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1 Total Quality Management: Tools and TechniquesUnit 5 Total Quality Management: Tools and Techniques 2 Total Quality Management (TQM)A management approach to long–term success through customer satisfaction. Based on the principle that every staff member must be committed to maintaining high standards of work in every aspect of a company's operations. In a TQM effort, all members of an organization participate in improving processes, products, services, and the culture in which they work. They achieve this using various quality tools. 3 4 Tools for TQM Pareto Diagram Fishbone/Ishikawa Diagram Check SheetProcess Flow Diagram Scatter Diagram Histogram Control Chart Acceptance Sampling Random Sampling Reliability Design of Experiments (DOE) Process Analysis Tools Quality Function Deployment ISO Series Benchmarking Total Productive Maintenance Management and Planning Tools Lean/Kaizen Quality Issues Six Sigma 5 Pareto Diagram Named after Vilfredo Pareto For vital few, useful manyIn descending order, left to right 6 Pareto Diagram 7 Pareto Chart 8 Fishbone Or Cause-And-Effect DiagramPersonnel Facility Processes Material Goal = Green Product Energy Tooling Product Customer 9 Cause-and-Effect DiagramAlso called fishbone or Ishikawa diagram Helps in tracing cause and effect relationships The effect or problem must first be defined or identified The effect can be positive or negative 10 Ishikawa/Fishbone Diagram 11 Check Sheet 12 13 14 Process Flow Diagram 15 Process Flow Diagram 16 Scatter Diagram 17 18 19 Histogram 20 Control Chart 21 Acceptance Sampling A sampling procedure in which a predetermined number (n) is selected from a lot (N) and inspected If the number of non-conforming units exceed a certain number, the lot is rejected 22 Acceptance Sampling Expressed as: N = 1000; n = 300; c = 3N = Lot size n = Sample inspected c = acceptable defective units 23 Random Sampling Applied HereIn random sampling, each item or element of the population has an equal chance of being chosen at each draw 24 Reliability Ability of a product to perform its intended function over a period of time 25 Design of experiments (DOE)Key objective is to determine those variables in a process or product that are critical parameters Experiments help to study the effects of those variables 26 Process Analysis Tool (Process Chart) 27 Failure Mode and Effects Analysis (FMEA)(Source: FMEA helps a team to identify potential failure modes based on past experience with similar products or processes, enabling the team to design those failures out of the system with minimum effort and resource expenditure 28 Quality Function Deployment (QFD)Helps transform customer needs into engineering characteristics A system that identifies and sets priorities for product, service and process improvement opportunities Leads to customer satisfaction 29 Quality Function Deployment (QFD) 30 ISO 9000 Series: ISO = International Organization for StandardsISO 9000 series has three standards: ISO 9000 covers fundamentals and vocabularies ISO 9001 is the general requirements ISO 9004 provides guidance for performance improvement in: Quality management system (QMS) Management responsibility Resource management Product/service realization Measurement, analysis, and improvement 31 ISO 9001:2008 Is part of the ISO 9000 family of standards, and is the document that lists the requirements an organization must meet to become ISO 9001 Registered. Is an internationally recognized Quality Management System. ISO 9001 does NOT define the actual quality of your product or service. The standard helps you achieve consistent results and continually improve the process. Thus, if you can make a good product most of the time, this helps you make it all of the time. 32 What is a Quality Management System?A set of policies, processes and procedures required for planning and execution (production/development/service) in the core business area of an organization. (i.e. areas that can impact the organization's ability to meet customer requirements.) ISO 9001:2008 is an example of a Quality Management System. 33 ISO 14000 ISO is the international standard for environmental management system (EMS) 34 Top 10 Countries for ISO 9001 Certificates - 2009Rank Country No. of certificates 1 China 257076 2 Italy 130066 3 Japan 68484 4 Spain 59576 5 Russian Federation 53152 6 Germany 47156 7 United Kingdom 41193 8 India 37493 9 USA 28935 10 Korea, Republic of 23400 35 Benchmarking The process of measuring products, services, and processes against those of organizations known to be leaders in one or more aspects of their operations 36 Total Productive Maintenance (TPM)Utilizing the entire workforce to obtain the optimum use of equipment through continuous search to improve maintenance 37 Management and Planning ToolsAffinity Diagram Interrelationship Diagraph Tree Diagram Prioritization Matrix Matrix Diagram Process Decision Program Chart (PDPC) Activity Network Diagram 38 Affinity Diagram This tool takes large amounts of disorganized data and information and enables one to organize it into groupings based on natural relationships. 39 Interrelationship DiagraphThis tool displays all the interrelated cause-and-effect relationships and factors involved in a complex problem and describes desired outcomes. 40 Tree Diagram This tool is used to break down broad categories into finer and finer levels of detail. It can map levels of details of tasks that are required to accomplish a goal or task. 41 Prioritization MatrixThis tool is used to prioritize items and describe them in terms of weighted criteria. It uses a combination of tree and matrix diagramming techniques to do a pair-wise evaluation of items and to narrow down options to the most desired or most effective. 42 Matrix Diagram This tool shows the relationship between items. At each intersection a relationship is either absent or present. 43 Process Decision Program Chart (PDPC)A useful way of planning is to break down tasks into a hierarchy, using a Tree Diagram. The PDPC extends the tree diagram a couple of levels to identify risks and countermeasures for the bottom level tasks. 44 Activity Network DiagramThis tool is used to plan the appropriate sequence or schedule for a set of tasks and related subtasks. It is used when subtasks must occur in parallel. The diagram enables one to determine the critical path (longest sequence of tasks). 45 Lean (Kaizen) Continuous improvementKaizen is a Japanese word for continuous improvement 46 Quality Issues Identifying quality problems Solving quality problemsImproving quality 47 To Boost Performance, Quality is Designed into Products as:Material Function Quality characteristics Performance Reliability Features Conformance Reliability Durability Service Aesthetics Reputation And more … 48 Quality is also Designed into the Manufacturing ProcessesManufacturing processes can be: Procedures Techniques Methods A series of actions that lead to a goal (definition) Should be specified by engineers who understand them Can be painstakingly detailed and planned Should be painstakingly followed, tested and checked Need trained personnel to understand them Need trained personnel to execute them Need appropriate quality tools to execute 49 Sample Industry Quality FailuresFord recalled 1.1M pickups for gas tank problem (August 1, 2011) Drug maker Johnson & Johnson cited on quality issues (November 26, 2010) Stork Craft Manufacturing, Inc. recalled more than 500,000 baby cribs (2009) Toyota recalled multiple models of their vehicles ( ) 50 Reason for Recall: Falling off Gas Tanks Due to Rusty StrapsFord to Recall 1.1M Pickups for Gas Tank Problem (August 1, 2011) Available at: Reason for Recall: Falling off Gas Tanks Due to Rusty Straps Ford F-150 Ford F-250 Ford F-350 Ford F-450 Ford F-550 Ford Edge Lincoln Blackwood Lincoln MKX 51 Stork Craft Manufacturing IncStork Craft Manufacturing Inc. Recalled More Than 500,000 Baby Cribs (2009) Reason For Recall: The mattress support bracket failures create risk of entrapment and suffocation. 52 Drug Maker Johnson & Johnson Cited on Quality IssuesReasons for Citation: Distribution of drugs that failed quality requirements Failure to identify product defects during routine testing Failure to detect incorrect expiration dates on drug labels Failure to adequately investigate product problems Failure to follow laboratory controls and inadequate training of lab staff 53 Toyota Recalls Failed to Address 'Root Cause' of Many Sudden Acceleration Cases 54 Toyota Recall TimelineFirst Recall (September 29, 2009): Gas Pedal Entrapment by Floor Mats: Camry Avalon Prius Tacoma Tundra ES 350 IS 250 and IS350 Recall expanded in January 27, 2010 to include: Highlander Corolla Venza Matrix Pontiac Vibe 55 Second Recall (January 21, 2010): Sticky Gas PedalsTundra Sequoia Avalon Camry Corolla Matrix RAV4 2010 Highlander Pontiac Vibe 56 Some Implications of Quality FailureLost business Lost customers Cost of lawsuits Damaged public image or reputation Cost of repairs Cost of scraps Cost of quality Loss of lives Cost due to injuries to customers Quality failures can be avoided 57 Common Quality PracticesSix Sigma ISO 9000 & series TL 9000 Total quality management (TQM) Lean manufacturing Statistical process control (SPC) Acceptance sampling Quality function deployment (QFD) Benchmarking Total productive maintenance (TPM) Design of experiment (DOE) Kaizen 58 Six Sigma A six sigma process is one in which % of the products manufactured are statistically expected to be free of defects (3.4 defects per million). 59 Common Quality Failure DenominatorsMost quality failures could be avoided Quality was designed into the products or processes (but) Engineers and personnel overlooked something Customers (users) risked their lives The companies paid a heavy price Workers (designers, inspectors, producers) are at the center of it all 60 Some Reasons for Quality FailuresPoor design of the product Lack of appropriate design in/of the manufacturing processes Lack of appropriate control or management of the manufacturing processes Lack of appropriately trained personnel to manage the manufacturing processes Poor planning and supervision of manufacturing processes Lack of worker initiative and responsibility 61 Simple Process Analysis ToolInspect Mix Pour Weigh Fail Pass Ship Dry Package Mold Grind Discard 62 Simple Process Analysis ToolMix Weigh Grind Fail Inspect Discard Pass Pour Mold Dry Ship Package 63 Simple Process Analysis ToolMix Weigh Grind Fail Inspect Discard Yes Pour Dry Mold Fail Pass Ship Inspect Package 64 Complex Process Analysis Tool 65 More Inspections Mean:More resources will be needed Better educated personnel will be needed More dedicated personnel will be needed More responsible personnel will be needed Better and safer products will be produced Happier and more satisfied customers 66 Key Quality Failure ObservationsQuality failures are preventable Good quality failure prevention demands comprehensive process/product analysis Good full-proof analysis demands trained, knowledgeable and dedicated quality personnel Quality improvement efforts should be continuous with dedicated personnel 67 Areas for Joint Industry-Schools Quality PartnershipsQualified quality personnel: Dedication Educated Ethical Fulfillment Topics of interest: Designing for quality Prevention of quality failures Providing training for company staff 2. TQM TOOLS AND TECHNIQUES 3. Acknowledgement We would like to thank our respected professor Mr.Kamaldeep Singh for giving us this opportunity to manifest our talents, improve our knowledge of the subject and broaden our horizons. This project has given us an opportunity to work together thus enhancing our team work and presentation skills. 4. A management approach for an organization. Centered on quality and members participation aiming at long term success through customer satisfaction and benefits to society. 5. Check sheet Pareto chart Flow chart Cause and effect diagram Histogram Scatter diagram Control chart 6. A simple means of data collection. Function to present information in an efficient graphical format. Defining characteristic of a check sheet is that data is recorded by making marks(“checks”). Data is read by observing the location and number of marks on the sheet. 8. Example of a Check sheet In a machine shop there is a costly CNC machine which was not giving the desired output. It was decided to visit the shop around 25 times in a week to check the reasons of machine not working. The check sheet was designed for collecting the data as follows. This data can be used further for attacking the important reasons. 9. Reasons for machine not working From Date: 01/12/2008 to 30/01/2009 Reading taken by: S.No Reason Count Total 1 Material not available //// // 7 2 Operator absent / 1 3 Operator away from machine /// 3 4 Machine under repair //// 4 5 Tool under repair //// /// 8 6 Miscellaneous /// 3 Total 26 10. Used to identify factors that have the greatest cumulative effect on the system. Pareto principle: 80% of problems stem from 20% of the various causes. A special type of bar chart created by plotting the cumulative frequencies of the relative frequency in decesending order. 11. For example, if your business was investigating the delay associated with processing credit card applications, you could group the data into the following categories: No signature Residential address not valid Non-legible handwriting Already a customer Other 13. Common type of chart. Defined as a pictorial representation of describing a process used to plan stages of a project. 15. Diagram showing the cause of a certain event. Used to identify potential factors causing an overall effect. Used to see all possible causes of a result and hopefully find the root of process imperfections. It is known as fishbone diagram because its shape is similar to side view of a fish skeleton. 17. A Histogram is a graphic summary of variation in a set of data. It enables us to see patterns that are difficult to see in a simple table of numbers. Can be analyzed to draw conclusions about the data set. A histogram is a graph in which the continuous variable is clustered into categories and the value of each cluster is plotted to give a series of bars. 18. The below example reveals the skewed distribution of a set of product measurements that remain nevertheless within specified limits. Without using some form of graphic this kind of problem can be difficult to analyze, recognize or identify. 20. A scatter plot is effectively a line graph with no line - i.e. the point intersections between the two data sets are plotted but no attempt is made to physically draw a line. The Y axis is conventionally used for the characteristic whose behaviour we would like to predict. Used, to define the area of relationship between two variables. 22. Control charts are a method of Statistical Process Control, SPC. (Control system for production processes). They enable the control of distribution of variation rather than attempting to control each individual variation. Upper and lower control and tolerance limits are calculated for a process and sampled measures are regularly plotted about a central line between the two sets of limits. 23. The plotted line corresponds to the stability/trend of the process. Action can be taken based on trend rather than on individual variation. This prevents over-correction/compensation for random variation, which would lead to many rejects. Product Release From a new approach to secondary data storage to inclusion of artificial intelligence (AI) that enhances productivity and efficiency, BMC AMI's January 2025 release breaks new ground in enabling what's possible on the mainframe. 1 Tools and techniques used in Total Quality ManagementJanuary 2012 Quality Management 2 Introduction One of the basic principles of Total Quality is management by facts It requires that each decision, each solution to a problem is based on relevant data and appropriate analysis Collecting and analyzing data can be difficult Use of Total Quality tools ensure better decision making, better solution to problems, improvement in productivity, products and services January 2012 Quality Management 3 Overview of Total Quality ToolsBasic 7 tools: The Pareto Chart Cause-and-Effect Diagrams Check Sheets Histograms Scatter Diagrams Stratification Run Charts and Control Charts January 2012 Quality Management 4 Overview of Total Quality ToolsOther tools: Statistical Process Control (SPC) 5S Flowcharts Failure mode and effects analysis Input-output diagram Design of Experiments (DOE) January 2012 Quality Management 5 Pareto chart Pareto charts are useful for separating the important from the trivial. Pareto charts are important because they can help an organization decide where to focus limited resources January 2012 Quality Management 6 Frequency of OccurrencePareto Chart The purpose is to separate the “vital few” from the trivial many. The number of production interruptions, and the reasons for the interruption, at an injection molding plant are recorded for one month. What information do we “see” from the Pareto? Machine Breakdown and Defective Production are the biggest contributors to production interruption. Type of Interruption Frequency of Occurrence Machine Breakdown 180 Defective Production 135 No Material 63 Change-over 56 Tool Breakdown 27 Defective Material 23 Maintenance 14 No Labor 9 January 2012 Quality Management 7 Cause and Effect DiagramThe purpose of the cause-and-effect diagram (Ishikawa of fishbone) diagram. is to help identify and isolate the causes of problems January 2012 Quality Management 8 Check sheet Check sheets make it easy to collect data for specific purposes and to present it in a way that automatically converts it into useful information The check sheet is a tool that facilitates collection of relevant data, displaying it in a visual form easily understood by the brain. Check sheets make it easy to collect data for specific purposes and to present it in a way that automatically converts it into useful information January 2012 Quality Management 9 Histogram Histograms have to do with variability. A histogram is a measurement scale across one axis and a frequency of like measurements on the other. Histograms have to do with variability. Two kinds of data are commonly associated with processes: attributes data and variables data. An attribute is something that the output product of the process either has or does not have. Variables data are data that result when something is measured. A histogram is a measurement scale across one axis and a frequency of like measurements on the other. January 2012 Quality Management 10 Scatter diagram Scatter diagram is used to determine the correlation between two variables. It can show a positive correlation, a negative correlation, or no correlation The scatter diagram is arguably the simplest of the seven basic quality tools. It is used to determine the correlation between two variables. It can show a positive correlation, a negative correlation, or no correlation.   Scatter Diagram Also called: scatter plot, X-Y graph Description The scatter diagram graphs pairs of numerical data, with one variable on each axis, to look for a relationship between them. If the variables are correlated, the points will fall along a line or curve. The better the correlation, the tighter the points will hug the line. When to Use a Scatter Diagram When you have paired numerical data. When your dependent variable may have multiple values for each value of your independent variable. When trying to determine whether the two variables are related, such as… When trying to identify potential root causes of problems. After brainstorming causes and effects using a fishbone diagram, to determine objectively whether a particular cause and effect are related. When determining whether two effects that appear to be related both occur with the same cause. When testing for autocorrelation before constructing a control chart. Scatter Diagram Procedure Collect pairs of data where a relationship is suspected. Draw a graph with the independent variable on the horizontal axis and the dependent variable on the vertical axis. For each pair of data, put a dot or a symbol where the x-axis value intersects the y-axis value. (If two dots fall together, put them side by side, touching, so that you can see both.) Look at the pattern of points to see if a relationship is obvious. If the data clearly form a line or a curve, you may stop. The variables are correlated. You may wish to use regression or correlation analysis now. Otherwise, complete steps 4 through 7. Divide points on the graph into four quadrants. If there are X points on the graph, Count X/2 points from top to bottom and draw a horizontal line. Count X/2 points from left to right and draw a vertical line. If number of points is odd, draw the line through the middle point. Count the points in each quadrant. Do not count points on a line. Add the diagonally opposite quadrants. Find the smaller sum and the total of points in all quadrants. A = points in upper left + points in lower right B = points in upper right + points in lower left Q = the smaller of A and B N = A + B Look up the limit for N on the trend test table. If Q is less than the limit, the two variables are related. If Q is greater than or equal to the limit, the pattern could have occurred from random chance. Scatter Diagram Example The ZZ-400 manufacturing team suspects a relationship between product purity (percent purity) and the amount of iron (measured in parts per million or ppm). Purity and iron are plotted against each other as a scatter diagram, as shown in the figure below. There are 24 data points. Median lines are drawn so that 12 points fall on each side for both percent purity and ppm iron. To test for a relationship, they calculate: A = points in upper left + points in lower right = = 18 B = points in upper right + points in lower left = = 6 Q = the smaller of A and B = the smaller of 18 and 6 = 6 N = A + B = = 24 Then they look up the limit for N on the trend test table. For N = 24, the limit is 6. Q is equal to the limit. Therefore, the pattern could have occurred from random chance, and no relationship is demonstrated January 2012 Quality Management 11 Scatter Diagram y = Production cost per unit ($) x = Production lot size It appears that as lot size increases, the cost per unit decreases (negative correlation) January 2012 Quality Management 12 Stratification Stratification is a tool used to investigate the cause of a problem by grouping data into categories. Grouping of data by common elements or characteristics makes it easier to understand the data and to draw insights from it. Stratification is a tool used to investigate the cause of a problem by grouping data into categories. Grouping of data by common elements or characteristics makes it easier to understand the data and to draw insights from it. January 2012 Quality Management 13 Run chart The run chart records the output results of a process over time For this reason, the run chart is sometimes called a trend chart January 2012 Quality Management 14 Run charts and Control chartsThe weakness of the run chart is that it does not tell whether the variation is the result of special causes or common causes. This weakness gave rise to the control chart. On such a chart, data are plotted just as they are on a run chart, but a lower control limit, an upper control limit, and a process average are added. The plotted data stays between the upper control limit and lower control limit while varying about the center line or average only so long as the variation is the result of common causes such as statistical variation. January 2012 Quality Management 15 Control chart The control chart is a run chart with added Control Limits. It make it possible to separate two types of variation: Common Cause and Special Cause. On such a chart, data are plotted just as they are on a run chart, but a lower control limit, an upper control limit, and a process average are added. The plotted data stays between the upper control limit and lower control limit while varying about the center line or average only so long as the variation is the result of common causes such as statistical variation. January 2012 Quality Management 16 Control Limits Control limits are statistical bounds that define the region within which the process naturally varies. These bounds are computed from the data. Upper Control Limit Within Control Limits Lower Control Limit When the process randomly fluctuates within the control limits, it is impacted only by common causes of variation and considered stable, or in statistical control. If the process is in control , 99.73% of all the points will fall between the control limits. January 2012 Quality Management 17 How the Control Chart is ConstructedWeek 2-6: Evaluate Process Behavior How the Control Chart is Constructed Johnson Controls, Inc © June 2007 0.0 4.0 8.0 12.0 16.0 R U C L 2.0 6.0 10.0 UCL = 8.9 LCL = 1.1 Compute and plot the control limits for the “Averages” chart. X Chart 1 .) 7 6 577 (5 LCL R A X 9 8 UCL x 2 = - + Range Chart January 2012 Quality Management W2-6 Process Behavior_Inst.ppt 18 How the Control Chart is ConstructedWeek 2-6: Evaluate Process Behavior How the Control Chart is Constructed Johnson Controls, Inc © June 2007 0.0 4.0 8.0 12.0 16.0 R U C L 2.0 6.0 10.0 UCL = 8.9 LCL = 1.1 Compute and plot the control limits for the “Range” chart. X Chart UCL = 14 LCL = D3R LCL = 0 x 6.7 = 0 UCL = D4R UCL = x 6.7 = 14 Range Chart LCL = 0 January 2012 Quality Management W2-6 Process Behavior_Inst.ppt 19 Statistical Process Control (SPC)Statistical Process Control (SPC) is a statistical method of separating variation resulting from special causes from natural variation in order to eliminate the special causes. It is used to monitor processes and indicate when they get out of control It can be applied to any process January 2012 Quality Management 20 Collecting Data for an SPC ChartAt least 20 subgroups of about n=5 data are required. The data within a subgroup should be collected close together in time (for example, 5 consecutively produced parts) Longer time intervals are used between subgroups. (Depending on the process and purpose of the study, these time intervals could be 15 min., 30 min., 1hr., 2 hr., or longer). Use a sampling frequency that captures normal changes in the process (changes in material, operators, etc.). January 2012 Quality Management 21 Week 2-6: Evaluate Process BehaviorSPC (p) Chart Johnson Controls, Inc © June 2007 Special Cause Variation Variation that demonstrates a deviation from the process’ “steady state”. Each week, n=500 invoices are sampled. The proportion of invoices needing correction is plotted for 20 weeks. P Chart of Rejected Invoices Common Cause Variation Routine, inherent process variation – the “steady state” variation that persists over time. What happened on the week 16? January 2012 Quality Management W2-6 Process Behavior_Inst.ppt 22 Week 2-6: Evaluate Process BehaviorJohnson Controls, Inc © June 2007 SPC (X Bar and R) Chart Range of Daily Production Cost per Week X Bar Control Chart – Average Daily Production Costs by Week Generally, the average and range are monitored simultaneously, so that the entire system can be evaluated. Range is a closer look at within group, X bar is between group January 2012 Quality Management W2-6 Process Behavior_Inst.ppt 23 Properties of the Normal DistributionWeek 2-7: Evaluate Process Capability Johnson Controls, Inc © June 2007 Properties of the Normal Distribution 68% of parts will fall between +/- 1 standard deviations from the mean 95% of the parts will fall between +/- 2 standard deviations from mean 99.73% of the parts will fall between +/- 3 standard deviations from mean January 2012 Quality Management W2-7 Process Capability_Inst.ppt 24 Standard deviation Standard deviation is a widely used measure of variability or diversity used in statistics and probability theory. It shows how much variation or "dispersion" exists from the average (mean, or expected value). A low standard deviation indicates that the data points tend to be very close to the mean, whereas high standard deviation indicates that the data points are spread out over a large range of values. The standard deviation of a statistical population, data set, or probability distribution is the square root of its variance. It is algebraically simpler though practically less robust than the average absolute deviation.[1][2] A useful property of standard deviation is that, unlike variance, it is expressed in the same units as the data. A plot of a normal distribution (or bell curve). Each colored band has a width of one standard deviation January 2012 Quality Management 25 Standard deviation (Sigma)January 2012 Quality Management 26 Example Consider a population consisting of the following eight values: These eight data points have the mean (average) of 40:8 =5 To calculate the population standard deviation, first compute the difference of each data point from the mean, and square the result of each: Next compute the average of these values, and take the square root: This is the population standard deviation; it is equal to the square root of the variance. January 2012 Quality Management 27 Population vs sample standard deviationThe formula is valid only if the eight values we began with form the complete population. If they instead were a random sample, drawn from some larger, "parent" population, then we should have used 7 (which is n − 1) instead of 8 (which is n) in the denominator of the formula, and then the quantity thus obtained would have been called the sample standard deviation January 2012 Quality Management 28 Process capability Process capability shows the relationship between the natural process limits (the control limits) and specifications Process in (statistical) control vs. Capable process January 2012 Quality Management 29 Week 2-6: Evaluate Process BehaviorJohnson Controls, Inc © June 2007 Specification Limits Specification Limits are applied to individual measurements. LSL USL Specification limits are decided by people. Control limits are determined by the data (voice of the process). January 2012 Quality Management W2-6 Process Behavior_Inst.ppt 30 Process Capability ImprovementCut Dimension (mm) Initial State: POOR CAPABILITY LSL USL Cut Dimension (mm) After Modified Collision Sensor Installed BETTER CAPABILITY LSL USL Cut Dimension (mm) After Auto Clamp Installed HIGH PROCESS CAPABILITY! January 2012 Quality Management 31 Cp Index Demonstrates Potential CapabilityWeek 2-7: Evaluate Process Capability Johnson Controls, Inc © June 2007 Cp Index Demonstrates Potential Capability 3 LSL USL Cp = 1 Cp = 2 4 Cp =1.33 6 Cp = (USL – LSL)/ 6s Cp is the ratio of Total Tolerance to the 6 Process Spread. It shows how capable the process would be if it were perfectly centered. Cp = Potential Capability This is a “Six Sigma” process. January 2012 Quality Management W2-7 Process Capability_Inst.ppt 32 Cpk Index Demonstrates Actual CapabilityUSL – Avg. 3s Cpk = LSL USL Cp = 2 Cpk = 1.33 Cpk takes into account any off-centering that actual occurs. Cp = 2 Cpk = 2 When process is centered, Cp = Cpk. January 2012 Quality Management 33 Process Sigma Level - TableWeek 2-7: Evaluate Process Capability Johnson Controls, Inc © June 2007 Process Sigma Level - Table PPM Sigma Level 3.4 6 233 5 6210 4 66807 3 308538 2 691462 1 Six Sigma “thinking” employs a 1.5 sigma shift. For example: if a process exhibits 4 Sigma capability in the short term, it would probably exhibit 2.5 capability in the long term. January 2012 Quality Management W2-7 Process Capability_Inst.ppt 34 Overview of Total Quality ToolsOther tools: 5S Flowcharts Failure mode and effects analysis Input-output diagram Design of Experiments (DOE) January 2012 Quality Management 35 5S 5S is the name of a workplace organization methodologyIt describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order. January 2012 Quality Management 36 5S (Seri, Seiton, Seiso, Seiketsu, Shitsuke)1S - Separate and Scrap Sort useful form useless 2S – Straighten Everything in its place 3S – Scrub Workplace and equipment clean 4S – Standardize Select the best practice 5S – Sustain Make sure rules are followed By organizing the workplace, unstable or wasteful situations become visible earlier, allowing for a quick, effective response. January 2012 Quality Management 37 Purpose of 5S A structured system to make abnormalities stick outThese abnormalities can then be addressed 5S is a cleanliness and organization PROCESS. 5S is expected to help keep an area neat and understandable (what, where, how many). Red tags are put on things not being used or out of place. You will also notice what it says: “ALWAYS TOUR READY.” January 2012 Quality Management 38 5S example January 2012 Quality Management 39 Flowchart A flowchart is a picture of the separate steps of a process in sequential order High level flowchart . Flowcharts are used in a total quality setting for charting the inputs, steps, functions, and outflows of a process to understand more fully how the function works and who or what has input into and influence on the process, its inputs and outputs, and even its timing. January 2012 Quality Management 40 Flowchart Detailed flowchart January 2012 Quality Management 41 FMEA Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service. “Failure modes” means the ways, or modes, in which something might fail. Failures are any errors or defects, especially ones that affect the customer, and can be potential or actual. “Effects analysis” refers to studying the consequences of those failures. January 2012 Quality Management 42 FMEA The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones. Failure modes and effects analysis also documents current knowledge and actions about the risks of failures, for use in continuous improvement. FMEA is used during design to prevent failures. Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service. January 2012 Quality Management 43 FMEA cycle Failure The loss of an intended function of a device under stated conditions. Failure mode The manner by which a failure is observed; it generally describes the way the failure occurs. Failure effect Immediate consequences of a failure on operation, function or functionality, or status of some item Indenture levels An identifier for item complexity. Complexity increases as levels are closer to one. Local effect The failure effect as it applies to the item under analysis. Next higher level effect The failure effect as it applies at the next higher indenture level. End effect The failure effect at the highest indenture level or total system. Failure cause Defects in design, process, quality, or part application, which are the underlying cause of the failure or which initiate a process which leads to failure. Severity The consequences of a failure mode. Severity considers the worst potential consequence of a failure, determined by the degree of injury, property damage, or system damage that could ultimately occur. January 2012 Quality Management 44 FMEA Failures are prioritized according tohow serious their consequences are (severity) how frequently they occur (occurrence) how easily they can be detected (detection). January 2012 Quality Management 45 FMEA process January 2012 Quality Management Step 1: OccurrenceIn this step it is necessary to look at the cause of a failure mode and the number of times it occurs. This can be done by looking at similar products or processes and the failure modes that have been documented for them in the past. 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 an occurrence ranking (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 1 or 0). This step is called the detailed development section of the FMEA process. Occurrence also can be defined as %. If a non-safety issue happened less than 1%, we can give 1 to it. It is based on your product and customer specification Step 2: Severity Determine all failure modes based on the functional requirements and their effects. Examples of failure modes are: Electrical short-circuiting, corrosion or deformation. 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 (critical). These numbers help an engineer to prioritize the failure modes and their effects. If the sensitivity 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 3: Detection When appropriate actions are determined, it is necessary to test their efficiency. In addition, 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 ranks the ability of planned tests and inspections to remove defects or detect failure modes in time. The assigned detection number measures the risk that the failure will escape detection. A high detection number indicates that the chances are high that the failure will escape detection, or in other words, that the chances of detection are low January 2012 Quality Management 46 Occurence Severity Detection January 2012 Quality ManagementRating Meaning 1 No known occurrences on similar products or processes 2/3 Low (relatively few failures) 4/5/6 Moderate (occasional failures) 7/8 High (repeated failures) 9/10 Very high (failure is almost inevitable 1 No effect 2 Very minor (only noticed by discriminating customers) 3 Minor (affects very little of the system, noticed by average customer) 4/5/6 Moderate (most customers are annoyed) 7/8 High (causes a loss of primary function; customers are dissatisfied) 9/10 Very high and hazardous (product becomes inoperative; customers angered; the failure may result unsafe operation and possible injury) 1 Certain - fault will be caught on test 2 Almost Certain 3 High 4/5/6 Moderate 7/8 Low 9/10 Fault will be passed to customer Severity Detection January 2012 Quality Management 47 FMEA example January 2012 Quality Management 48 FMEA example January 2012 Quality Management 49 Types of FMEA Process: analysis of manufacturing and assembly processes Design: analysis of products prior to production Concept: analysis of systems or subsystems in the early design concept stages Equipment: analysis of machinery and equipment design before purchase Service: analysis of service industry processes before they are released to impact the customer System: analysis of the global system functions Software: analysis of the software functions January 2012 Quality Management 50 The Input-Process-Output (IPO) DiagramIPO Diagrams are “high-level” process maps. Input: Substance(s) that enter the system. Process: Actions taken upon or using the input. Output: Tangible item(s) that result from the processing, and exit the process. January 2012 Quality Management 51 IPO - High Level Process MapsOnline Module 2 - grasp the situation Johnson Controls, Inc © Proprietary & Confidential IPO - High Level Process Maps “Hire Employee” INPUTS PROCESS OUTPUTS Personnel Request Form Candidates for the position Resumes Person placed in position Rejected candidates Closed-out PR Form Post Position Review Resumes Select Candidates Interview Make Offer January 2012 Quality Management 2-grasp the situation_ ppt 52 Design of Experiments Design of experiments (DOE) is a sophisticated method for experimenting with complex processes for the purpose of optimizing them. DOE allows multiple factor adjustments simultaneously It reduces the number of tests needed to find an optimal situation by factor 10 It also shows which factors are critical and which are not January 2012 Quality Management 53 Problem Solving and Decision MakingA problem is a situation in which what exists does not match what is desired or, put another way, the discrepancy between the current and the desired state of affairs. Problem solving in a total quality setting is not about putting out fires. It is about continual improvement. January 2012 Quality Management 54 Problem Solving and Decision MakingSecuring reliable information is an important part of problem solving and decision making. Recommended tools: Cause-and-effect diagrams Flowcharts Pareto charts Run charts Histograms Control charts Scatter diagrams January 2012 Quality Management 55 PDCA Establish the objectives and processes necessary to deliver results in accordance with the expected output (the target or goals). Implement the plan, execute the process, make the product Study the actual results (measured and collected in "DO" above) and compare against the expected results (targets or goals from the "PLAN") to ascertain any differences Request corrective actions on significant differences between actual and planned results January 2012 Quality Management 56 Problem Solving January 2012 Quality Management Continuous Improvement 57 Diagnose the problem Basic 5 times WhyThe intent of asking "Five times Why“ is to assure that the root causes and not symptoms are corrected. The "Five-Why Process" was introduced at Toyota to find solution to manufacturing problems, but this approach can be applied to any other area as well. Ask "Why this problem happened?" to discover its underlying problem then ask "Why?" again to go deeper by another level until you reach the root cause. Time: 1 min.(2-3) Read: Slide Say: Toyota became the best manufacturing company in the world. We are implementing the same concepts at JCI that made Toyota great. January 2012 Quality Management Continuous Improvement 58 5 times Why Why did the machine stop? A fuse in the machine has blown Why did the fuse blow? Circuits overloaded Why did the circuit overload? The bearings have been damaged and locked up Why have the bearings been damaged? There was insufficient lubrication Why was there insufficient lubrication? The oil pump on the machine is not circulating enough oil Why is the pump not circulating enough oil? Pump intake is clogged with metal shavings Why is the intake clogged with metal shavings? There is no filter on the pump intake Time: 1 min.(2-3) Read: Slide Say: Toyota became the best manufacturing company in the world. We are implementing the same concepts at JCI that made Toyota great. And therefore…. Asking "why" repeatedly, possibly more than five times, directs the focus towards real causes, so problems can be solved permanently. January 2012 Quality Management Continuous Improvement 59 D4 – Use Problem Solving Tools to Diagnose the probable Root Cause“Problem Analysis (PA)“ is used to find the true cause of a positive or negative deviation. When people, machinery, systems or processes are not performing as expected, problem analysis provides a structured process to identify and verify the cause. The PA process describes the problem with a clear Problem Statement and Problem Specification (“IS / IS NOT”). Time: 1 min.(2-3) Read: Slide Say: Toyota became the best manufacturing company in the world. We are implementing the same concepts at JCI that made Toyota great. January 2012 Quality Management Continuous Improvement 60 IS / IS NOT January 2012 Quality Management Continuous Improvement 61 Six Sigma The most complex and sophisticated methodology, within Total Quality, for problem solving and process improvements is Six Sigma January 2012 Quality Management 1. Total quality management By:- Bhushan Sabl 2. Total quality management tools and techniques Introduction Literature review TQM implementation steps Classification of tools Categories of tools and techniques Roadmap for TQM implementation Process measurement Conclusion 3. Total quality management Managing the entire organization so that it excels on all dimensions of products and services that are important to the customer. Fundamental operational goals 1. Careful design of the product or service 2. Ensuring that the organization’s system can consistently produce the design. 4. Literature review TQM can take place in three phases diagnosis and preparation (II) management focus and commitment (III) intensive improvement. (I) The diagnostic and preparation phase of TQM requires the introduction of a number of fact finding tools, some of which are “cost of quality” and “Departmental Purpose Analysis (DPA)”. 5. TQM implementation steps 6. Classification of TQM tools Qualitative tools:- consist mainly of subjective inputs, which often do not intend to measure something of a numerical nature. Quantitative tools:-involve either the extension of historical data or the analysis of objective data, which usually avoid personal biases that sometimes contaminate qualitative tools. 7. Categories of TQM tools Qualitative tools: · flow charts · cause-and-effect diagrams · multi-voting · affinity diagram · process action teams · brainstorming · election grids · task lists. Quantitative tools: · Shewart cycle (PDCA) · control charts · scatter diagrams · Pareto charts · sampling · run charts · histograms. 8. TQM tools as primary area of implementation 1) customer-based 2) management-based 3) employee-based 4) supplier-based 5) process-based 6) product-based. 9. Tools used in implementation Customer based Management based Employee based Supplier Based Process Based Product based Customer survey Communication Empowerm ent Supplier training Just in time Bench marking Customer need analysis leadership circles Quality Supplier documentation Quality Design of improvem experiments ent Crosstraining Supplier certification Lead time reduction Concurrent engineering Bench marking Product flow analysis Quality function deployment Quality teams Brainstormi ng Nominal group technique 10. TQM tools implementation roadmap 11. Process measurement   What is happening? How is the process performing? Is the process improving? Is the process satisfying customer requirements? The best tools for this purpose is check sheet, Pareto chart, histogram, scatter diagram, runchart and statistical process control (SPC). The data collected by these tools can be used to measure the process. 12. Other purposes of process measurement understanding what is happening provide objective performance feedback evaluate the need for improvement evaluate the impact of changes set schedules and performance targets. 13. conclusion The correct selection and use of tools and techniques is a vital component of any successful TQM implementation plan. The TQM tools and techniques can be divided into simple tools for solving a special problem and complex one that cover all functions within the company. 1. Total Quality Management 2. Definition TQM refers to a quality emphasis that encompasses the entire organization, from supplier to customer. 3. TQM in services The personal component of services is more difficult to measure than the quality of tangible component. 4. Operations manager plays a significant role in addressing several major aspects of service quality. 1. The tangible component of services 2. The process 3. Customer expectations 4. Exceptions 5. Tools for the statistical quality control 1. Check sheets 2. Scatter diagrams 3. Cause and Effect diagrams 4. Pareto charts 5. Flow charts 6. Histograms 7. Control charts 8. Cause and effect diagram It is another tool for identifying quality issues and inspection points . It is also known as Ishikawa diagram or a fish bone chart. 9. Pareto charts Pareto charts are method of organizing errors ,problems, or defects to help focus on problem solving efforts.Room service 54 Check in delays 12 Hours the pool is open 4 Minibar prices 3 Miscellaneous 2 Total 75 11. Flow charts / Process diagrams 13. Control charts Control charts are graphic representation of data over time that show lower limits for the process we want to control as shown in the figure.