develop the product,
5. Develop and validate the process,
6. Translate the resulting plan to the operating personnel.

+ He advocated the accounting and analysis of quality costs to focus attention on quality problems.

+ He emphasized that upper management in particular needed training and experience in managing for quality. At the operational level, his focus was on increasing conformance to specifications through the elimination of defects, supported by statistical analysis.

+ Founded Juran Institute in 1979 to provide training, consulting services for improving business performance and attaining quality leadership.

+ His book 'Managerial Breakthrough' (1964) presented the concept of '**Universal Breakthrough Sequence (or Breakthrough improvement)**', which has now evolved into Six Sigma, the basis for quality initiatives worldwide.

+ Juran described quality from the customer perspective as having two aspects:

- (i) Higher quality means a greater number of features that meet customers' needs.
- (ii) Freedom from trouble' – higher quality consists of fewer defects.

+ Juran is recognized as the person who added the human dimension to quality – broadening it from its statistical origins, and thus helping develop the concept of TQM.

Contributions of Crosby to TQM.

Biographical:

* Philip B. Crosby (1926-2001)

* Was Corporate Vice President for Quality at International Telephones & Telegraph (AT&T) for 14 years after working his way up from line inspector.

* After leaving AT&T, he established Philip Crosby Associates in 1979 to develop and offer training programs. Guided GM, Chrysler, Xerox, Motorola, etc. in quality management.

* He wrote 13 books on quality, many of which were translated into 17 languages, sold millions of copies, and changed the way management looked at quality. Two of his most popular books are: 'Quality is Free' (1979) and 'Quality Without Tears' (1984).

Contributions:

* He developed the concept of **Zero Defects**.

* He stated that "doing it right the first time" is less expensive than the costs of detecting and correcting defects.

* The book 'Quality Without Tears' contains the essence of Crosby's philosophy embodied in two concepts:

- (i) **Absolutes of Quality Management**
- (ii) **Basic Elements of Improvement.**

BARRIERS IN TQM IMPLEMENTATION

* Many organizations, especially small ones with niche products, are comfortable with their current state. They are satisfied with their current level of performance and profits. Organizations with this culture will see little need for TQM until they begin to lose market share.

Awareness comes about when (a) the organization loses market share or (b) TQM is mandated by the customer, or (c) management realizes that TQM is a better way to run a business and compete in domestic and world markets.

Once an organization embarks on TQM, the following are some of the major obstacles encountered in implementation:

- Lack of management commitment: Management does not allocate sufficient time and resources for TQM implementation. The purpose is not clearly, consistently communicated to all personnel. Management's compensation is not linked to quality goals such as failure costs, customer complaints, and cycle time reduction.
- Inability to change organizational culture: Even individuals resist change; changing an organization's culture is much more difficult and may require as much as 5 years or more. Exhortations, speeches, slogans are effective only in the short run.
- Improper planning: Absence of two-way communication of ideas during the development of the plan and its implementation.
- Lack of continuous training and education.
- Inadequate use of empowerment and teamwork.
- Lack of employee involvement.
- Non-cooperation of first-line managers and middle management.
- Lack of clarity in vision.
- Emphasis on short-term results.
- Setting of unmanageable, unrealistic goals.
- Bureaucratic system.
- TQM is considered as a quick-fix solution to current problems.
- Treating suppliers as adversaries to be manipulated, taken advantage of Adversarial relationship between workers/unions and management. Motivating employees through fear of punishment.
- Failure to continually improve. Tendency to sit back and rest on one's laurels. Rigidly sticking to one 'success formula'. Lack of access to data and results. Paying inadequate attention to internal and external customers. Ineffective measurement techniques for key characteristics of the organization. Inability to understand the changing needs and expectations of customers. Absence of effective feedback mechanism.

UNIT II TOM PRINCIPLES

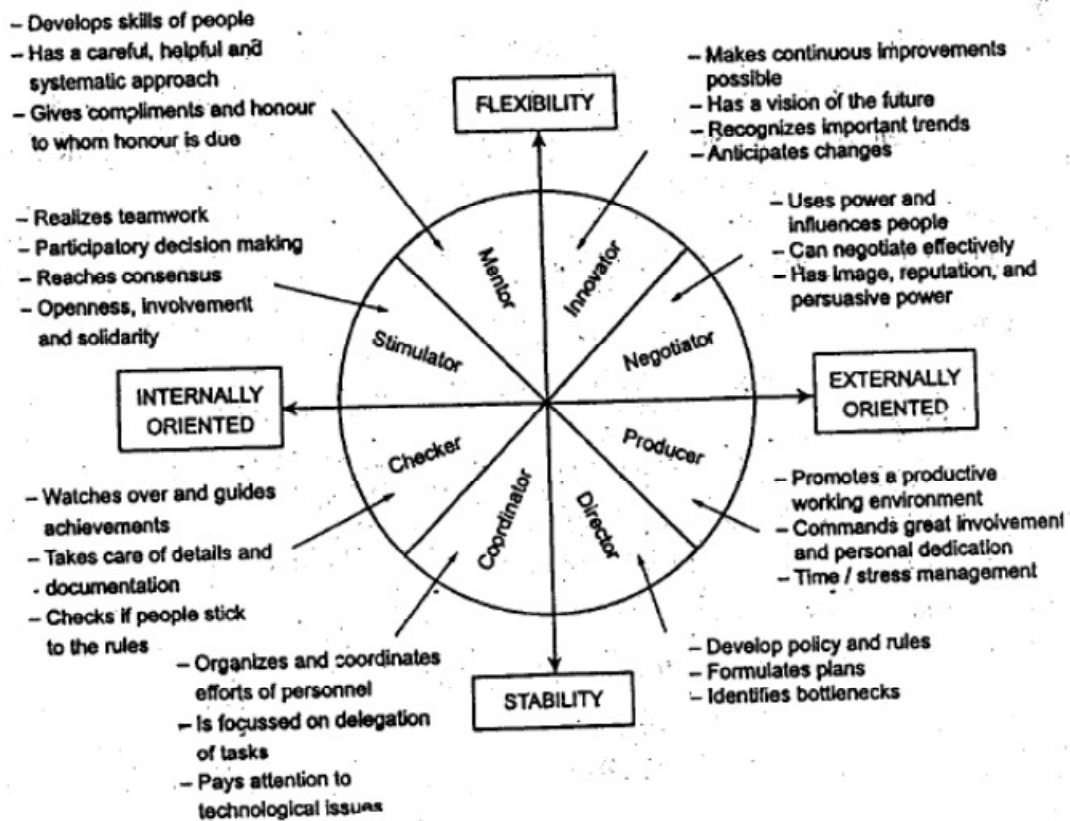
LEADERSHIP

The process of influencing others towards the accomplishment of goals. He triggers the will to do, shows the direction and guide the group members towards the accomplishment of goals.

CHARACTERISTICS OF QUALITY LEADERS

1. Customers first
2. Value people
3. Build supplier partnership
4. Empower people
5. Strive for excellence
6. Demonstrate involvement / commitment
7. Explain & deploy policy
8. Improve communication
9. Promote teamwork
10. Benchmark continuously
11. Establish system
12. Encourage collaboration

LEADERSHIP ROLES

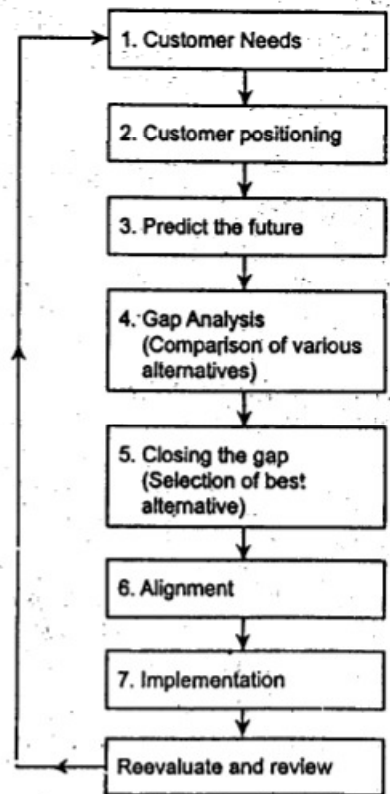


ROLE OF SENIOR MANAGEMENT

1. Study and investigate TQM concepts and issues
2. Set clear quality policies and provide challenging tasks
3. Establish customer satisfaction as a long term goal
4. To become coaches and cheer leaders for encouraging and supporting the managers during transition phase of the transformation
5. To stimulate employees to be involved
6. To attend TQM training programs
7. To up hold norms and issues
8. To create a basic of trust, respect and open communication which ensures individual participation and continuous improvement.
9. To monitor whether quality improvement programs are conducted as planned.

STRATEGIC QUALITY PLANNING

It sets the long term direction of the organization in which it wants to proceed in future. Can be defined "As the process of deciding on objectives of the organization, on changes on this objective, on the resource used to obtain these objectives and on the policies that are to govern the acquisition use and disposition of these resources"



Strategic planning cycle

Quality statements

VISION STATEMENT: It is a short declaration of what an organization aspires to be tomorrow. It is an ideal state which may never be achieved.

Example: —To continuously enrich knowledge base of practioners in mobility industry and institutions in the service of humanity - SAE

MISSION STATEMENT: Describes the function of the organization. It provides the clear statement of purpose for the employees, customers and suppliers.

Example: “Facilitating world class technical education through high quality institutions, academic excellence and innovative research and development programmes, technology forecasting and global manpower planning, promoting industry institute interaction, inculcating entrepreneurship - AICTE

QUALITY POLICY STATEMENT:

It is a guide for everyone in the organization as to how they provide products and services to the customer. Written by the CEO feedback from workforce and approved by quality council.

Example: —Xerox is a quality company. Quality is the basic business principle for Xerox. Quality means providing our external and internal customers with innovative products and service that fully satisfy their requirements. Quality is the job of every employeell – Xerox Corporation

THE CUSTOMERS

- The most important people in the business
- Not dependent on the organization, but the organization depends on them.
- Not an interruption to work but are the purpose of it.
- Doing a favor when they seek business and not vice-versa.
- A part of business, not outsiders and they are life blood of the business
- People who come with their needs and jobs
- Deserve the most courteous and attentive treatment.

TYPES OF CUSTOMERS

Internal Customer: The customer inside the company are called internal customers

External Customers: An external customer is the one who used the product or service or who purchase the products or service or who influences the sale of the product or service.

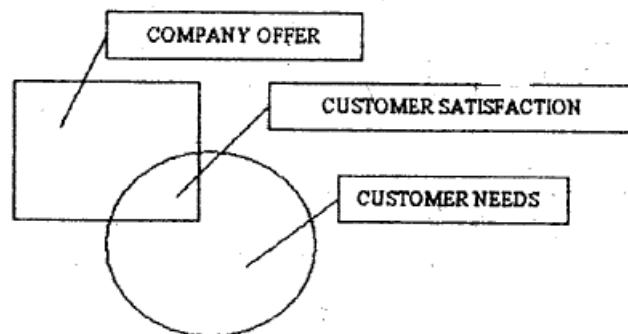
CUSTOMER SATISFACTION

The Customer is the King - Emphasized by Today's Buyers Market. TQM's Purpose is meeting or exceeding customer expectations, so that the customers are delighted. The customer satisfactions must be the primary goal of any organization.

customer satisfaction model

Teboul's Model of customer satisfaction as shown in figure

From the above diagram it is understood that the company should strive for increasing the intersection portion i.e. Customer Satisfaction.



CUSTOMER COMPLAINTS (FEEDBACK)

Customer feedback must be continuously solicited and monitored to reduce the dissatisfied customers as much as possible.

CUSTOMER FEEDBACK OR CUSTOMER COMPLAINT IS REQUIRED

1. To discover customer dissatisfaction
2. To identify customer's needs
3. To discover relative priorities of quality
4. To compare performance with the competition
5. To determine opportunities, for improvement

TOOLS USED FOR COLLECTING CUSTOMER COMPLAINTS

- **Comment card** - Low cost method, usually attached to warranty card
- **Questionnaire** - Popular tool, costly and time consuming - by mail or telephone preferably multiple choice questions or a point rating system (1 to 5) or (1 to 10)
- **Customer Focus groups** - Meeting by a representative of the company with the group of customers. Imprint analysis is an emerging technique to obtain intrinsic feelings using customer meetings, word associations, discussion, relaxation techniques etc.
- **Phone** - Toll free Telephone numbers
- **Customer visits** - Visit customer's place of business.
- **Report cards** - Usually, send to customer on a quarterly basis.
- **The internet and computer** - It includes newsgroups, electronic bulletin board mailing lists,
- Employee feedback.
- **Mass Customization** - Capturing the voice of customers using data of what customer want instead of what customer is thinking about buying and manufacturing exact what they want.

SOLVE CUSTOMER COMPLAINTS

- Complaints can be collected from all sources (letters, phone -calls, meetings and verb inputs)
- Develop procedures for complaint resolution, that include empowering front-line personnel.
- Analyze complaints, but understand that complaints do not always fit into new categories
- Work to identify process and material variations and then eliminate the root cause.
- When a survey response is received, a senior manager should contact the customer and strive to resolve the concern.
- Establish customer satisfaction measures and constantly monitor them.
- Communicate complaint information, as well as the result of all investigation solution, to all people in the organization. .
- Provide a monthly complaint report to the quality council for their evaluation and needed, the assignment of process improvement teams.
- Identify customer's expectations beforehand rather than afterward through complaint analysis.

CUSTOMER RETENTION.

More powerful and effective than customer satisfaction

It is the process of retaining the existing customer

Customer care can be defined as every activity which occurs within the organization that ensures that the customer is not only satisfied but also retained.

SIGNIFICANCE OF CUSTOMER RETENTION

- 60% of organizations future revenue will come from exiting customers
- 2% increase in customer retention has 10% decrease in operating cost.
- 96% of unhappy customers do not complain but 3 times likely to convey to other customers about their bad experience.
- 91% of unhappy customers never purchase goods and services from you.
- It costs 5 times more to attract the customer than retaining the existing customer.
- Customer retention creates customer loyalty and moves customer satisfaction to a next level called customer delight.

EMPLOYEE INVOLVEMENT

It is the total involvement from every person at all levels in the organization

ASPECTS OF EMPLOYEE INVOLVEMENT

1. Employee motivation
2. Employee Empowerment
3. Teams and Team work
4. Recognition and Reward Schemes
5. Performance Appraisal

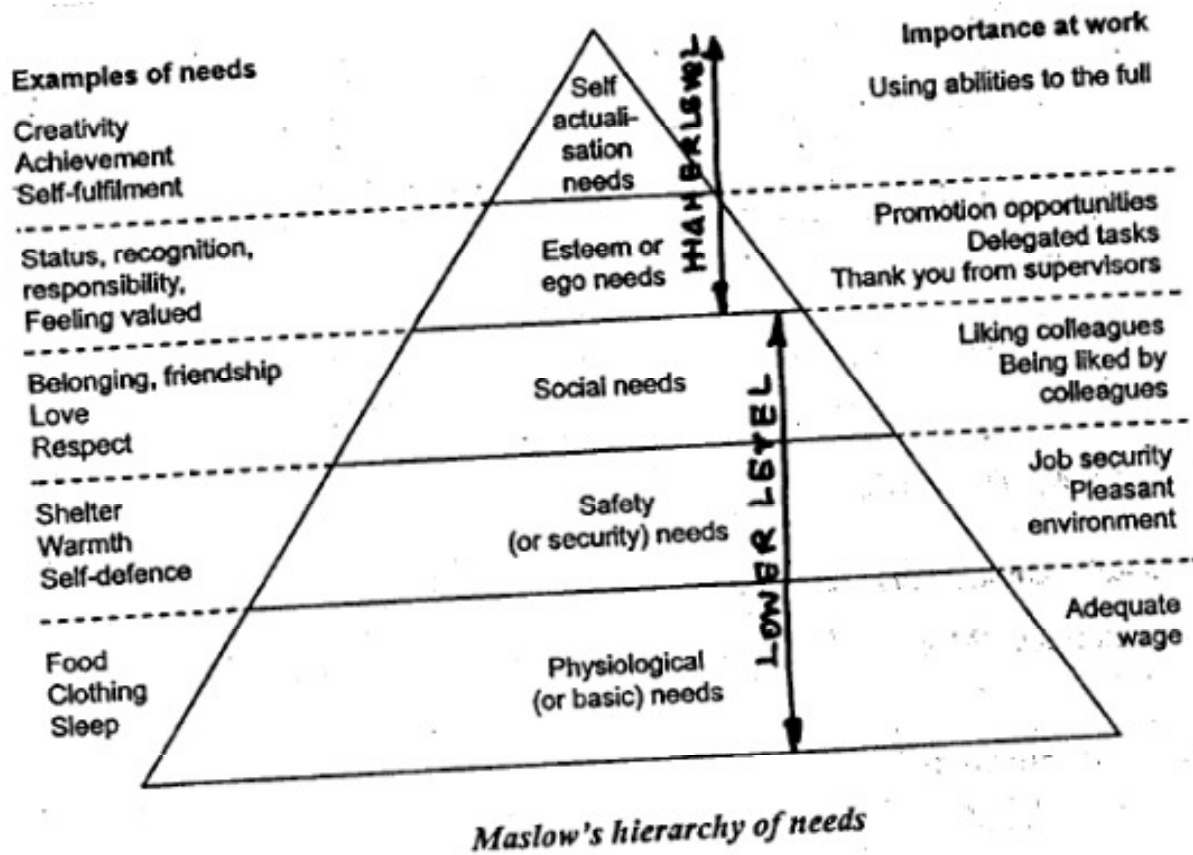
EMPLOYEE MOTIVATION

It is the process of stimulating people or attempting to influence other to do your will or accomplish desire goals through the possibility of reward

1. Improves employee involvement
2. Reduces absenteeism and increases turn over
3. Promotes job satisfaction

THEORIES OF MOTIVATION

1. Maslow's Hierarchy of needs



HERZBERG'S TWO FACTOR THEORY

1. Motivation Factor: People are motivated by recognition, responsibility, achievement, advancement and the work itself. These are called as motivators
2. Dissatisfies or Hygiene Factor: Low salary, minimal fringe benefits, poor working conditions, ill defined organizational policy, mediocre technical supervision are dissatisfies which implies they are preventable.

EMPLOYEE WANTS

1. Good pay factor is normally in the middle of ranking.
2. Normal Wants are interesting work, appreciation, involvement job security, Good pay, Promotion/growth, Good working conditions, Loyalty to employees, Help with personal problems and Tactful Discipline.

EMPLOYEE EMPOWERMENT.

It is an environment in which people have the ability, the confidence and the commitment to take his responsibility and ownership to improve the process and initiate the necessary steps to satisfy customer requirements within well-defined boundaries in order to achieve organizational values and goals.

Job Enrichment: Is expanding content of the Job.

Job Empowerment: Is expanding the context of the job.

GENERAL PRINCIPLES OR CHARACTERISTICS FOR 'EMPOWERING EMPLOYEES

1. Tell people what their responsibilities are.
2. Given the authority equal to the responsibility assigned to them.
3. Set standards of excellence.
4. Give them knowledge information and feed back.
5. Trust them and treat them with dignity and respect.

CONDITIONS TO CREATE THE EMPOWERED ENVIRONMENT

1. Every one should understand the need to change
2. The system need to change to new paradigm.
3. The organization must provide information, education, and skill to its employees.

TEAMS AND TEAM WORKS

A team can be defined as a group of people working together to achieve common objectives or goals
Team work is the cumulative actions of the team during which each member of the team subordinates his individual interest and opinions for the fulfilling of objectives of the group.

TYPES OF TEAMS

Process improvement team: Involved in improvement of sub processes or processes. Usually has 6-10 members. Disbanded when the objective is reached. May include the local supplier and customer depending on the location

Cross functional teams: 6-10 members temporary team. Members are Top management level from various functional areas of management. Discuss complex problems and break down into smaller parts to refer it to various departmental teams for further solution.

Natural work teams: Not voluntary and the total work unit is part of the team. Manager also a part of the team and the management selects the projects to be improved. Managers must also ensure that the entire team is comfortable with each other.

Self directed / self managed work team: Extension of natural work teams but here the group of individuals is empowered not only to do work but manage it. No manager will present but a coordinator (Which will be normally rotated among members) will be appointed. Additional responsibilities of the team hiring/ dismissal, performance evaluation, customer relations, supplier relations, recognition/rewards and training.

CHARACTERISTICS OF SUCCESSFUL TEAMS

1. **Sponsor:** In order to have effective liaison with quality council, there should be sponsor. The sponsor is a person from the quality council, he is to provide support to the organization
2. **Team Charter:** A team charter is a document that defines the team's mission boundaries, the background of the problem, the team's authority and duties and resources. It also identifies the members and their assigned roles – leader, recorder, time keeper and facilitator.

3. **Team Composition:** Not exceeding 10 members except natural work team and self managed teams.
4. **Training:** The team members should be trained in the problem solving techniques team dynamics and communication skills
5. **Ground Rules:** The team should have separate rules of operation and conduct. Ground rules should be discussed with the members, whenever needed it should be reviewed and revised
6. **Clear objectives, Accountability :** Periodic status report should be submitted to quality council for review
7. **Well defined decision procedure, Resources:** Adequate information should be provided
8. **Trust by the management, Effective problems solving:** Not by hunches or quick fires
9. **Open communication, Appropriate Leadership, Balanced participation and Cohesiveness**

ELEMENTS OF EFFECTIVE TEAM WORK

Regular scheduling with a fixed time limit, purpose, role and responsibilities, activities, decision, results and recognition.

TEAM MANAGEMENT WHEEL

To make a lean more effective a team management wheel has been evolved. The activities are advising, innovating, promoting, developing, organization, producing, inspecting, maintaining and linking. The roles of wheel are advisor, explore, organizer and controller.

STAGES OF TEAM DEVELOPMENT

- Forming stage- Initial stage with only group of individuals and no team work. Team purpose, roles are created.
- Storming Stage -Initial agreement roles are challenged. Hostilities, emerge which may be resolved
- Norming Stage-Formal informal relations get established.
- Performing Stage -Team operates in a successful manner with trust, openness, healthy conflict and decisiveness among the members.
- Maintenance stage – Functioning should not deteriorate with time Evaluating Stage – Evaluating team performance

RECOGNITION AND REWARD.

Recognition is a process whereby management shows acknowledgement (Verbal or written) of an employee outstanding performance. Recognition is a form of employee +ve motivation.

Reward is a tangible one such as increased salaries, commission, cash bonus, gain sharing etc., to promote desirable behavior. It can be even theatre tickets, dinner for two, a small cash awards, etc., The employees are recognized to improve their morale, show the company's appreciation for Better Performance, create satisfied and motivated workplace and stimulate creative efforts.

INTRINSIC VS EXTRINSIC REWARDS

INTRINSIC REWARDS	EXTRINSIC REWARDS
Related to feeling of accomplishment or self worth 1. Non monetary forms of recognition to acknowledge achievement of quality improvement goals 2. Celebrations to acknowledge achievement of quality improvement goals	Related to pay or compensation issues 1. Profit sharing 2. Gain sharing 3. Employment security 4. Compensation time 5. Individual based performance systems

<p>3. Regular expression of appreciation by managers and leaders to employees to acknowledge achievement of quality improvement goals</p> <p>4. 360o performance appraisals feedback from co-workers, subordinates or customers is incorporated into performance appraisal</p> <p>5. Formal suggestion system available for individuals to make quality improvement suggestion</p> <p>6. Developmental based performance appraisals</p> <p>7. Quality based promotion</p>	<p>6. Quality based performance appraisals</p>
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STEVE SMITH'S TWENTY DIFFERENT WAYS TO RECOGNIZE THE EMPLOYEES

- Send thank letter whenever possible
- Develop behind the scenes award
- Create the best ideas of the year booklet
- Feature the quality team of the month and put their picture in prominent place
- Honor peers by recognizing them
- Allow people to attend meetings in your name when you are not available
- Involve teams with external customers and suppliers by visiting them
- Invite a team for coffee or lunch whenever possible
- Create a visibility wall displaying posters, pictures, to thank the contributions of employee
- Credit the team to higher authorities when their ideas are accepted
- Take interest in employee's development
- Get the team picture in company newspaper
- Mention the ideas of others during your meetings, so that they are recognized
- Write a letter of praise to contributed team member and copy to boss
- Ask people to help you with the project which is difficult but challenging
- Send a team to special seminars, workshops to cover topics they are really interested in
- Ask your boss to send a letter of acknowledgement and thanks
- Honor outstanding contribution with awards
- Have a stock of small gifts to give to people on the spot whom you catch doing things right
- Promote or nominate for promotion, those people who contribute most

PERFORMANCE APPRAISAL.

It is a systematic and objective assessment or evaluation of performance and contribution of individual

Needs Identifying employees for salary revision, promotion, transfer, demotion, lay off To determine training needs of employee To take organizational inventory of people To know personal strength and weakness of individuals To validate the selection procedure

APPRAISAL FORMATS

Ranking (From highest to lowest), Narrative (Telling strength and weakness), Graphics (Graphical display of duties by rating), Forced choice (Placing each employee with a predetermined % like Good 25%, Poor 10% etc) Performance appraisal.

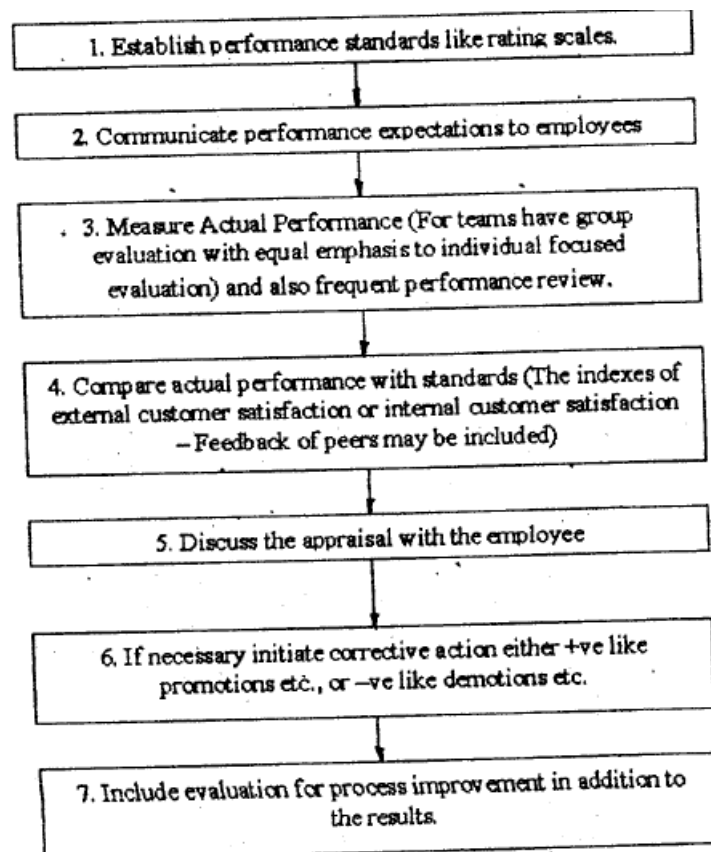
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APPRAISAL PROCESS



BENEFITS OF PERFORMANCE APPRAISAL

1. Provides a feedback to identify employees for salary revision, transfer, lay-off
2. Helps in determining training needs of employee
3. Provides organization inventory of people

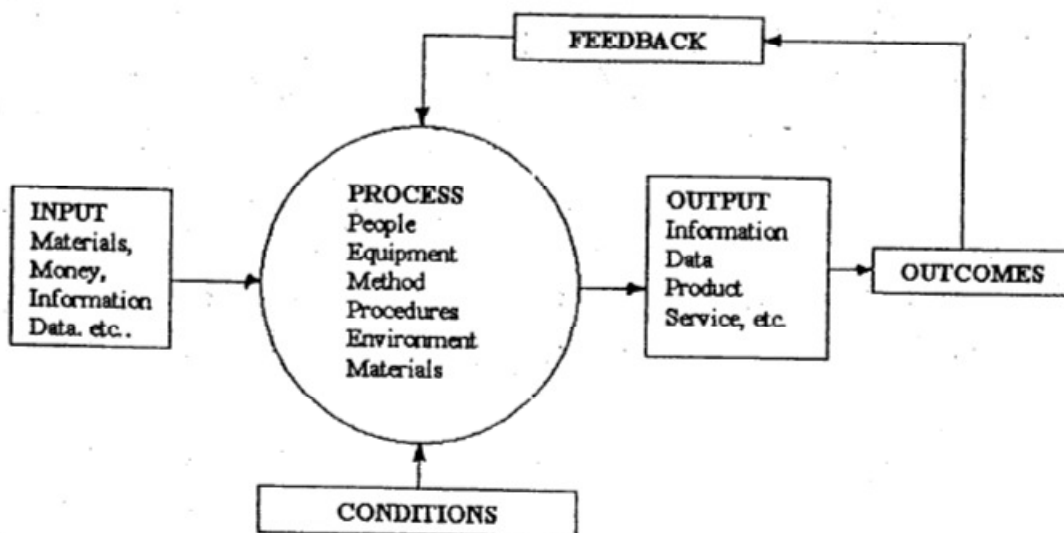
4. Helps to evaluate personal strength and weakness of individuals
5. To validate the selection procedure.
6. Provide the basis for promotion, demotion etc
7. May provide some information on external factors like family circumstances, health, financial or personal matters that may be affecting the performance

CONTINUOUS PROCESS IMPROVEMENT (CPI)

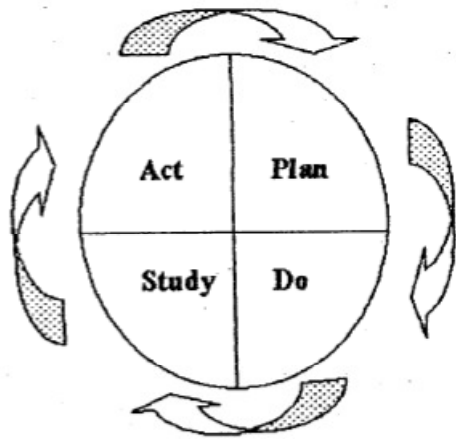
- TQM has been defined as a philosophy based on quest for progress and continual improvement in the areas of cost, reliability, quality, innovation, efficiency and business effectiveness
- It is a continuous learning process which never stops and is cyclic and iterative
- To do CPI, we have different approaches such as Juran Trilogy, PDSA cycle, Kaizen and 5S concept

INPUT / OUTPUT PROCESS MODEL

The process refers to business and production activities of an organization. Example Purchasing, Engineering, Marketing and Accounting



PDSA CYCLE



It is also called as Deming Cycle or Deming Wheel. Developed by Walter A. Shewart and popularized by Edward Deming

PLAN

- Identify the problem, plan and opportunities
- Observe and analyze
- Isolate the real causes
- Determine corrective actions

DO

- Prepare
- Apply
- Check application

STUDY / CHECK

- Check results
- Compare with goals

ACT

- Standardize and consolidate
- Prepare next stage of planning

BENEFITS OF PDSA CYCLE

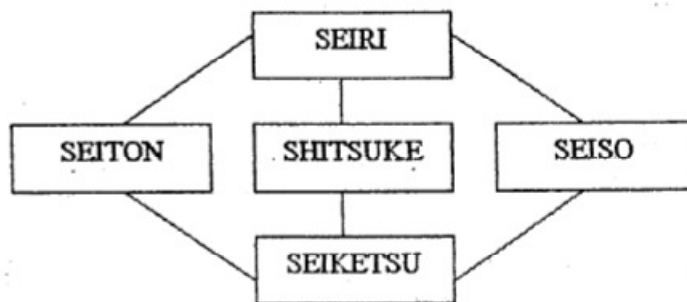
- Daily routine management for the individual and or the team
- Problem solving process
- Project management
- Continuous development
- Vendor development
- Human resource management
- New product development
- Process trials

5S HOUSE KEEPING

This is a house keeping technique used to establish and maintain a productive and quality environment in an organization. This method is invented in Japan which will give safer, more efficient and more productive operation results in boosting of morale of workers, job involvement and satisfaction and ownership of their responsibilities.

JAPANESE TERM	MEANING
SEIRI	Cleaning – Throw away all rubbish unrelated materials in the work place
SEITON	Arranging – Set everything in proper place for quick retrieval and storage
SEISO	Sweeping – Clean the work place, every thing with out fail
SEIKETSU	Maintaining Cleanliness – Standardizing the way of maintaining cleanliness
SHISUKE	Self Discipline – Practice ‘5S’ daily. Make it a way or life. This also means commitment

RELATIONSHIP BETWEEN VARIOUS 5S



OBJECTIVES OF 5S

- Create a neat and clean work place
- Create systemize day to day working
- Improve work efficiency
- Standardize work practice
- Improve work discipline
- Improve the quality of work and products

FACTORS IN IMPLEMENTING 5S

Participation by all - Should be understood and practiced by all employees

Top management commitment – CEO and Senior management team need personally commitment practice and supervise the program

Should be self sustaining – Banners, slogan posters and new tutors should be fully utilized to draw attention of every one

Review the program – Every month group of people from different areas of responsibilities plan and evaluate each zone

BENEFITS IN IMPLEMENTING 5S

- Work place becomes proud place to work
- Results in good image and- generates business
- Operations become easier and safer in work place
- Disciplined people
- Improve productivity' and morality
- Better quality awareness
- More usable space
- Less Material handling time
- Less production cost
- Preventive maintenance
- High employee involvement
- Less accidents
- More time to improvement.

SUPPLIER PARTNERSHIP

A commitment to continuous quality improvement cannot be translated into reality without treating supplier as partner

PRINCIPLES OF CUSTOMER / SUPPLIER RELATION

- Both the customer and the supplier are fully responsible for the control quality
- Both the customer and the supplier should be independent of each other and respect each other's independence
- The customer is responsible for providing the supplier with clear and sufficient requirements so that the supplier can know precisely what to produce
- Both the customer and the supplier should enter into a non adversarial contract with respect to quality, quality, price, delivery method and terms of payments
- The supplier is responsible for providing the quality that will satisfy the customer and submitting necessary data upon the customer's request
- Both the customer and the supplier should decide the methods to evaluate the quality of the product or service to the satisfaction of both parties
- Both the customer and the supplier should establish in the contract the method by which they can reach an amicable settlement of any disputes that may arise
- Both the customer and the supplier should continually exchange information, sometimes using multifunctional teams, in order to improve the product or service quality

- Both the customer and the supplier should perform business activities such as procurement, production and inventory planning, clerical work and system so that an amicable and satisfactory relationship is maintained
- When dealing with business transactions both the customer and the supplier should always have the best interest of the end user in mind

SUPPLIER PARTNERING

It is defined as a continuing relationship, between a buying firm and supplying firm, involving a commitment over an extended time period, an exchange of information, and acknowledgement of the risks and rewards of the relationship.

BENEFITS OF SUPPLIER PARTNERING

Improved Quality Reduced cost Increased Productivity Increased efficiency Increased market share Increased opportunity for innovation Continuous improvement of products/services. .

JAPANESE REVIEW OF PARTNERING

The Japanese partnering concept is **KELRESTU** – developing long term relationships with a few key suppliers rather than having short term relationship with many suppliers.

Key elements to Partnering Long term Commitment Trust Shared vision - To satisfy the end users is the common goal of both supplier and customer.

SUPPLIER SOURCING

Sole sourcing - only one supplier for the entire organization. This may be forced. to happen because of patent, technical specification, raw material location, monopolistic supplier

Multiple sourcing - For a single item having two or more supplier, resulting in better quality, better service at lower cost

UNIT III TQM TOOLS & TECHNIQUES I

THE SEVEN TRADITIONAL TOOLS OF QUALITY

- I - Pareto chart
- II - Flowchart
- III - Cause-and-Effect Diagrams
- IV - Check Sheets
- V - Histograms
- VI - Scatter Diagrams
- VII - Control Charts

Pareto chart:

Italian economist Vilfredo Pareto Shows on a bar graph which factors are more significant. This method helps to find the vital few contributing maximum impact.

Purpose: The purpose of the Pareto chart is to prioritize problems No company has enough resources to tackle every problem, so they must prioritize.

Pareto Principle: The Pareto concept was developed by the describing the frequency distribution of any given characteristic of a population. Also called the 20-80 rule, he determined that a small percentage of any given group (20%) account for a high amount of a certain characteristic (80%).

Conclusion: The most important thing in improving quality is to start somewhere, doing something. As you begin using the Pareto chart to decide where your problems are, you will discover many things about your processes and will come because you will know where to improve.

Flowchart:

A technique that separates data gathered from a variety of sources so that patterns can be seen (some lists replace "stratification" with or "run chart").

Purpose: Flow Charts provide a visual illustration of the sequence of operations required to complete a task.

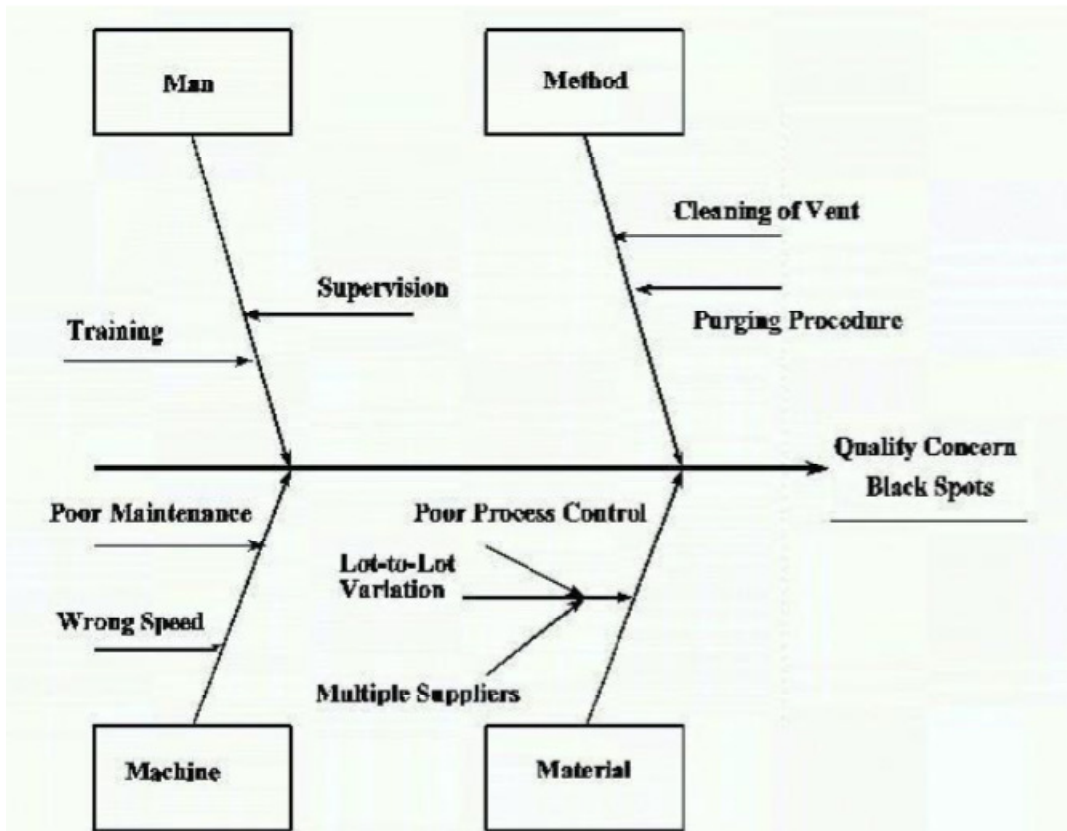
A picture of the steps the process undergoes to complete it's task. Every process will require input(s) to complete it's task, and will provide output(s) when the task is completed. Flow charts can be drawn in many styles. Flow charts can be used to describe a single process, parts of a process, or a set of processes. There is no right or wrong way to draw a flow chart. The true test of a flow chart is how well those who create and use it can understand it.

Input —————> Process —————> Output

Cause-and-Effect Diagrams

1943 by Mr. Kaoru Ishikawa at the University of Tokyo

Purpose: One important part of process improvement is continuously striving to obtain more information about the process and it's output. Cause-and-effect diagrams allow us to do not just that, but also can lead us to the root cause, or causes, of problems



Constructing the Cause-and-Effect Diagram:

Step 1: Select the team members and a leader. Team members knowledgeable about the quality. Team members focus on the problem under investigation.

Step 2: Write the problem statement on the right hand side of the page, and draw a box around it with an arrow running to it. This quality concern is now the effect.

Step 3: Brain-storming. The team members generate ideas as to what is causing the effect.

Step 4: This step could be combined with step 3. Identify, for each main cause, its related sub-causes that might affect our quality concern or problem (our Effect). Always check to see if all the factors contributing to the problem have been identified. Start by asking why the problem exists.

Step 5: Focus on one or two causes for which an improvement action(s) can be developed using other quality tools such as Pareto charts, check sheets, and other gathering and analysis tools.

Conclusion: Improvement requires knowledge. The more information we have about our processes the better we are at improving them. Cause-and-effect diagrams are one quality tool that is simple yet very powerful in helping us better understand our processes.

Check Sheets

Purpose: Check sheets allow the user to collect data from a process in an easy, systematic, and organized manner.

Data Collection: Before we can talk about check sheets we need to understand what we mean by data collection. This collected data needs to be accurate and relevant to the quality problem. The first is to establish a purpose for collecting this data. Second, we need to define the type of data that is going to be collected. Measurable data such as length, size, weight, time,...etc., and

countable data such as the number of defects. The third step is to determine who is going to collect that data and when it should be collected.

Histograms

Purpose: To determine the spread or variation of a set of data points in a graphical form. It is always a desire to produce things that are equal to their design values.

Histograms: A histogram is a tool for summarizing, analyzing, and displaying data. It provides the user with a graphical representation of the amount of variation found in a set of data.

Constructing a Histogram: The following are the steps followed in the construction of a histogram:

Data collection: To ensure good results, a minimum of 50 data points, or samples, need to be collected

Calculate the range of the sample data: The range is the difference between the largest and smallest data points. *Range = Largest point - smallest point.*

Calculate the size of the class interval. The class interval is the width of each class on the X axis. It is calculated by the following formula:

Class interval = Range / Number of classes.

Calculate the number of data points (frequency) that are in each class. A tally sheet is usually used to find the frequency of data points in each interval.

Conclusion: Histogram is simple tools that allow the user to identify and interpret the variation found in a set of data points. It is important to remember that histograms do not give solutions to problems.

Scatter Diagrams

Purpose: To identify correlations that might exist between a quality characteristic and a factor that might be driving it.

Scatter Diagrams: A scatter diagram is a nonmathematical or graphical approach for identifying relationships between a performance measure and factors that might be driving it. This graphical approach is quick, easy to communicate to others, and generally easy to interpret.

Interpreting the Results: Once all the data points have been plotted onto the scatter diagram, you are ready to determine whether there exists a relation between the two selected items or not. When a strong relationship is present, the change in one item will automatically cause a change in the other. If no relationship can be detected, the change in one item will not effect the other item. There are three basic types of relationships that can be detected to on a scatter diagram: 1. Positive relationship 2. Negative relationship 3. No relationship

Conclusion: Scatter diagrams allow the user to graphically identify correlations that could exist between a quality characteristic and a factor that might be driving it. It is a quality tool that is simple, easy to communicate to others, and generally easy to interpret

Control Charts

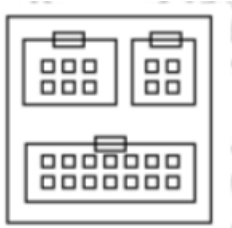
Purpose: Process is in control and to monitor process variation on a continuous basis. Identifying the tolerance level in the variations. Control charts is one SPC tool that enables us to monitor and control process variation. Types of variation Common and Special Cause Variation

Control charts: Developed in the mid 1920's by Walter Shewhart of Bell labs. There are two basic types of control charts, the average and range control charts. The first deals with how close the process is to the nominal design value, while the range chart indicates the amount of spread or variability around the nominal design value. A control chart has basically three line: the upper control limit UCL, the center line CL, and the lower control limit LCL. A minimum of 25 points is required for a control chart to be accurate.

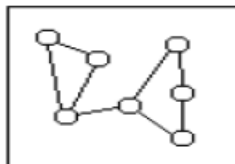
NEW MANAGEMENT TOOLS

Seven New Management and Planning Tools In 1976, the Union of Japanese Scientists and Engineers (JUSE) saw the need for tools to promote innovation, communicate information and successfully plan major projects. A team researched and developed the seven new quality control tools, often called the seven management and planning (MP) tools, or simply the seven management tools. Not all the tools were new, but their collection and promotion were. The seven MP tools, listed in an order that moves from abstract analysis to detailed planning, are:

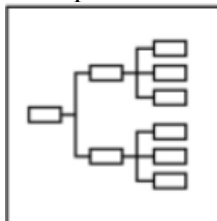
1. Affinity diagram: organizes a large number of ideas into their natural relationships.



2. InterRelations diagram: shows cause-and-effect relationships and helps you analyze the natural links between different aspects of a complex situation.



3. Tree diagram: breaks down broad categories into finer and finer levels of detail, helping you move your thinking step by step from generalities to specifics.



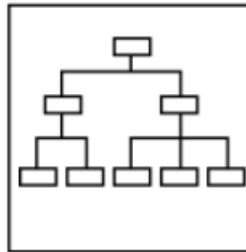
4. Matrix diagram: shows the relationship between two, three or four groups of information and can give information about the relationship, such as its strength, the roles played by various individuals, or measurements.

	a	b	c	d	e	f
1						
2						
3						
4						
5						
6						

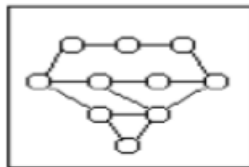
5. Matrix data analysis: a complex mathematical technique for analyzing matrices, often replaced in this list by the similar prioritization matrix. One of the most rigorous, careful and time-consuming of decision-making tools, a prioritization matrix is an L-shaped matrix that uses pairwise comparisons of a list of options to a set of criteria in order to choose the best option(s).

	a	b	c	d	e	f
1						
2						
3						
4						
5						
6						

6. Arrow diagram: shows the required order of tasks in a project or process, the best schedule for the entire project, and potential scheduling and resource problems and their solutions



7. Process decision program chart (PDPC): systematically identifies what might go wrong in a plan under development.



SIX SIGMA

Six Sigma has evolved over the last two decades and so has its definition. Six Sigma has literal, conceptual, and practical definitions. Features that set Six Sigma apart from previous quality improvement initiatives include –
 clear focus on achieving measurable and quantifiable financial returns from any project.
 etc. to lead and implement the Six Sigma approach.
 assumptions and guesswork.

At Motorola University, we think about Six Sigma at three different levels:

- As a metric
- As a methodology
- As a management system

Essentially, Six Sigma is all three at the same time.

Six Sigma as a Metric

The term "Sigma" is often used as a scale for levels of "goodness" or quality. Using this scale, "Six Sigma" equates to 3.4 Defects Per Million Opportunities (DPMO). Six Sigma started as a defect reduction effort in manufacturing and then applied to other business processes for the same purpose. Taking the 1.5 sigma shift into account, short-term sigma levels correspond to the following long-term DPMO values (one-sided):

- One Sigma = 690,000 DPMO => efficiency 31%
- Two Sigma = 308,000 DPMO => efficiency 69.2%
- Three Sigma = 66,800 DPMO => efficiency 93.32%
- Four Sigma = 6,210 DPMO => efficiency 99.379%
- Five Sigma = 230 DPMO => efficiency 99.977%
- Six Sigma = 3.4 DPMO => efficiency 99.9997%

Six Sigma as a Methodology

As Six Sigma has evolved, there has been less emphasis on the literal definition of 3.4 DPMO, or counting defects in products and processes. Six Sigma is a business improvement methodology that focuses an organization on:

- Understanding and managing customer requirements
- Aligning key business processes to achieve those requirements
- Utilizing rigorous data analysis to minimize variation in those processes
- Driving rapid and sustainable improvement to business processes

At the heart of the methodology is the DMAIC model for process improvement. DMAIC is commonly used by Six Sigma project teams and is an acronym for:

DMAIC - The basic methodology consists of the following five steps:

- ❑ **Define** process improvement goals that are consistent with customer demands and the enterprise strategy.
- ❑ **Measure** key aspects of the current process and collect relevant data.
- ❑ **Analyze** the data to verify cause-and-effect relationships. Determine what the relationships are, and attempt to ensure that all factors have been considered.
- ❑ **Improve** or optimize the process based upon data analysis using techniques like Design of Experiments.
- ❑ **Control** to ensure that any deviations from target are corrected before they result in defects. Set up pilot runs to establish process capability, move on to production, set up control mechanisms and continuously monitor the process.

DMADV

The basic methodology consists of the following five steps:

- **Define** design goals that are consistent with customer demands and the enterprise strategy.
- **Measure** and identify CTQs (characteristics that are **Critical To Quality**), product capabilities, production process capability, and risks.
- **Analyze** to develop and design alternatives, create a high-level design and evaluate design capability to select the best design.
- **Design** details, optimize the design, and plan for design verification. This phase may require simulations.
- **Verify** the design, set up pilot runs, implement the production process and hand it over to the process owners.

Implementation roles –

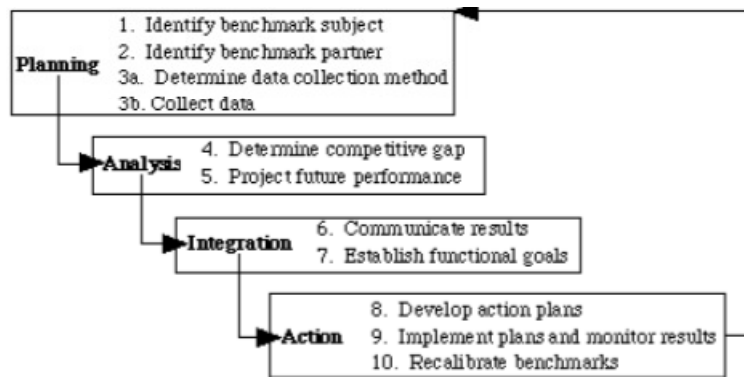
One of the key innovations of Six Sigma is the professionalizing of quality management functions. Prior to Six Sigma, quality management in practice was largely relegated to the production floor and to statisticians in a separate quality department. Six Sigma borrows martial arts ranking terminology to define a hierarchy (and career path) that cuts across all business functions and a promotion path straight into the executive suite.

BENCHMARKING

"Benchmarking: A continuous, systematic process of evaluating and comparing the capability of one organization with others normally recognized as industry leaders, for insights for optimizing the organizations processes." **Benchmarking** is the process of comparing the cost, time or quality of what one organization does against what another organization does. The result is often a business case for making changes in order to make improvements. The systematic process of comparing an organization's products, services and practices against those of competitor organizations or other industry leaders to determine what it is they do that allows them to achieve high levels of performance. (Society for Human Resources Management)

Advantages of benchmarking

Benchmarking is a powerful management tool because it overcomes "paradigm blindness." Benchmarking opens organizations to new methods, ideas and tools to improve their effectiveness. It helps crack through resistance to change by demonstrating other methods. Allows employees to visualise the improvement which can be a strong motivator for change Helps to identify weak areas and indicates what needs to be done to improve.



THE BENCHMARKING PROCESS

The formal 10-step benchmarking process is shown in outline below.

1. PLANNING.

The essential steps are those of any plan development: what, who and how.

What is to be benchmarked:

Every function of an organization has or delivers a product or output. Benchmarking is appropriate for any output of a process or function, whether it's a physical good, an order, a shipment, an invoice, a service or a report.

To whom or what will we compare?

Business-to-business, direct competitors are certainly prime candidates to benchmark. But they are not the only targets. Benchmarking must be conducted against the best companies and business functions regardless of where they exist.

How will the data be collected?

There is no one way to conduct benchmarking investigations. There is an infinite variety of ways to obtain required data – and most of the data you will need are readily and publicly available. Recognize that benchmarking is a process not only of deriving quantifiable goals and targets, but more importantly, it is the process of investigating and documenting the best industry practices, which can help you achieve goals and targets.

2. ANALYSIS.

The analysis phase must involve a careful understanding of your current process and practices, as well as those of the organizations being benchmarked. What is desired is an understanding of internal performance on which to assess strengths and weaknesses.

3. INTEGRATION.

Integration is the process of using benchmark findings to set operational targets for change. It involves careful planning to incorporate new practices in the operation and to ensure benchmark findings are incorporated in all formal planning processes.

Steps include:

Gain operational and management acceptance of benchmark findings. Clearly and convincingly demonstrate findings as correct and based on substantive data.

Develop action plans.

Communicate findings to all organizational levels to obtain support, commitment and ownership.

4. ACTION.

Convert benchmark findings, and operational principles based on them, to specific actions to be taken. Put in place a periodic measurement and assessment of achievement. Use the creative talents of the people who actually perform work tasks to determine how the findings can be incorporated into the work processes. Any plan for change also should contain milestones for updating the benchmark findings, and an ongoing reporting mechanism. Progress toward benchmark findings must be reported to all employees. 5. Maturity. Maturity will be reached when best industry practices are incorporated in all business processes, thus ensuring superiority. Tests for superiority:

If the now-changed process were to be made available to others, would a knowledgeable businessperson prefer it?

Do other organizations benchmark your internal operations?

Maturity also is achieved when benchmarking becomes an ongoing, essential and self-initiated facet of the management process. Benchmarking becomes institutionalized and is done at all appropriate levels of the organization, not by specialists.

Types of Benchmarking.

- Process benchmarking - the initiating firm focuses its observation and investigation of business processes with a goal of identifying and observing the best practices from one or more benchmark firms. Activity analysis will be required where the objective is to benchmark cost and efficiency; increasingly applied to back-office processes where outsourcing may be a consideration.
- Financial benchmarking - performing a financial analysis and comparing the results in an effort to assess your overall competitiveness.
- Performance benchmarking - allows the initiator firm to assess their competitive position by comparing products and services with those of target firms.
- Product benchmarking - the process of designing new products or upgrades to current ones. This process can sometimes involve reverse engineering which is taking apart competitors products to find strengths and weaknesses.
- Strategic benchmarking - involves observing how others compete. This type is usually not industry specific meaning it is best to look at other industries.
- Functional benchmarking - a company will focus its benchmarking on a single function in order to improve the operation of that particular function. Complex functions such as Human Resources, Finance and Accounting and Information and Communication Technology are unlikely to be directly comparable in cost and efficiency terms and may need to be disaggregated into processes to make valid comparison

Implementation in manufacturing

Poka-yoke can be implemented at any step of a manufacturing process where something can go wrong or an error can be made. For example, a jig that holds pieces for processing might be modified to only allow pieces to be held in the correct orientation, or a digital counter might track

the number of spot welds on each piece to ensure that the worker executes the correct number of welds.

Shigeo Shingo recognized three types of poka-yoke for detecting and preventing errors in a mass production system:

1. The *contact* method identifies product defects by testing the product's shape, size, color, or other physical attributes.

2. The *fixed-value* (or *constant number*) method alerts the operator if a certain number of movements are not made.

3. The *motion-step* (or *sequence*) method determines whether the prescribed steps of the process have been followed.

Either the operator is alerted when a mistake is about to be made, or the poka-yoke device actually prevents the mistake from being made. In Shingo's lexicon, the former implementation would be called a *warning* poka-yoke, while the latter would be referred to as a *control* poka-yoke.

FMEA

Failure modes and effects analysis (FMEA) is a procedure for analysis of potential failure modes within a system for the classification by severity or determination of the failures' effect upon the system. It is widely used in the manufacturing industries in various phases of the product life cycle and is now increasingly finding use in the service industry as well. Failure causes are any errors or defects in process, design, or item especially ones that affect the customer, and can be potential or actual. *Effects analysis* refers to studying the consequences of those failures.

Step 1: Severity

Determine all failure modes based on the functional requirements and their effects. Examples of failure modes are: Electrical short-circuiting, corrosion or deformation. It is important to note that a failure mode in one component can lead to a failure mode in another component. Therefore each failure mode should be listed in technical terms and for function. Hereafter the ultimate effect of each failure mode needs to be considered.

A failure effect is defined as the result of a failure mode on the function of the system as perceived by the user. In this way it is convenient to write these effects down in terms of what the user might see or experience. Examples of failure effects are: degraded performance, noise or even injury to a user.

Each effect is given a **severity number(S)** from 1(no danger) to 10(important). These numbers help an engineer to prioritize. If the severity of an effect has a number 9 or 10, actions are considered to change the design by eliminating the failure mode, if possible, or protecting the user from the effect. A severity rating of 9 or 10 is generally

reserved for those effects which would cause injury to a user or otherwise result in litigation.

Step 2: Occurrence

In this step it is necessary to look at the cause of a failure and how many times it occurs. This can be done by looking at similar products or processes and the failures that have been documented for them. A failure cause is looked upon as a design weakness. All the potential causes for a

failure mode should be identified and documented. Again this should be in technical terms. Examples of causes are: erroneous algorithms, excessive voltage or improper operating conditions.

A failure mode is given a **probability number**(O), again 1-10. Actions need to be determined if the occurrence is high (meaning >4 for non safety failure modes and >1 when the severity-number from step 1 is 9 or 10). This step is called the detailed development section of the FMEA process.

Step 3: Detection

When appropriate actions are determined, it is necessary to test their efficiency. Also a design verification is needed. The proper inspection methods need to be chosen. First, an engineer should look at the current controls of the system, that prevent failure modes from occurring or which detect the failure before it reaches the customer.

Hereafter one should identify testing, analysis, monitoring and other techniques that can be or have been used on similar systems to detect failures. From these controls an engineer can learn how likely it is for a failure to be identified or detected. Each combination from the previous 2 steps, receives a **detection number**(D). This number represents the ability of planned tests and inspections at removing defects or detecting failure modes. After these 3 basic steps, Risk Priority Numbers (RPN) are calculated.

Risk Priority Numbers RPN do not play an important part in the choice of an action against failure modes. They are more threshold values in the evaluation of these actions. After ranking the severity, occurrence and detectability the RPN can be easily calculated by multiplying these 3 numbers: $RPN = S \times O \times D$ This has to be done for the entire process and/or design. Once this is done it is easy to determine the areas of greatest concern. The failure modes that have the highest RPN should be given the highest priority for corrective action. This means it is not always the failure modes with the highest severity numbers that should be treated first. There could be less severe failures, but which occur more often and are less detectable.

Uses of FMEA

Development of system requirements that minimize the likelihood of failures. Development of methods to design and test systems to ensure that the failures have been eliminated. Evaluation of the requirements of the customer to ensure that those do not give rise to potential failures. Identification of certain design characteristics that contribute to failures, and minimize or eliminate those effects. Tracking and managing potential risks in the design. This helps avoid the same failures in future projects. Ensuring that any failure that could occur will not injure the customer or seriously impact a system.

Advantages

- Improve the quality, reliability and safety of a product/process Improve company image and competitiveness
- Increase user satisfaction Reduce system development timing and cost Collect information to reduce future failures
- capture engineering knowledge Reduce the potential for warranty concerns
- Early identification and elimination of potential failure modes Emphasis problem prevention Minimize late changes and associated cost Catalyst for teamwork and idea exchange between functions

Disadvantages

- If used as a top-down tool,
- FMEA may only identify major failure modes in a system.

- Fault tree analysis (FTA) is better suited for "top-down" analysis. When used as a "bottom-up" tool FMEA can augment or complement FTA and identify many more causes and failure modes resulting in top-level symptoms.
- It is not able to discover complex failure modes involving multiple failures within a subsystem, or to report expected failure intervals of particular failure modes up to the upper level subsystem or system. Additionally,
- the multiplication of the severity, occurrence and detection rankings may result in rank reversals, where a less serious failure mode receives a higher RPN than a more serious failure mode. The reason for this is that the rankings are ordinal scale numbers, and multiplication is not a valid operation on them. The ordinal rankings only say that one ranking is better or worse than another, but not by how much. For instance, a ranking of "2" may not be twice as bad as a ranking of "1," or an "8" may not be twice as bad as a "4," but multiplication treats them as though they are.