Seven quality tools

PART ONE: SEVEN QUALITY TOOLS

INTRODUCTION

For the reason of human factor and human reliability, it is inevitable that there could be occurred some kind of faults and errors even in well planned and technically equipped organizations and systems. The errors or unplanned risks that might be happened during the project, can lead the customer to have negative opinion about the management team. Also some faults and risks might not being able to fix or might be too expensive to overcome it. Therefore a well prepared quality management plan is essential for an organization in order to ensure that the management plan that the project team works on, meet the customer satisfaction and their needs. At this stage Ishikawa's seven quality tools are quite helpful to determine, identify and evaluate the problems, their causes and suggestions for a continuous improvement process. These tools can be listed as; Histogram, Flow Chart, Scatter Diagram, Pareto Chart, Cause and Effect Diagram, Check Sheet and Control Chart.

1. HISTOGRAM

1. 1 Purpose of Histogram

Histogram is used in order to define the variation and frequency of occurrence of a set of data in a graphical and numerical form.

1. 2 Description

In most of the visual presentations, frequency distribution is used, and each of them is made in order to indicate how often that particular data occurs for in certain of time. And the most common way to show the frequency of

occurrence is one of the quality tools called histogram. They may look like bar charts, but there are differs in some ways.

Histogram is a powerful tool in terms of showing the all data set in one diagram. It is helpful, when it is needed to show the comparison of one data to another. They are the graphical way of indication and provide to investigate and evaluate the data visually. It is invented by French statistician A. M Guerry. As a distinct from the Pareto Chart, in histogram, only the frequency of occurrence of one type of property of the product is shown. The particular property of the product that leads us to use histogram must be numerical and variable. The following figure 1 is given as an example. Here, one particular property of the products, the number of defective numbers in the next 1000 product and their probability of occurrence are shown as numerically. As you see from the figure, a pile of defective number is in the middle of the distribution. It is shown like a bell shaped curve which is usually called normal distribution.

We usually use a Histogram when;

- The data we use to visualize is numerical.
- There is a need to assess if the process is likely to meet the customer’s requirement.
- There is a need to identify the shape of the distribution that the histogram will show, for that particular data.
- Making a comparison of the outputs of more than one process, to assess if they are differing from each other or not.

When making a histogram with the purposes defined above, one should pay attention some points such as;

- The survey data should be variable.
- The observed data should place the X axis, while frequency should be place Y axis.
- In one histogram only one particular quality characteristic is considered, and observed data values regarding with this characteristic are placed on X axis.
- The column intervals should be same with one another.
- In order to reach the more accurate distribution, it should be paid attention to insert no less than 50 data points.

1. 3 Construction of Histogram

While making a Histogram, there are some steps which should be followed. These are shown as follows:

- In order to reach more verifiable results, at least 50 data points should be gathered.
- Finding the difference between the highest and lowest data points, this is called as Range.
- Collected data points should be divided on to X axis according to their number. For example if we have below 50 data points, X axis should be divided into 5 to 7 intervals. The same, for 50 to 100 data points, axis should be divided into 8-10 intervals. For over 250 data points, number of intervals must be between 15 and 20. Determining the number of classes is the crucial step, since during the interpretation of the

variation in the data set, it will show the effectiveness of the histogram.

- Each size of interval must be calculated by the following formula ;
- Size of Interval = Range/ Number of Classes
- By using the smallest and largest data points, the boundary of the histogram should be defined.
- Before the last step there is needed to make the calculation of frequency of each class.
- Final step is drawing the Histogram and plotting the related data.

1. 4 Conclusion

Histogram is a useful tool to identify and make an interpretation for the variation that is faced in a set of data. Anything we need to show or point out, we can do it by the quality tool of histogram in a simple and clear way. But it is important to always consider that, histogram cannot give solutions to the problems, but they can shed some lights on the improvement processes.

2. FLOW CHARTS

2. 1 Purpose of Flow Charts

Flow Charts give a visual explanation of the progression of activities which are needed to complete a task. The high level flow charts help people who use them, to understand complicated processes without details which cause confusion. The detailed flow charts help people who use them, to analyze their processes to improve the efficiency and to optimize.

Also people who will involved in constructing process of flow chart, start to understand the process better. Since they are involved in, they start to be

more interested to the improvement of quality and process. They start to determine the parts to improve the process. They also start to understand how all the people and all the process involved and fit into the overall business.

2. 2 Description of Flow Chart

Flow charts are visual charts which show processes by breaking down them into activities. Also they show how these activities related to each other from start to finish.

To understand a process, making a flow chart is the first step. Whether this process is a managerial or production one, these charts provide a visual explanation of the steps which are needed to complete the tasks. When we look at the flow chart, we can see how this process and the steps of this process are included in and fit into the overall business.

Flow charts can be prepared in many types. Pictures, symbols or just circles and squares can be used to draw a flow chart. Also these charts can show a process or just a part of a process or many processes together. There is not one way to draw a flow chart and also there is no wrong ways to draw a flow chart. The scale of how well a flow chart is, should be parallel with how well the people who draw and use it, understand it.

2. 3 Construction of Flow Charts

While preparing a flow chart, the people who will be involved in, should be identified correctly. These people should be the ones who practically perform the process and stakeholders of the process.

Since to construct a flow chart takes more time then expected, enough time should be given out to the team members to complete their work.

In the construction process of flow chart, the crucial step is asking questions. Here are the examples of questions that will help to construct a flow chart:

- Which thing will happen first? (defining start point)
- Which will happen next? (listing major steps in order)
- To where do the outputs of this process go? (defining the direction)
- From where do the inputs of this process come? (defining the direction)
- How do the inputs reach the process?
- Which thing will happen last? (defining stop point)

After defining the data to construct a flow chart, standardized graphical symbols are used to document the process. Then the results can be reviewed to compare to real process and to confirm if it is right and complete.

2. 4 Types of Flow Charts

There are four general flow chart types. These differ according to different perspective of people who modeled them:

- Document Flow Charts: They display controls over a document that flow through a system.
- Data Flow Charts: They display controls over a data which flows in a system.
- System Flow Charts: They display controls in a resource or physical level.

- Program Flow Chart: They display the controls in a program inside a system.

Whereas there are many classification of flow charts like that is showed in the up.

2. 5 Conclusion

Flow charts provide a visual illustration and explanation of process to user. These charts are the first steps to understand each process. Also these charts inspire team work and involvement to the business by employee.

3. SCATTER DIAGRAM

3. 1 Purpose of Scatter Diagram

Scatter diagram is mostly used when there is a need to identify the correlation of two variables that somehow affect each other, to observe the altering in one variable when the other one is changed.

3. 2 Description

Using Scatter Diagram enables us to predict what kind of function is more suitable to present the relation of two variables. Two ways to demonstrate the relation between the variables are to determine the degree of relation numerically and graphically. Indeed, Scatter diagram shows the direction and quantity of the linear correlation of two variables. The direction and the quantity of the linear correlation of two variables are measured and defined by a phenomenon called correlation coefficient which is shown as “ r”. This r value is always between -1 and 1. In the case r= 0 means, there is no relation between the variables. The higher “ r” number closer to 1, the more positive correlation between the variables. On the contrary the lowest “ r” number closer to -1, the more negative correlation.

In the figure below, the correlation between the waiting line between eruptions and the eruption duration of a geyser in USA. From the relation of two variables, what we can conclude from this diagram is, there are two types of eruptions. “ Short wait-short duration eruptions” and “ Long wait-long duration eruptions”. The closeness between the points represents the level of correlation between variables, that are placed in X and Y axis.

3. 3 Construction of Scatter Diagram

While making a Scatter Diagram, there are some steps in order, that should be followed:

- Choosing two items, that we want to examine the correlation between. Usually, it is better to use two variables that are potential for a cause and effect relationship. For instant, an effect and its cause can be the inputs for the scatter diagram
- Data gathering. As in the histogram, using as much as data will lead us to have more verified and accurate results.
- Placing the data points on to X and Y axis.
- Plotting the each set of paired data on to coordinate axis. There will be dots depends on how many data points we collected.
- Evaluation of the Chart and results.

3. 4 Evaluation of the Scatter Diagram

The interpretation of the results we can detect from the diagram can vary depends upon the relationship presented indiagram. If there is a strong relationship between two variables, a change in one item will automatically affect the other one to change. But if there is no relation, a change in one

will not affect the other one at all. So, the interpretation is divided into 3 categories;

- Positive relationship: The variable on the X axis is increases as the other one on Y axis increases, or vice versa. The slope of the best fit line is positive.
- Negative relationship: As the variable on the X axis increases while the other variable on Y axis decreases, or vice versa. The slope of the best fit line is negative.
- No relationship: There is no relation defined between the variables on X and Y axis. Their altering does not affect each other.

3. 5 Conclusion

Scatter diagrams presents the user the correlations between a quality characteristics and a factor that might be affected with it. What make this quality tools so useful is that; it is easy to use, to interpret and to communicate to others.

4. PARETO CHARTS

4. 1 Purpose of a Pareto Chart

The Pareto charts set priorities within the problems to decide which problems must be tackled first. Since no organization has enough resources to deal with all the problems, the prioritization is important. A pareto chart lists graphically the main points in a brief and shows the connected importance of the different points between data groups.

The purpose of Pareto chart is to stress the most important between set of factors. In quality control, it usually symbolizes the most usual origins of

deficiencies, the defect types that have high frequency or the customer complaints' most common reasons and etc. The Pareto charts are especially useful to improve the process in manufacturing.

4. 2 Description of Pareto Chart

Italian economist Vilfredo Pareto developed the Pareto concept by depicting the frequency distribution of a population's given characteristics. Pareto chart is a kind of chart which includes both a line graph and bars. The bars shows the values in going down order, and the line graph displays the cumulative sum up of each category, left to right.

Pareto charts set the data's priorities from highest frequency to lowest. These charts determine the " vital few " classes which explains the largest connected frequencies and set apart the " unimportant many ".

The Pareto chart can provide answers to the questions which will be helpful to find the largest issues that the business or team is facing, to get the highest rate of improvement where the team should focus their efforts.

4. 3 Construction of Pareto Chart

To start to draw a Pareto chart, the range of data should be segmented into groups (segments, categories, bins, etc.). Then the categories or columns should be ranked order (begin with the highest frequency column on the left and continue to the right). Then the number of data points which exist within each group should be determined and the graphic should be prepared by paying attention to match the categories with frequencies. Above the data categories, a connected frequency line should be calculated and placed. This is the cumulative of each categories percentage.

The start point of construction of a Pareto chart is to choose a process which is not producing yields. If the process requires rework or scrap, then the reasons for this rework or scrapping these parts are identified and a list is made for the causes of problems. Now, we have enough amounts of data to make a chart. After making Pareto chart, it can see which problems are the most effective to cause trouble, there should be two or three which are outstanding. Then we can concentrate to these problems which are most troublesome. After using Pareto chart to improve the process, to check how the improvement worked, we can do another Pareto chart and the problems that are causing the largest harm and must be tackled, will be shown in this chart again.

In the Pareto chart example, frequency of occurrence showed in the left vertical axis. And the right axis represents the cumulative percentage of total number of occurrences. Since the numbers of reasons decreasing, the shape of the cumulative function is concave function.

4. 4 Conclusion

There is no wrong problem or wrong process choice to use Pareto charts. To improve quality, the most important thing is doing something and starting from somewhere. To decide where your business has problems, if you start to use Pareto chart, you will find out several things about your business or processes and you will learn where to develop.

5. CAUSE AND EFFECT DIAGRAM

5. 1 Purpose of Cause and Effect Diagram

Cause and effect Diagram plays an important role in order to come up with a good output from a project and to provide a continuous improvement

process since it gives us the idea about the root cause or causes of the treats and problems throughout the project. One who chooses the cause and effect diagram as a graphical presentation will have the idea of what is the essential root cause that leads us for that particular quality problem.

5. 2 Description

Cause and effect diagram is also one of Ishikawa's seven quality tools developed in University of Tokyo in 1943. It has been using in order to determine, investigate and show the root causes of a problem or consequence. This diagram is also useful to display both all the related causes of a problem with the problem, in one diagram. This allows us to be able to see all the things in one page and will clear the situation. The Problem, consequence or the situation that we want to work on is written on the right side of the diagram, while all the possible related causes are written on the left side. As can be seen from the figure 5, the sub-causes are linked to the main causes, and they all together forms the fishbone. Since the shape is more or less look like a bone of fish, it is also called as " Fish Bone Diagram".

It is clear that we can end up with the causes by starting from the problems by using statistical methods. But apart from that, what the cause and effect diagram gives us that it shows the direct and explicit relation between the consequences and their causes, visually. And the causes to display are mainly divided into 6 main categories; Man/People, Measurement, Machines/Equipment, Materials, Methods and Environment.

5. 3 Construction of the Cause and Effect Diagram

The steps should be followed when making a cause and effect diagram demonstrated as the following:

- A project team for drawing the Cause and Effect Diagram is formed. It should be paid attention that the each member of the group has the pre-knowledge about the quality concern. One of the members is selected as the facilitator. S/he is the responsible to listen and note the ideas and thoughts presented by the other team members in an easy and understandable manner.
- The concern which is related the situation and needed to be improved must be identified as an effect, and draw a box around it and add an arrow towards to it.
- The next step must be the brain storming that must be held by the team members about what could be the entities causing this effect that is identified at previous step. Also the likelihood of relation between these causes, must be investigated.
- This step must be followed with the previous step. Because here, the sub-causes that are somehow related and affect the main causes must be identified and analyzed. Make sure that all the possible factors that contributing the main cause are defined. When preparing the diagram, environmental and business factors must be identified detail. And each team member’s opinion should be taken in order to define all the possible causes to the problem.
- The last step must be focusing the causes more in detail which an improvement plan can be developed for by using other quality tools

and techniques. The causes will be focused must agreed by the team members.

5. 4 Conclusion

Cause and Effect diagram are very effective and powerful among the quality tools in the manner that making a better understanding on our project. This diagram requires a team work, and pre-knowledge about the process project that we are working on. Since this diagram provides us an improvement for our project, it requires knowledge for sure. Because the more information that team members have, the more opportunity to improve them to come up with better outputs.

6. CHECK SHEETS

6. 1 The Purpose of Check Sheets

Check sheets provide to collect data from a process in a systematic, organized and easy manner.

6. 2 The Description of Check Sheets

Check sheet is a simple document which we use for data collection in real time and in the location where the data is created. The check sheet is typically a blank form which is designed to register the needed information in a quick, efficient and easy way.

Since the data collection is the beginning point of statistical analysis, it is very important and can sometimes become messy and unorganized exercise. Check sheet is a simple form that we can use for data collection in a structured manner and we can convert it into useful information easily. Check sheets present information in a graphical format effectively. A check sheet is a form or table which is used to register data as it is collected. Also

check sheets help to organize collected data by category. They display that how many times each particular value happens, and the information that check sheets provide, is becoming more helpful as more data is collected.

The check sheets' main application is to register data that shows how often different problems happen, and to register the frequency of incidents which are thought to be reasons of problems.

Check sheets are used to identify clearly what is being observed. The events that are being observed should be classified clearly. The data collection process should be taken easy and the data should be grouped in a way which makes data reliable and valuable. Similar problems must be in similar categories. Then a format which will give the most helpful information with the less effort should be created.

Check sheets are effective ways to display data and they are easy to use. They show the root reason of problems. Also check sheets are the first steps to construct other graphical tools. It provides an organized uniform data collection.

6. 3 Construction of a Check Sheet

To create a check sheet first step should be defining the events, problems or processes to be recorded and to categorize these events. If there are events which are not easily categorized into any of the existing group, then a category of other should be added for these events.

Then for the data recording, suitable intervals and periods should be identified. This time interval should be representative. And the check sheet

should be designed to be used during data recording and it should be easy to understand. All columns should be properly classified. The data collection should be performed during the agreed time interval, and everyone should understand the tasks and events that are recorded. The data should be analyzed to identify events with unusually high or low frequencies. Then the information should be plotted on a check sheet.

There are four main types of check sheets:

6. 3. 1 Defective Item Check Sheet

To identify what types of defects or problems occur during the process, this type of check sheets are used. In these check sheets there is usually a list of problems or defects that can occur during the process. When a defect or problem occurs, a mark is placed in the column of this problem. The data that is used is countable in this type of check sheets. The table below shows an example for a defective item check sheet used in wave solders manufacture process.

Defect Type	Insufficient Solder	Cold Solder	Solder Bridge	Blow Holes	Excessive Solder
Frequency	xxxxxxx	xx	xxx	xxxxxxxxxxxxxxx	xx
Total	7	2	3	14	2

Table 1. Wave Solder Defect Count

6. 3. 2 Defective Location Check Sheet

This type of check sheets helps to find the location of defect or problem on the product. These are used if the external appearance of products is important. This type of check sheets generally consist a picture of product. To indicate the place of defects that are occurring on the surface of the product, marks can be made on the picture.

6. 3. 3 Defective Cause Check Sheet

This type of check sheets are used to find the causes of defects or problems. During data collection, more then one variable is monitored for this type. For example, the data about type of machine, date, time and operator can be monitored in the same check sheet. Table below is an example of this type of check sheets. As it is seen from the table, most of the error is occurring in the afternoon shift and in the machine 2. This means that machine 2 has problems when it is used in the afternoon shift.

		Machine 1	Machine 2
Operator A	Morning	X	X
	Afternoon	XX	XXXXXX
Operator B	Morning	X	XX
	Afternoon	XX	XXXXXXXXX

n

Table 2: Defect cause check sheet

X= Number of times that there is an error occurs

6. 3. 4 Checkup Confirmation Check Sheet

To being sure that proper procedures are being applied, this type of check sheets is being used. This type of check sheets generally has a list of tasks which are required to be accomplished before the action will be taken. Final inspection, operation checks, service performance, machine maintenance check sheets are the examples of checkup confirmation check sheets.

6. 4 Conclusion

Check sheets are helpful methods to collect data. They are easy to use and understand and also they let user to collect data in an easy, organized and systematic manner. There are many types of check sheets are being used. The most common types are defective item, defective location, defective cause and checkup confirmation check sheets.

7. CONTROL CHARTS

7. 1 Purpose of Control Charts

It is a tool used to ensure that whether the business or production process is under control continuously and to help the improvement of the process performance by the studying variation and its source. Using control charts will help us to make the adjustments of the quality of output of the process where it is needed.

7. 2 Description

Control charts are formed in order to examine if the process is statistically in control and the variation of the process within time. Control charts give us notice in advance of possible problems that can be happened in near future. By the control charts one can interpret about the variation that are obtained from the data of a process and keep the process in control. And the method used is called Statistical Control Process. The aim of the control charts is to keep the variations that might be occur during the project in the quality manner within acceptable the upper and lower limits. Control charts only give notice to us about the existence of defect; it does not give any solution to overcome it. Here are some benefits to use Control charts;

- To expose the essential changes of the quality properties.
- To measure quality change performance.
- To determine the average level of the quality properties.

On control charts 3 levels must be defined. These are Upper control limit (UCL), Center line (CL) and lower control limits (LCL). These limits or lines are calculated from samples that are taken from the particular process. And the points in the chart refer to the samples and usually minimum 25 points are required to come up with an accurate control chart.

According to the data type we have, selecting the best suitable control charts, will lead us to reach the result faster and efficiently. Types of control charts can be defined mainly defined as the average and range control charts. The average control charts show the closeness of the process to the nominal design value, while range control charts indicate the quantity of variability and spread around the nominal value.

7. 3 Construction of Control Charts

Construction of a control chart involves three main steps:

7. 3. 1 Mathematical Model

Step 1: Data Collection

First we need to decide which quality characteristic of the process or product will be examined. Then m samples of n units are chosen for controls. For each unit, the determined quality characteristic is measured and recorded in a spreadsheet.

Step 2: Plot data In each case, the X axis of a control chart shows sample numbers. Data plotted depends on the chart type for the Y axis:

Step 3 : Calculate the central line and control limits

The table below shows the information about central lines and control limits for both types of control charts :

The coefficients used in formulas depend on the sample number n and they are shown in quality books.

PART TWO: THE SEVEN MANAGEMENT TOOLS

The seven management and planning tools are used in isolation or in an integrated fashion, are designed to improve planning and implementation, it may require more time during the planning stage, and it is intended to save time later as a result of better planning.

The Seven Management tools are the following;

- The Affinity Diagram

- The Inter-Relationship Digraph
- The Tree Diagram
- The Activity Network Diagram
- Prioritization Matrices
- The Matrix Diagram
- The Process Decision Program Chart

1. AFFINITY DIAGRAM

The origin of the affinity diagram can be traced to a data analysis technique called the KJ Method, developed by Kawakita Jiro. The affinity diagram is largely a creative brainstorming process in which consensus is reached by visual (written) rather than verbal means. The affinity diagram can also be used as a management and planning tool that can help with the systematic analysis of large amounts of data. It is best used for translating large amounts of complex, apparently unrelated information, into natural and meaningful groupings of data.

Grouping related items helps t