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# Analysis of Software Quality Tools Samsung Galaxy Note 7 Recall Case

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**ABSTRACT:** Seven quality control tools are a set of the QC tools that can be used for improving the performance of the production processes, from the first step of producing a product or service to the last stage of production. In this paper, we will be discussing the seven quality models and how they can be used to detect the defects, analyse them and therefore help prevention of similar issues occurring in future, with an example of Samsung's smartphone recall case that happened in late 2016. Samsung Electronics is aSouth Korean multinational company manufacturing mobile phone along with some other electronic products like lithium-ion batteries, hard disks, etc.Samsung Galaxy Note 7 was the smartphone from the Note series which was launched in August 2016. Within very few days of sales many complaints were received by the company about phone battery explosion and related problems from different parts of the world. In this paper, we have analysed the case using various quality control tools and the importance of using them for identifying issues and preventing them from occurring again in future. We have assumed some data for effective study of the tools.

**KEYWORDS:** Software Quality Control tools, Fishbone diagram, Pareto chart, Histogram, Checksheet, Control Chart, Run chart, Scatter diagram, Error detection, Error preventon, Bugs, Fast charge technology, Lithiom-ion battery, Testing Process, Design Issues, Smartphone.

## I. INTRODUCTION

The 7 QC Tools are simple statistical tools used for problem solving. These tools were either developed in Japan or introduced to Japan by the Quality Gurus such as Deming and Juran. In terms of importance, these are the most useful. Kaoru Ishikawa has stated that these 7 tools can be used to solve 95 percent of all problems. These tools have been the foundation of Japan's astonishing industrial resurgence after the Second World War. For solving quality problems seven QC tools used are Pareto charts, Cause & Effect Diagram, Histogram, Control Charts, Run charts, Scatter Diagrams, and Check Sheets. All this tools are important tools used widely at manufacturing field to monitor the overall operation and continuous process improvement. This tools are used to find out root causes and eliminate them, thus the manufacturing process can be improved. Figure 1 indicates the relationships among these seven tools and their utilizations for the identification and analysis of improvement of quality.

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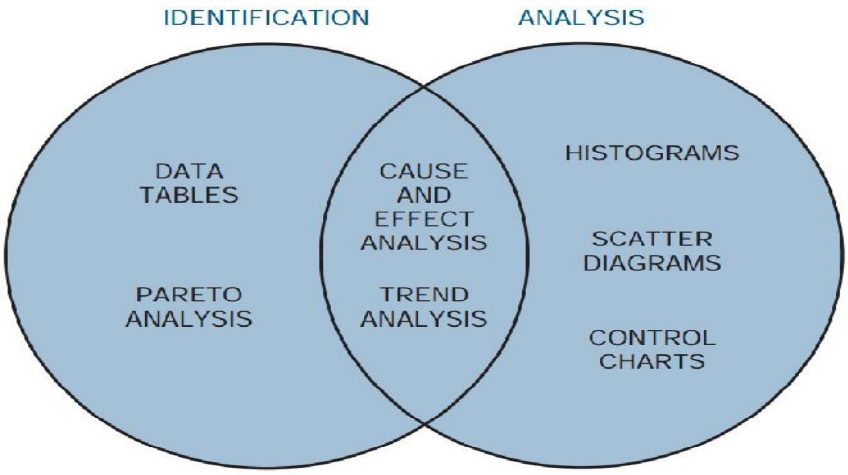


Fig. 1.7 QC Tools

## II. FISHBONE DIAGRAM (ISHIKAWA)

Kaoru Ishikawa is considered by many researchers to be the founder and first promoter of the 'Fishbone' diagram (or Cause-and-Effect Diagram) for root cause analysis and the concept of Quality Control (QC) circles. Cause and effect diagram was developed by Dr. Kaoru Ishikawa in 1943. It has also two other names that are Ishikawa diagram and fishbone because the shape of the diagram looks like the skeleton of a fish to identify quality problems based on their degree of importance. The cause and effect diagram is a problem-solving tool that investigates and analyzes systematically all the potential or real causes that result in a single effect. On the other hand, it is an efficient tool that equips the organization's management to explore for the possible causes of a problem. This diagram can provide the problem-solving efforts by "gathering and organizing the possible causes, reaching a common understanding of the problem, exposing gaps in existing knowledge, ranking the most probable causes, and studying each cause". The generic categories of the cause and effect diagram are usually six elements (causes) such as environment, materials, machine, measurement, man, and method. Further, "potential causes" can be indicated by arrows entering the main cause arrow.

The following diagram describes the Ishikawa diagram for Samsung Galaxy Note 7 recall:

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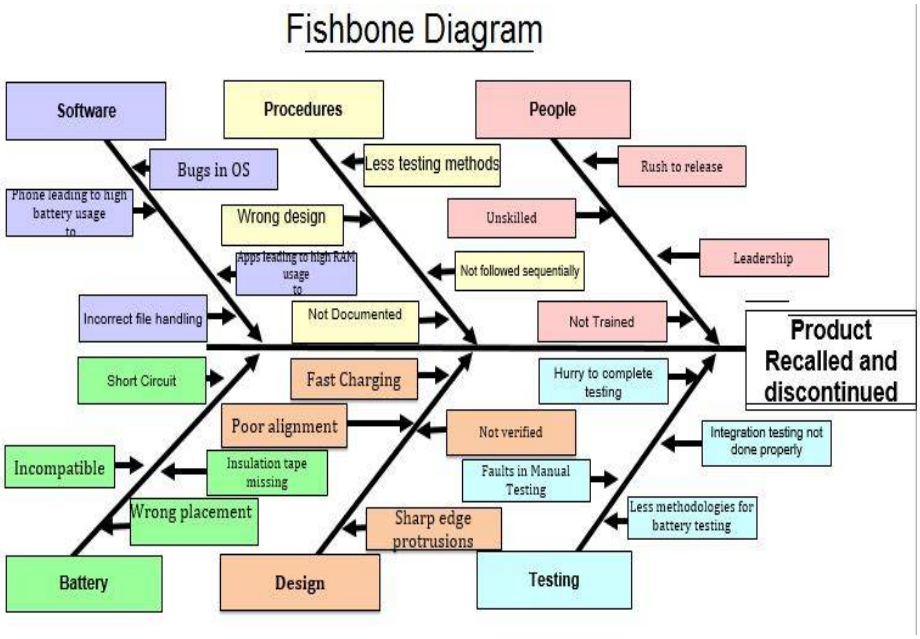


Fig. 2. Ishikawa diagram for Samsung Galaxy Note 7 recall:

From the diagram we can say that the major problems that caused the recall of over 2.5 million phones were:
1. OS BUGS
2. IMPROPER TESTING
3. UNSKILLED LABOUR
4. SHORT CIRCUIT
5. MISSING INSULATION TAPE
6. DESIGN
7. WRONG BATTERY PLACEMENT
8. SHARP EDGE PROTRUSIONS
9. OVERUSE OF BATTERY
10. IGNORANCE FOR TESTING
11. POOR ALIGNMENT
12. FAST CHARGE

All this problems were then deeply studied and the major reason was concluded to be the design and placement of battries that lead to short circuit and explosion in some cases.

## III. HISTOGRAM

Histogram is very useful tool to describe a sense of the frequency distribution of observed values of a variable. It is a type of bar chart that visualizes both attribute and variable data of a product or process, also assists users to show the distribution of data and the amount of variation within a process. It displays the different measures of central tendency (mean, mode, and average). It should be designed properly for those working into the operation process can easily utilize and understand them. Also, a histogram can be applied to investigate and identify the underlying distribution of the variable being explored. Histograms are useful in studying patterns of distribution and in drawing conclusions about the process based on the pattern.

The histogram for the various defects mentioned in Ishikawa diagram will be as follows:

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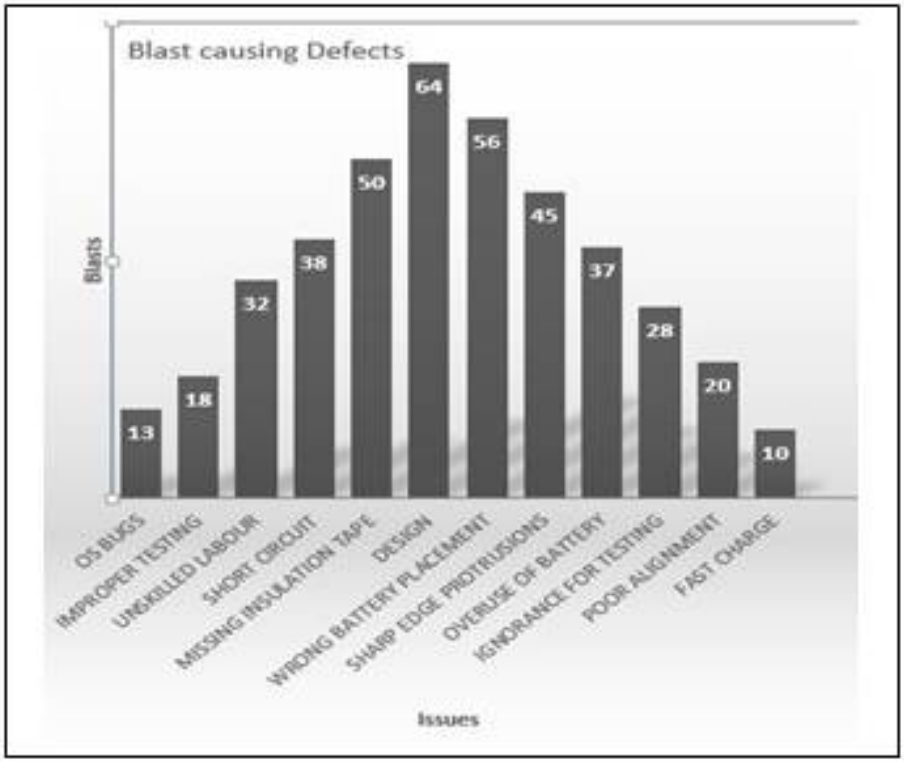


Fig.3. histogram

The histogram shows the major reasons for the explosion of battery was wrong architectural design because of which 64 phones were exploded followed by other issues such as wrong placement of battery and missing insulation tape surrounding the battery. This three issues need to be solved on highest priority followed by other issues.

## IV. RUN CHART

A run chart is a line graph of data plotted over time. By collecting and charting data over time, we can find trends or patterns in the process. Because they do not use control limits, run charts cannot tell if a process is stable. However, they can show how the process is running. The run chart can be a valuable tool at the beginning of a project, as it reveals important information about a process before we have collected enough data to create reliable control limits. Run charts are often used with baseline data at the beginning of a project. A process is defined as a series of activities that transforms a set of inputs into a specific set of outputs. Process change happens over time. Determining if a change has happened – and if that change lasts over time – is important to process improvement. A run chart is used to determine whether or not the central tendency of a process is changing.
Processes fall into one of four states:

- Ideal
- Threshold
- Brink of chaos
- State of chaos

When a process operates in the ideal state, the process has proven stability and target performance over time. This process is predictable and its output meets customer expectations. A process that is in the threshold state is predictable; however, it does not consistently meet customer needs. The brink-of-chaos state reflects a process that is unpredictable, but the outputs of the process still meet customer requirements. This process can produce nonconformance at any

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moment – it is only a matter of time. The fourth process state is the state of chaos, which produces unpredictable levels of nonconformance.
The Run chart for the Note 7 phablet phone crises can be as follows:

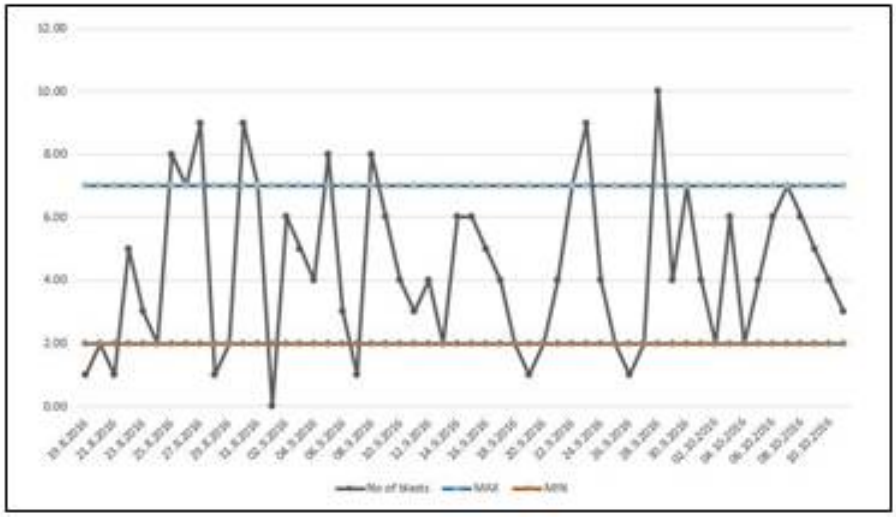

Fig.4. run chart for Samsung galaxy note 7 case

The run chart shows as there are 19 points that are either beyond the MIN-MAX boundary or on the boundary, the process is in the 'state of chaos' and needs to be admitted soon.

## V. CONTROL CHART

The control chart is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit. These lines are determined from historical data. By comparing current data to these lines, a conclusion can be drawn about whether the process variation is consistent (in control) or is unpredictable (out of control, affected by special causes of variation).
Control Chart can be used:

- When controlling ongoing processes by finding and correcting problems as they occur.
- When predicting the expected range of outcomes from a process.
- When determining whether a process is stable (in statistical control).
- When analyzing patterns of process variation from special causes (non-routine events) or common causes (built into the process).
- When determining whether your quality improvement project should aim to prevent specific problems or to make fundamental changes to the process.

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The control chart for our example

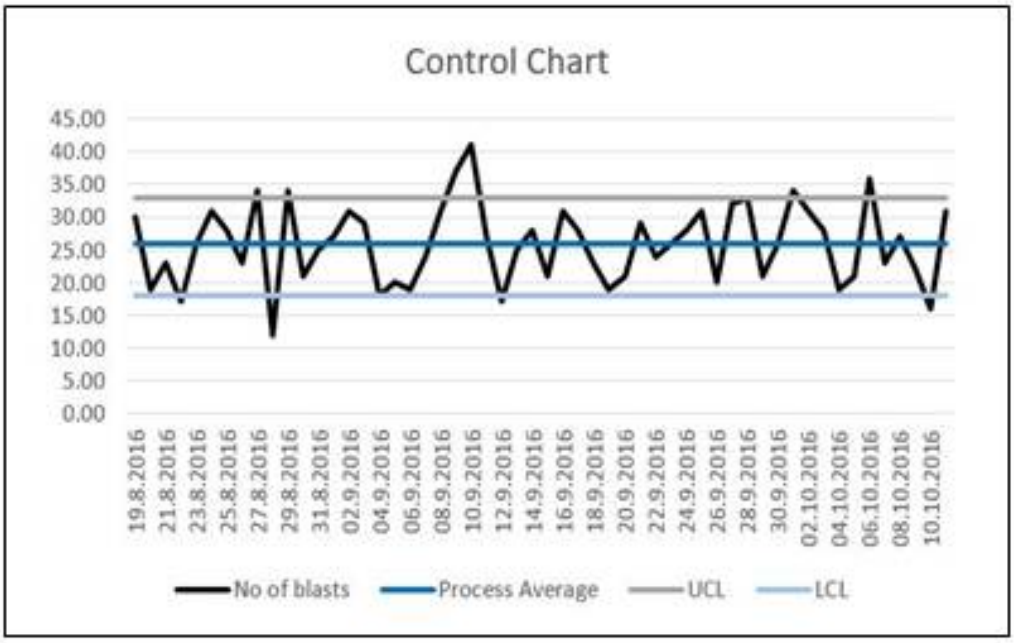


Fig.5. control chart

This control chart shows about 2 patterns, 2 shifts that may be the reasons for the cause.

The control chart for problems caused due to various suppliers:

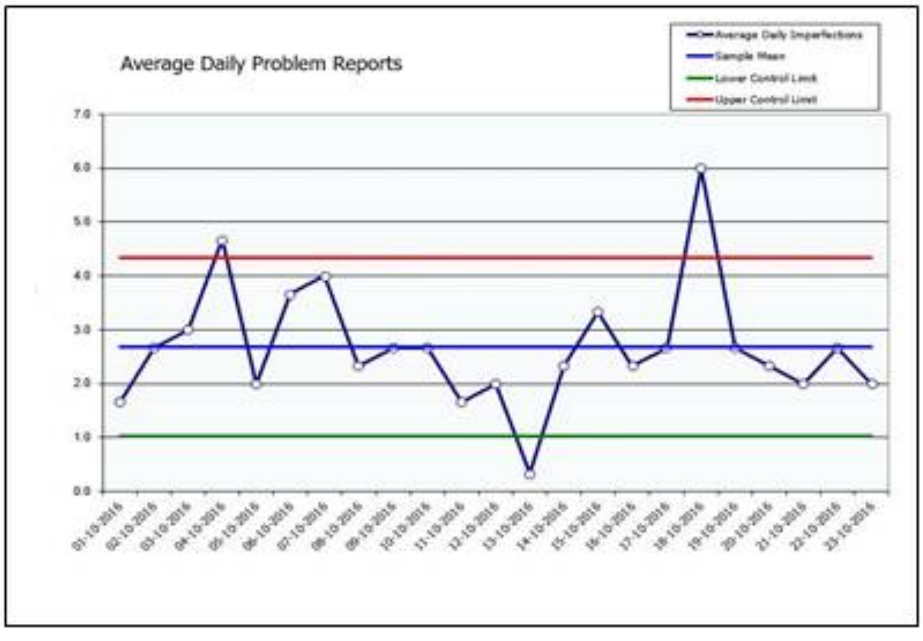


Fig .6.control chart for problems caused due to various suppliers

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This control chart shows the pattern created due to different battery suppliers, which can further lead to major cause of issues.

## VI. PARETO CHART

A Pareto chart is a bar graph. The lengths of the bars represent frequency or cost (time or money), and are arranged with longest bars on the left and the shortest to the right. In this way the chart visually depicts which situations are more significant.
Pareto Chart can be used:

- When analyzing data about the frequency of problems or causes in a process.
- When there are many problems or causes and you want to focus on the most significant.
- When analyzing broad causes by looking at their specific components.
- When communicating with others about your data.

Pareto chart in the case of Galaxy Note 7:

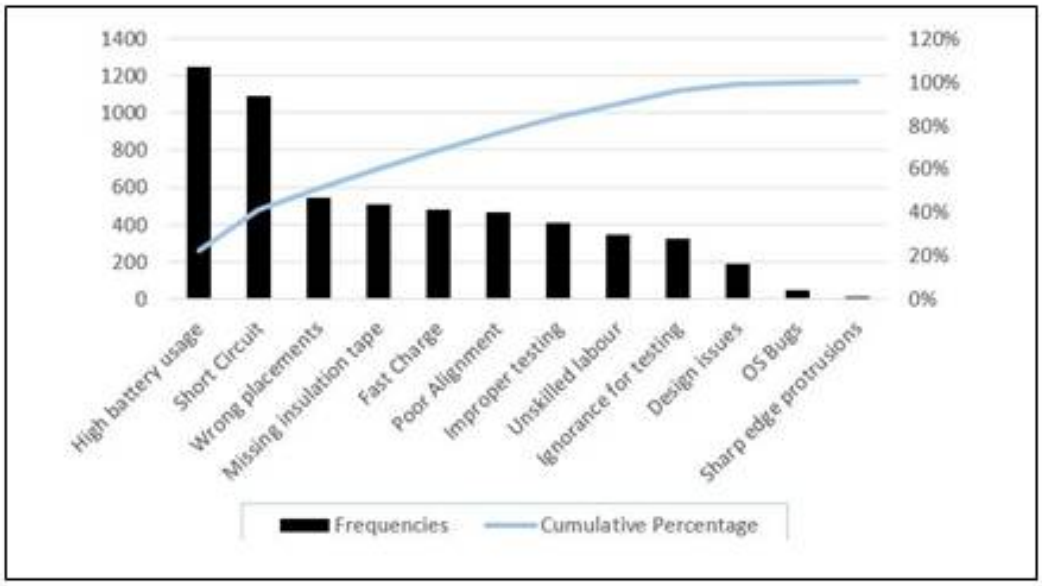


Fig.7. Pareto chart in the case of Galaxy Note 7

The Pareto chart concludes that the major problems such as high usage of phone, which is directly proportional to high battery usage, leads to Short circuit inside the phone. Which according to pareto principle concludes roughly 80% of effects come from 20% of the causes which are the first two from the chart.

## VII. CHECK SHEET

The Check Sheet is a simple document that is used for collecting data in real time and at the location where the data is generated. The document is typically a blank form that is designed for the quick, easy, and efficient recording of the desired information, which can be either quantitative or qualitative. When the information is quantitative, the check sheet is sometimes called a tally sheet. The check sheet is one of the seven basic tools of quality control made popular by Dr. Kaoru Ishikawa.
A defining characteristic of a check sheet is that data is recorded by making marks (“checks”) on it. A typical check sheet is divided into regions, and marks made in different regions have different significance. Data is read by observing the location and number of marks on the sheet.

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Check sheet for Note 7 case:

| Error Causes | Total | Column1 | Serious | Column2 | Moderate | Column3 | Minor | Column4 |
|---|---|---|---|---|---|---|---|---|
| Error | No | % | No | % | No | % | No | % |
| High Battery Usage | 1250 | 22% | 600 | 20% | 355 | 24% | 395 | 30% |
| Short Circuit | 1090 | 19% | 596 | 20% | 350 | 24% | 144 | 11% |
| Wrong Placements | 542 | 10% | 250 | 8% | 92 | 6% | 200 | 15% |
| Missing Insulation Tape | 510 | 9% | 300 | 10% | 150 | 10% | 60 | 5% |
| Fast Charge | 480 | 8% | 150 | 5% | 130 | 9% | 200 | 15% |
| Poor Alignment | 467 | 8% | 356 | 12% | 78 | 5% | 33 | 3% |
| Improper Testing | 412 | 7% | 200 | 7% | 150 | 10% | 62 | 5% |
| Unskilled Labour | 345 | 6% | 110 | 4% | 80 | 5% | 115 | 9% |
| Ignorance for testing | 322 | 6% | 300 | 10% | 11 | 1% | 11 | 1% |
| Design Issues | 190 | 3% | 90 | 3% | 50 | 3% | 50 | 4% |
| OS Bugs | 45 | 1% | 0 | 0% | 10 | 1% | 35 | 3% |
| Sharp Edge Protrusions | 10 | 0% | 0 | 0% | 0 | 0% | 10 | 1% |
| **Total** | 5663 | | 2952 | | 1456 | | 1315 | |

Check sheet shows the quantitative data of the issues and categorize them as Serious, Moderate and Minor. The priority can be set using this data to solve the errors.

## VIII. SCATTER DIAGRAM

The scatter diagram is known by many names, such as scatter plot, scatter graph, and correlation chart. This diagram is drawn with two variables, usually the first variable is independent and the second variable is dependent on the first variable.

The scatter diagram is used to find the correlation between these two variables. This diagram helps you determine how closely the two variables are related. After determining the correlation between the variables, you can then predict the behavior of the dependent variable based on the measure of the independent variable. This chart is very useful when one variable is easy to measure and the other is not.

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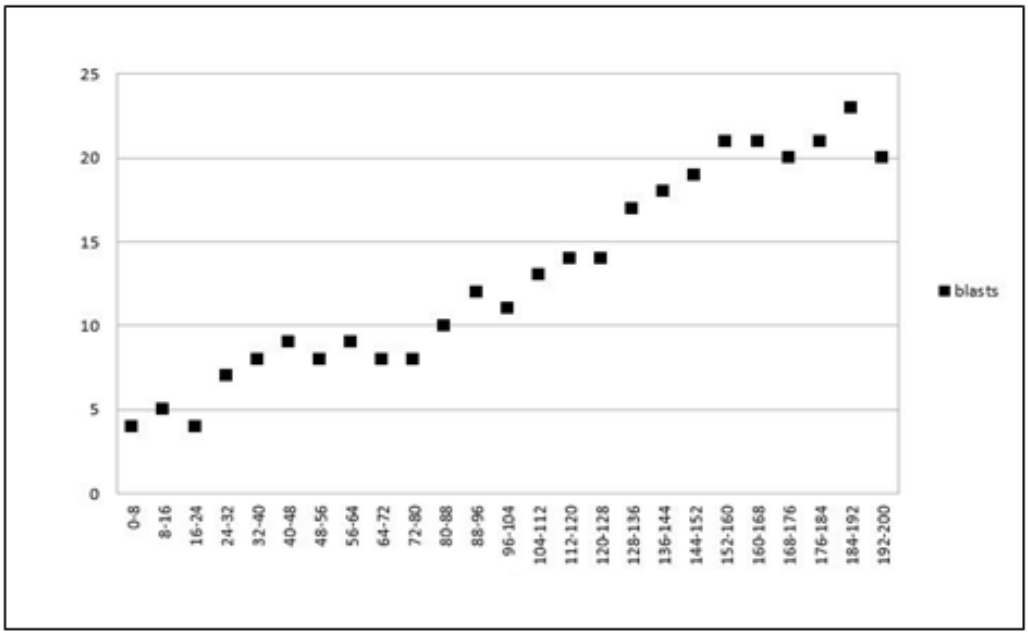


Fig. 8. Scatter diagram in case of Galaxy Note 7

Scatter diagram: Hours vs Phone blasts.

The scatter diagram shows a strong positive co-relation, the complaints of phone blasts from various parts of the world kept on increasing as hours were passing by after the launch of Samsung Galaxy Note 7 smartphone.

## IX. 5 WHY: ROOT CAUSE ANALYSIS TECHNIQUE

The 5 Whys technique is one of the most effective tools for root cause analysis. Every team faces difficulties in its daily work. However, using the 5 Whys will help you find the root cause of any problem and protect the process from recurring mistakes and failures.
The 5 Whys method is part of the Toyota Production System. Developed by Sakichi Toyoda, a Japanese inventor and industrialist, the technique became an integral part of the Lean philosophy.

5 whys in case of Samsung Galaxy Note 7 recall case:

1. Why was the phone recalled?
2. Why did the batteries explode?
3. Why there was not appropriate testing?
4. Why were labours not skilled?
5. Why was the training not conducted?

After answering all these questions, the root cause was found out and Samsung would work on it to avoid similar problems in future.

## X. TAKT TIME

Takt is the maximum amount of time in which a product needs to be produced in order to satisfy customer demand.
First, takt ensures that all the capacity in a business is planned and utilized and still meets overall customer demand. By and large, takt will help to deliver the right product (RP) at the right time (RT) in the right quantity (RQ) to the

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customer. Second, takt creates a constant pulse across your processes, which will immediately highlight capacity issues, synchronization issues among processes, quality issues and many others.
Takt time is the rate at which you need to complete a product in order to meet customer demand. To define takt time, you need to divide the production time available by the customer demand.

$$\text{Takt time} = \frac{\text{Total Available Production Time}}{\text{Average Customer Demand}}$$

In the case of Samsung Note 7, the formula will be:

$$\text{Takt time} = \frac{\text{Number of hours in a day}}{\text{Average no. of explosions in 10 countries}}$$

$$\text{i.e.,Takt time} = \frac{24*60}{10*15}$$

$$\text{Takt time} = 9.6$$

Therefore, the frequency of explosion was approximately 1 explosion in 9.6 minutes around 10 countries.

## XI. POKA YOKE

Poka Yoke is a quality management concept developed by a Matsushita manufacturing engineer named Shigeo Shingo to prevent human errors from occurring in the production line.
The main objective of poke yoke is to achieve zero defects. Poka Yoke is more of a concept than a procedure. Thus, its implementation is governed by what people think they can do to prevent errors in their workplace, and not by a set of step-by-step instructions on how they should do their job.

Poka Yoke in the case of Samsung Galaxy Note 7:

- Having a proper vendor selection process.
- Quality check report of the batteries should be provided by the vendors.
- Samsung should have a dedicated testing lab with skilled employees.
- Samsung should produce own batteries so that quality is not compromised.
- The company should produce body fitted batteries.
- Notify users to not use their phones if the battery is over used and passes the heating temperature threshold.

## XII. CONCLUSION

This study identified that is very essential to apply all seven QC tools for troubleshooting issues within production processes in the organizations. Doubtlessly, all of the aforementioned quality tools should be considered and used by management for identifying and solving quality problems during producing the products and services. Thus, the production processes can be affected and improved by multiple factors of these statistical QC tools. The following Figure interprets how the 7 QC should be employed from first step to end of production processes for identifying the problems of quality performance and controlling them:

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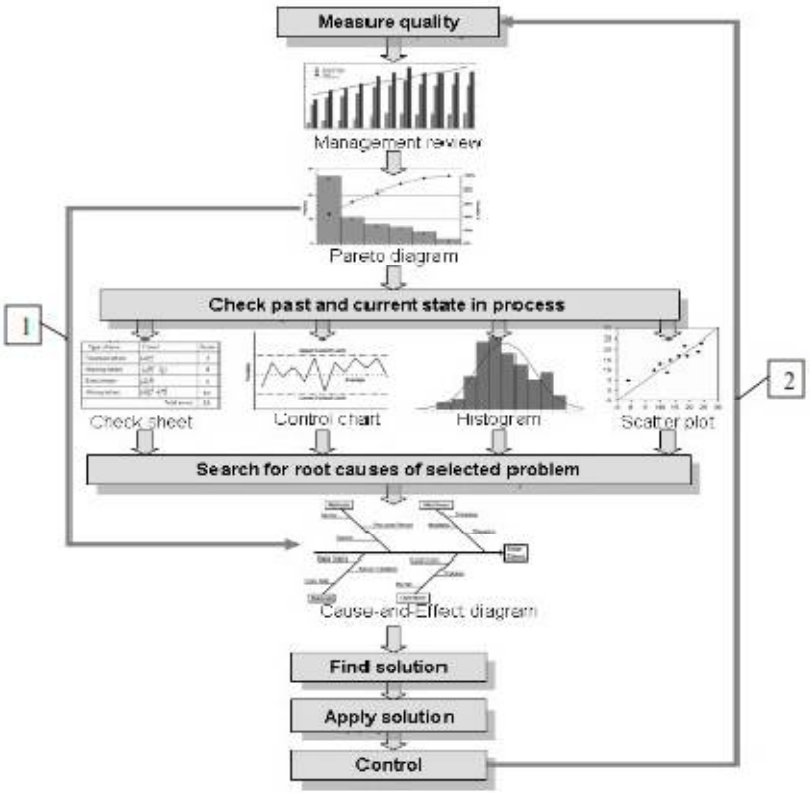


Fig.9. sequential use of quality tools

In the case of Samsung Galaxy Note 7, the 2.5million units of phone had to be recalled and company discontinued the product. The life span of the product was only two months.
Had Samsung implemented some of these tools between the processes of production of Note 7, this major crises wouldn't have taken place. Samsung seems to have implemented all the quality tools post product recall and now have come up with various techniques like "8 point battery checkup" to avoid such problems in future.

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