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1.SCATTER DIAGRAMS

Scatter diagram:

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Purpose:

- The Scatter diagrams is a graphical representation of relationship between two variables.
- It can be a cause and their effect and between two causes.
- It also reveals the nature of relationship between two variables and their approximate strength.

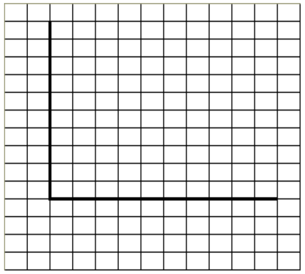
Application:

It can be used in diverse areas

- Relationship between an ingredient and the product hardness
- Relationship between the cutting speed of a blade .
- Variations observed in length of parts
- Relationship between the illumination levels on the production floor
- Mistakes made in quality inspection of product produced.

Data collection:

- Draw an "L" form just like in a graph paper (see the below figure). Make your scale units at even multiples, such as 10, 20, etc. so as to have an even scale system.



- On the Horizontal axis (Known as the "X" axis, from Left to Right) you place the Independent or "cause" variable.
- On the Vertical axis (Known as the "Y" axis, from Bottom to Top) you place the Dependent or "effect" variable.
- Plot your data points at the intersection of your data plots of the X and Y values. For Example = X = 5, Y = 2. Go right 5 spaces, and then go up 2 spaces to plot the point.

Scatter diagram:

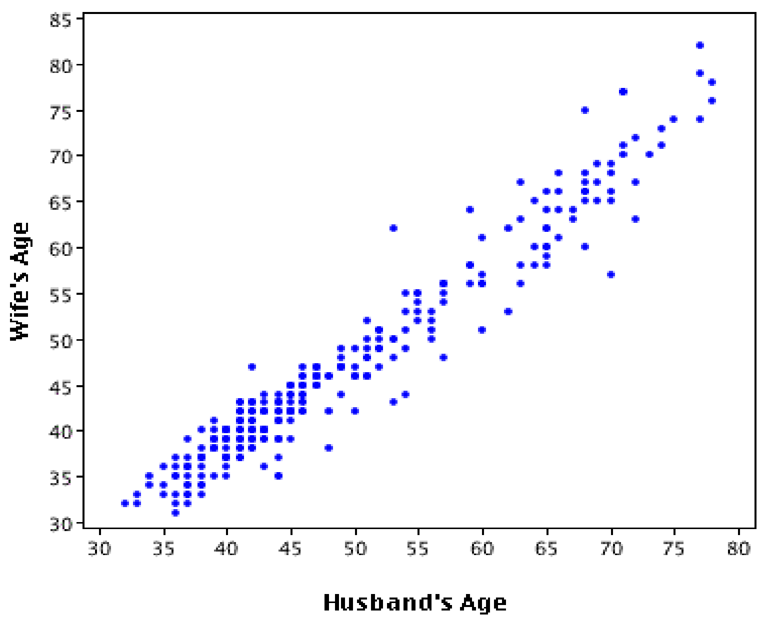
Analysis &Type of Patterns:,

After plotting You can see that the data pattern moving ,the pattern can be interpreted based on below types

- Perfect Positive Correlation
- Positive Correlation
- Negative Correlation
- Perfect negative correlation
- No Correlation

(a) **Perfect Positive Correlation** :.

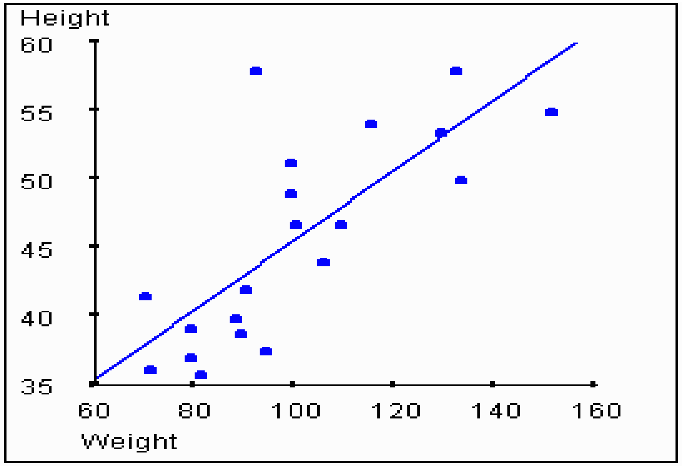
When the value of 'Y' increases as the value of 'X' increases, it is called Perfect Positive correlation.



Scatter diagram:

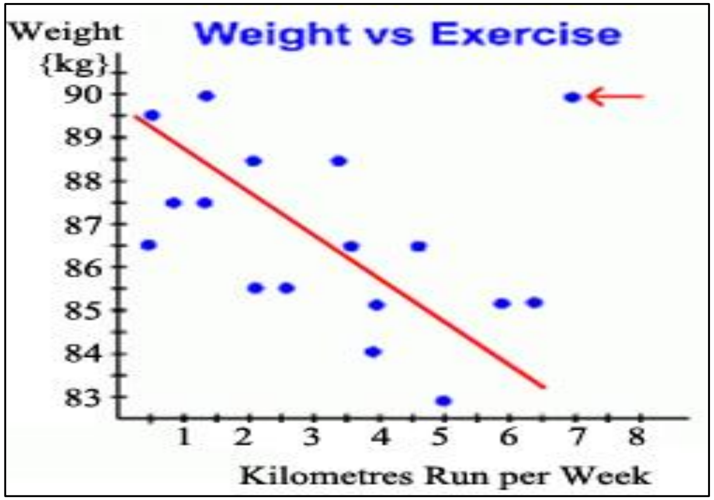
PDCA

(b) <u>Positive Correlation</u> :



When the value of 'Y' increases some what as the value of 'X' increases, we can say there is weak correlation or possibility of Positive correlation

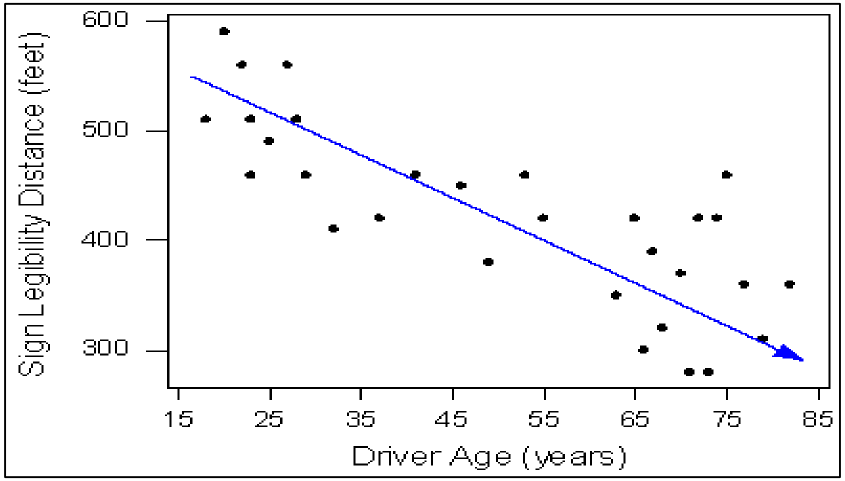
(C) <u>Negative Correlation</u> :.



When the value of 'Y' decreases some what as the value of 'X' increases, we can say there is weak correlation or possibility of Negative correlation.

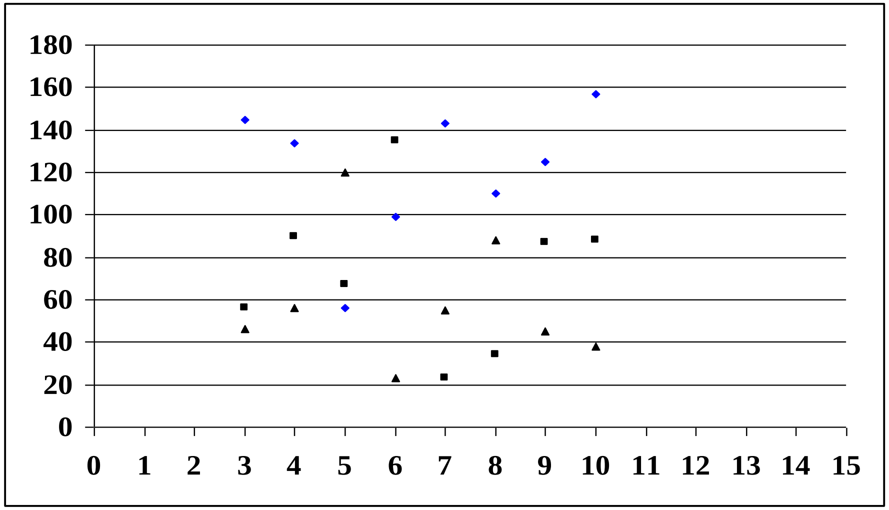
Scatter diagram:

(d) Perfect Negative Correlation :.



When the value of ‘Y’ increases as the value of ‘X’ decreases s, it is called Perfect negative correlation

(e) No Correlation :.



When the value of ‘Y’ decreases does not seem to increase or decrease with ‘X’ in the range of values of ‘X’, then we can say there is no correlation

Conclusion:

- Tool that can be used to show the relationship between "paired data", and can provide more useful information about a production process

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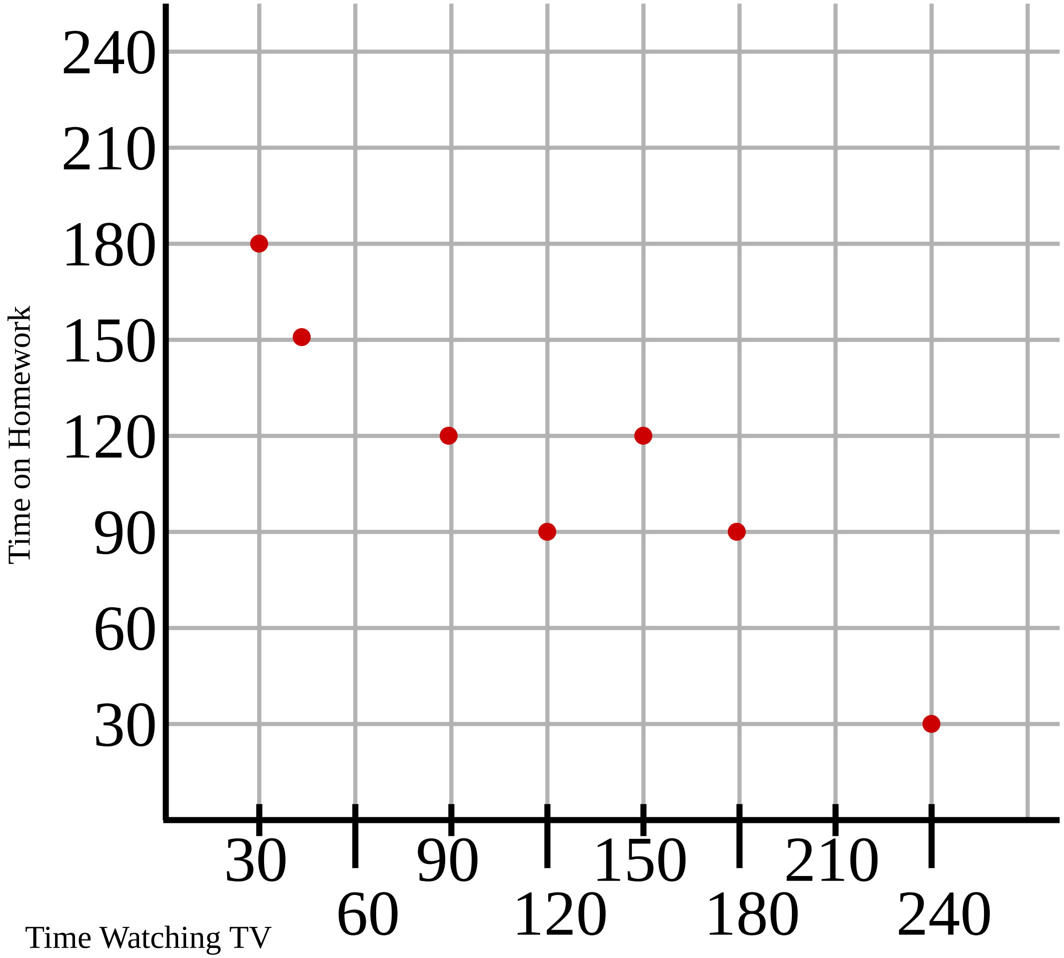
Example:

Plot the data on the graph such that homework time is on the y-axis and TV time is on the x-axis..

Student	Time Spent Watching Tv (min)	Time Spent Doing Homework (min)
A	30	180
B	45	150
C	120	90
D	240	30
E	90	90
F	150	90
G	180	90

Plot the data on the graph such that homework time is on the y-axis and TV time is on the x-axis.

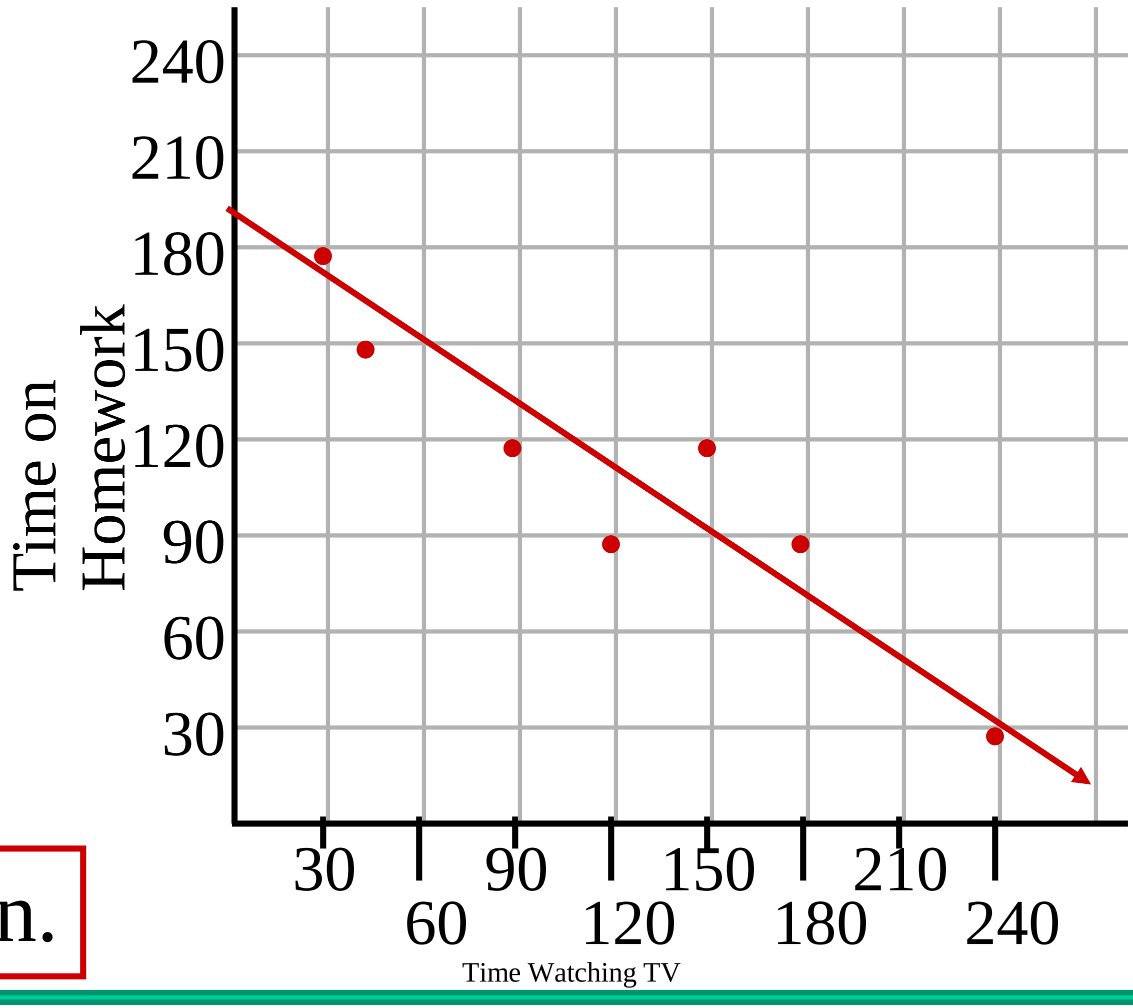
Homework	TV
30 min.	180 min.
45 min.	150 min.
120 min.	90 min.
240 min.	30 min.
90 min.	120 min.
150 min.	120 min.
180 min.	90 min.



Describe the relationship between time spent on homework and time spent watching TV.

Trend appears linear.

Trend is decreasing.



Time on TV ↑

Time on HW ↓

Negative correlation.

Exercise:

A driver keeps a record of the distance travelled and the amount of fuel in his tank on a long journey.

Distance Travelled (km)	*Fuel in Tank* (litres)
0	80
50	73
100	67
150	61
200	52
250	46
300	37

Exercise:

Every day Peter picks the ripe tomatoes in his greenhouse. He keeps a record of their mass and the number that he picks. His results are listed in the following table:

Number of Tomatoes Picked	*Total Mass* (grams)
20	1.2
50	3
100	6
120	7.2
200	12

Exercise:

Chris carries out an experiment in which he measure the extension of a spring when he hangs different masses on it. The following table lists his results.

Mass (grams)	*Extension* (cm)
1	40
3	180
2	60
5	270
8	390
6	220
7	420

2.STRATIFICATION

Purpose:

stratification is the sorting of data according to certain criteria or variables. Underlying patterns within the strata may be completely different than the combined total.
By stratifying data, a problem-solving team can identify the key problem categories to focus their efforts

Application:

- Stratification is the basis for other tools like Pareto analysis, and it is used in conjunction with other tools such as scatter diagrams, histograms, or box plots to make them more powerful.

Data collection:

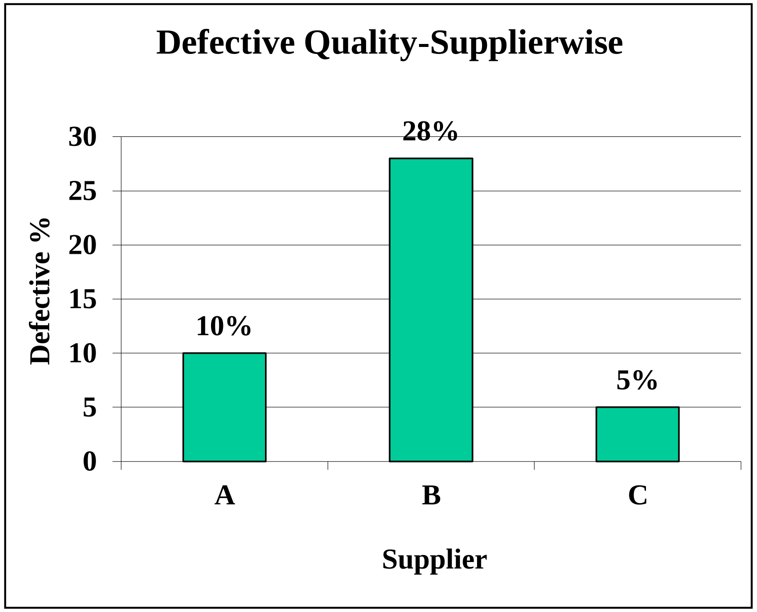
- Select Stratification variables.
- Establish categories for each stratification variable, categories may be discrete or range of values.

Analysis :

•Sort the data into the categories of stratification variable.

- Find the total for each category.
- Present the results in graphic form to enable effective communication.

Stratification is carried out as under.

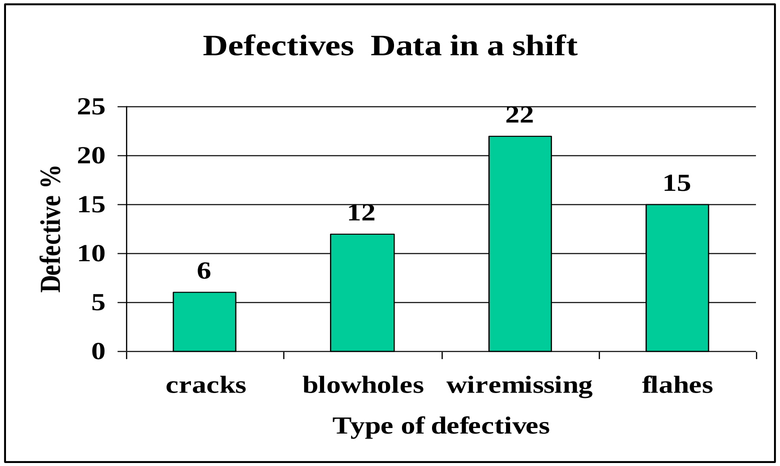


a)Material Base :

Supplier-wise and Lot-wise

(b) Defects Data in Shifts :

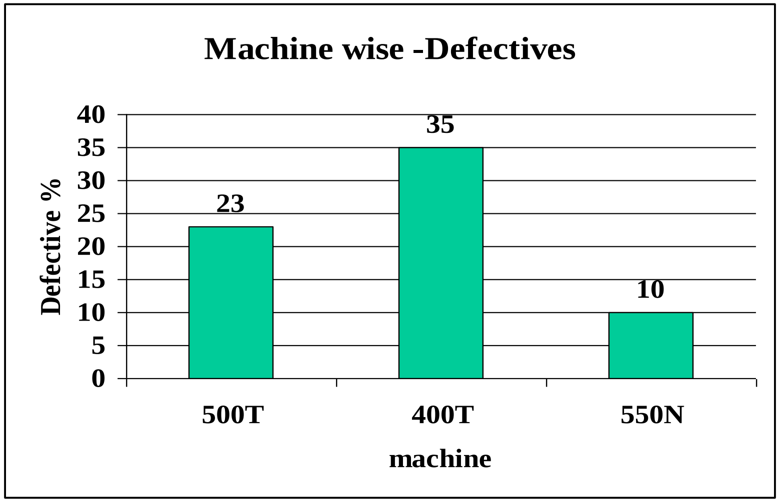
Influence of temperature, humidity and other conditions. (Grid casting)



(C) Machine/Equipment Base :.

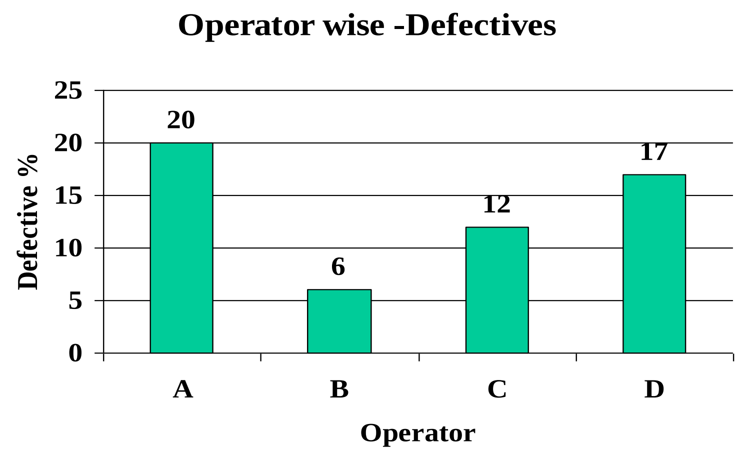
When the same product is made in parallel on several machines.

(For ex, In Plastics)



(b) Operator wise :

Suppose in grid casting these are the rejections

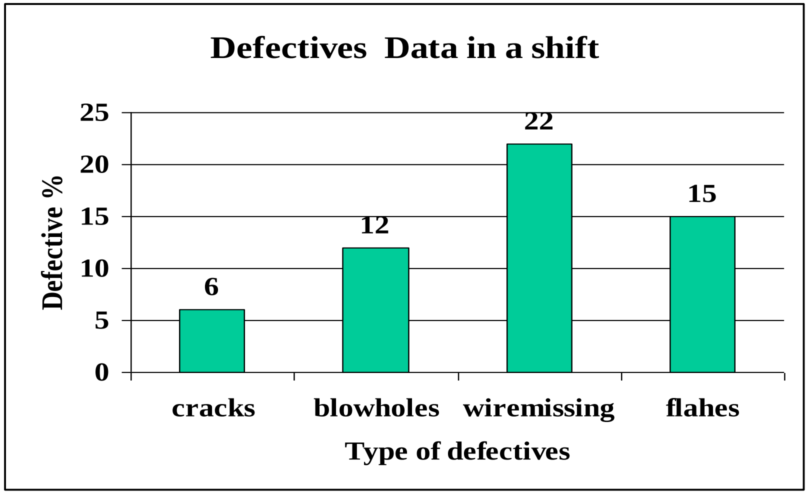


Conclusion:

Stratification alone will not normally point out exactly what the root causes of a problem are. It will, however, point out which areas need further investigation in order to have a full understanding of how the problem originated.

(b)Example

Grid casting rejections



Defect type	qty
cracks	6
Blow holes	12
wiremissing	22
flashes	15

(b)Exercise

BUS MILEAGE/LTR

BUS TYPE	MILEAGE/LTR
VOLVO	15
ASHOK LEYLAND	10
TATA	16
TOYOTA	17

(C)Exercise

Supplier wise Air conditioner cost 1 ton

AC Manufacturer	Cost
Toshibha	35000
LG	36000
LLoyd	31000
Blue star	34000

3. PARETO DIAGRAM

PARETO DIAGRAM

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Purpose:

The Pareto principle is to concentrate on "vital few" rather than "trivial many" in tackling quality problems. The Pareto diagram is a tool for identifying few actually important causes for defectives which result in large proportion of defectives, instead of concentrating on large number of causes which contributes to a small proportion of the total defectives. Some list of purposes are

- Breaks big problem into smaller pieces
- Identifies most significant factors
- Shows where to focus efforts & selection of problem

Application:

Since Pareto Charts convey information in a way that enables you to see clearly the choices that should be made, they can be used to set priorities for many practical applications in your command. Some examples are:

- Process improvement efforts for increased unit readiness
- Skills you want your division to have
- Customer needs
- Suppliers
- Investment opportunities

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Data collection:

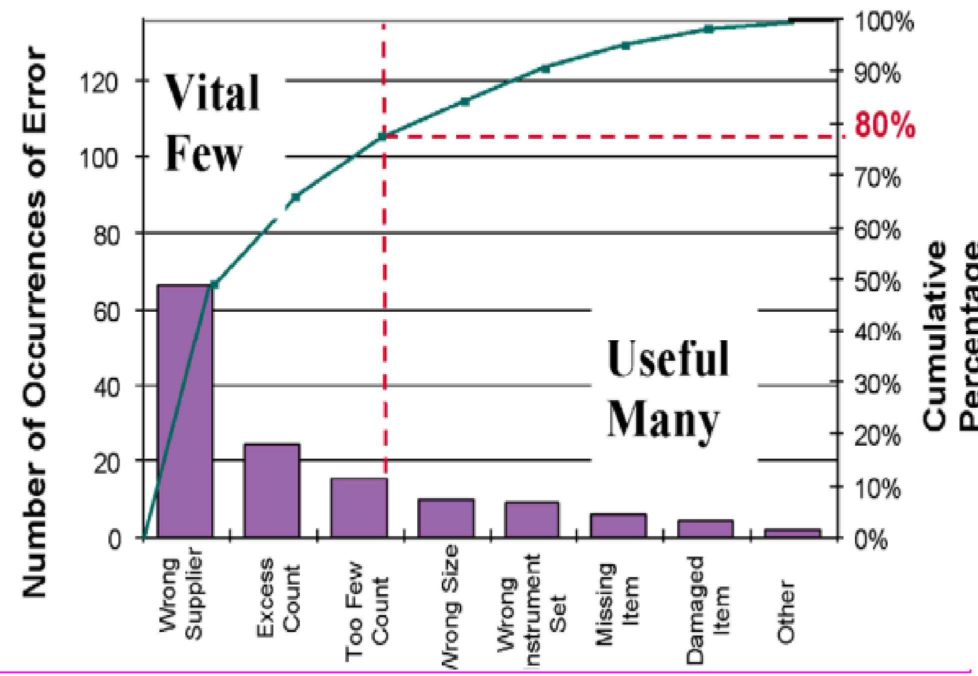
- Step 1: Form an explicit table listing the causes and their frequency as a percentage.
- Step 2: Arrange the rows in the decreasing order of importance of the causes (i.e., the most important cause first)

Analysis :

- Step 3: Add a cumulative percentage column to the table
- Step 4: Plot with causes on x- and cumulative percentage on y-axis
- Step 5: Join the above points to form a curve
- Step 6: Plot (on the same graph) a bar graph with causes on x- and percent frequency on y-axis
- Step 7: Draw line at 80% on y-axis parallel to x-axis. Then drop the line at the point of intersection with the curve on x-axis. This point on the x-axis separates the important causes (on the left) and trivial causes (on the right)

Analysis :

- Step 8: Explicitly review the chart to ensure that at least 80% of the causes are captured with the right edge of that category's bar. Connect all the dots with straight lines.



Conclusion:

- When you look at a Pareto Chart, you can see break points in the heights of the bars which indicate the most important categories. This information is useful when you are establishing priorities.
- As you can see in the example we've just looked at, you can detect a big breaks in the heights of the bars when you categorize the data in a different way

Example : On Data of website errors

Step 1: Arrange in descending order

Error (Cause)	Count
Broken Links	349
Spelling Errors	169
Missing Title Tag	79
Missing Description Tag	77
Broken Image	45
Script Error	30
Incorrect Use of Headings	15
Missing ALT tags	14
Browser Compatibility	12
Security Warning	9

CONSTRUCTING A PARETO CHART : P D C A

Step 2: Calculate the percentage contribution and cumulative percentage

Error (Cause)	Count	% contribution	Cumulative %
Broken Links	349	43.68%	43.7
Spelling Errors	169	21.15%	64.8
Missing Title Tag	79	9.89%	74.7
Missing Description Tag	77	9.64%	84.4
Broken Image	45	5.63%	90.0
Script Error	30	3.75%	93.7
Incorrect Use of Headings	15	1.88%	95.6
Missing ALT tags	14	1.75%	97.4
Browser Compatibility	12	1.50%	98.9
Security Warning	9	1.13%	100.0

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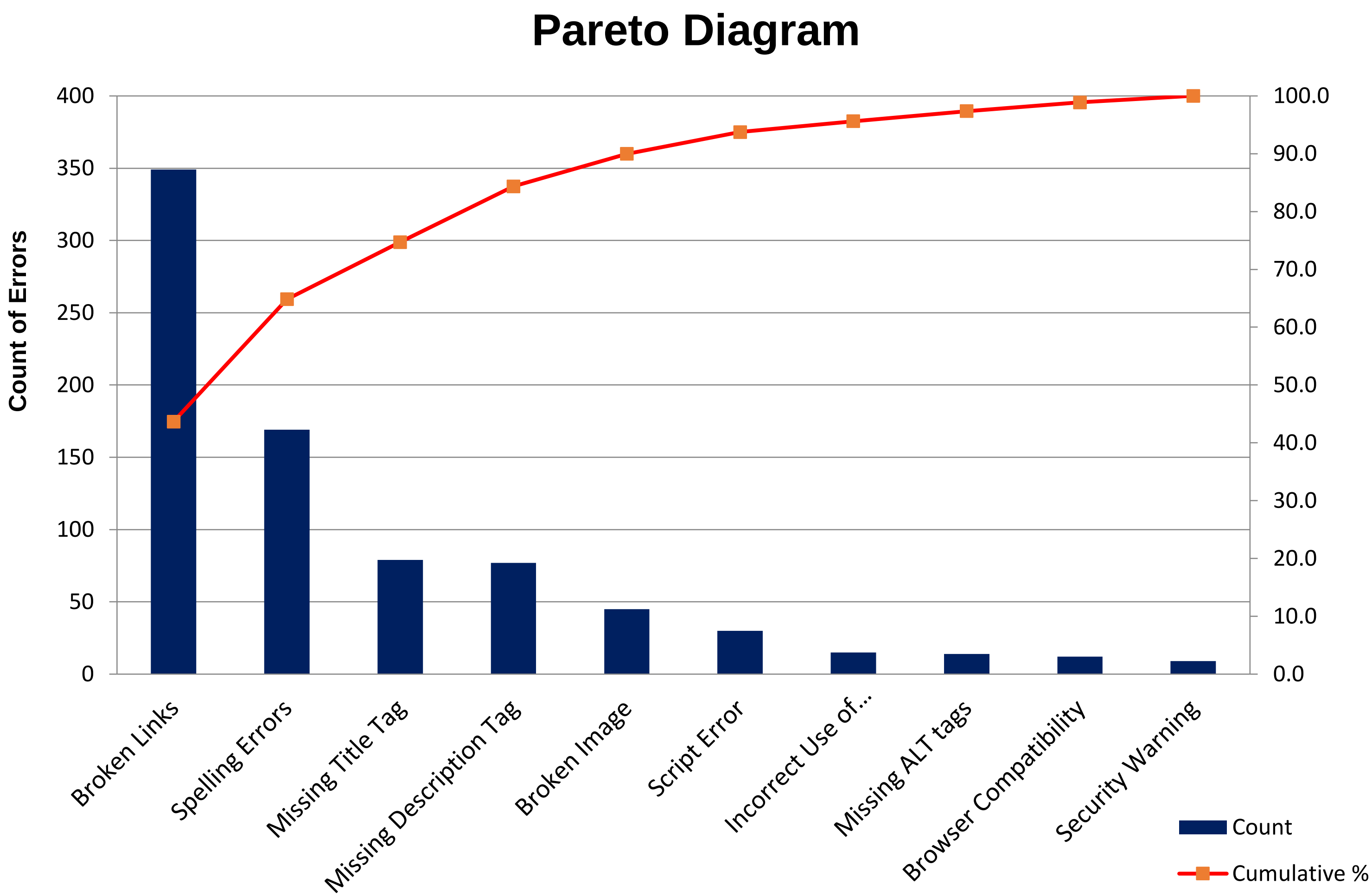
PARETO Analysis for the defects in Grid Casting :



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CONSTRUCTING A PARETO CHART : P D C A

Type of Defect	Quantity
Motor winding	20
Bend in fan blades	15
Cracks on rod	14
Capacitor	10
Scratches	12
Regulator	40
Bend in screws	25
Others	14
Total	150

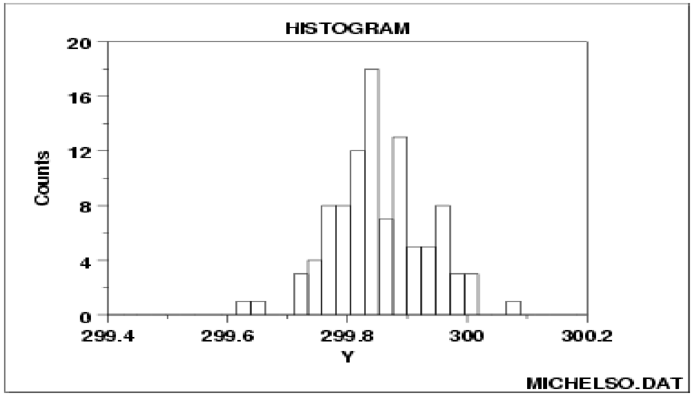
type of defect	quantity
Shrink	64
Porosity	14
Weld Lof	10
Shell inclusion	5
Hard Alpha inclusion	4
tungsten inclusion'	2

HISTOGRAM

Histogram

Purpose:

purpose of a Histogram is to take the data that is collected from a process and then display it graphically to view how the distribution of the data, centers itself around the mean, or main specification. From the data, the histogram will graphically show:



- The center of the data.
- The spread of the data.
- Any data skewers (slant, bias or run at an angle).
- The presence of outliers.
- The presence of multiple modes (or peaks) within the data.

Application :

Assess the system's current situation and to study results of improvement actions
The histogram's shape and statistical information help you decide how to improve the system
If the system is stable, you can make predictions about the future performance of the system.

Data collection:

Collect at least 50 consecutive data points from a process..
Step 1 - Count number of data points
Step 2 - Summarize on a tally sheet

Histogram

Data analysis:

Step 3 - Compute the Range, Range = Maximum-Minimum

Step 4 - Determine number of intervals From the table

Step 5 - Compute interval width,

Interval width= $\frac{Range+Least\ count}{Number\ of\ intervals}$

Step 6 - Specify the class boundaries.

- The lower limit of the first class is =minimum value- 0.5*least count
- The upper imit of the first class is =minimum value+ interval width

Step 7 - Ensure that

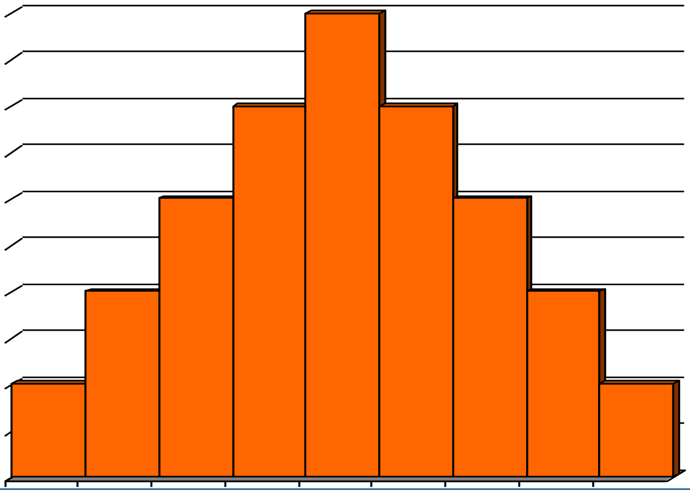
a) Classes are continuous

b) All classes have same width& plot the graph

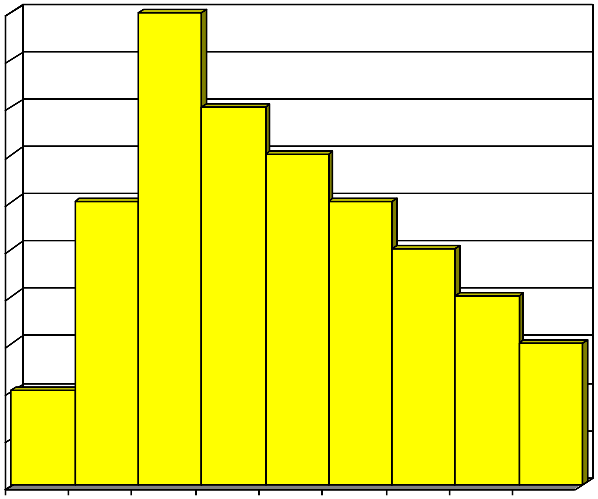
No. of Observations(N)	Recommended No. of classes or groups (K)
≤ 50	6
51 - 100	7
101 - 200	8
201 - 500	9
501 - 1000	10

Typical histogram shapes

Normal:. A common pattern is the bell–shaped curve known as the “normal distribution.” In a normal distribution, points are as likely to occur on one side of the average as on the other. Be aware, however, that other distributions look similar to the normal distribution. Statistical calculations must be used to prove a normal distribution..

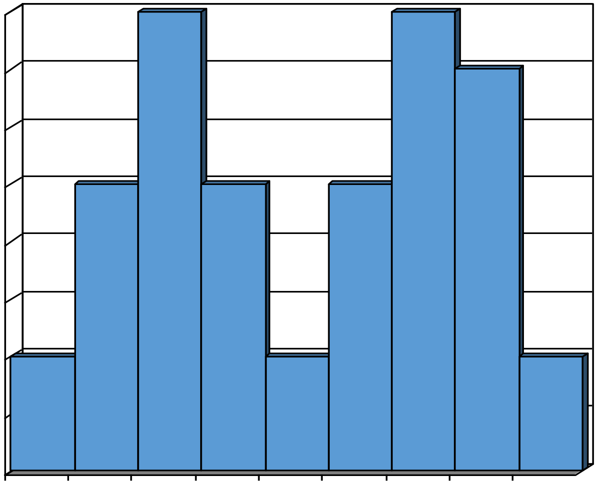


Typical histogram shapes



Skewed. The skewed distribution is asymmetrical because a natural limit prevents outcomes on one side. The distribution's peak is off center toward the limit and a tail stretches away from it

.**For example**,. natural limits are holes that cannot be smaller than the diameter of the drill bit or call-handling times that cannot be less than zero. These distributions are called right or left–skewed according to the direction of the tail



Double-peaked or bimodal.: The bimodal distribution looks like the back of a two-humped camel. The outcomes of two processes with different distributions are combined in one set of data.

For example, a distribution of production data from a two-shift operation might be bimodal, if each shift produces a different distribution of results. Stratification often reveals this problem.

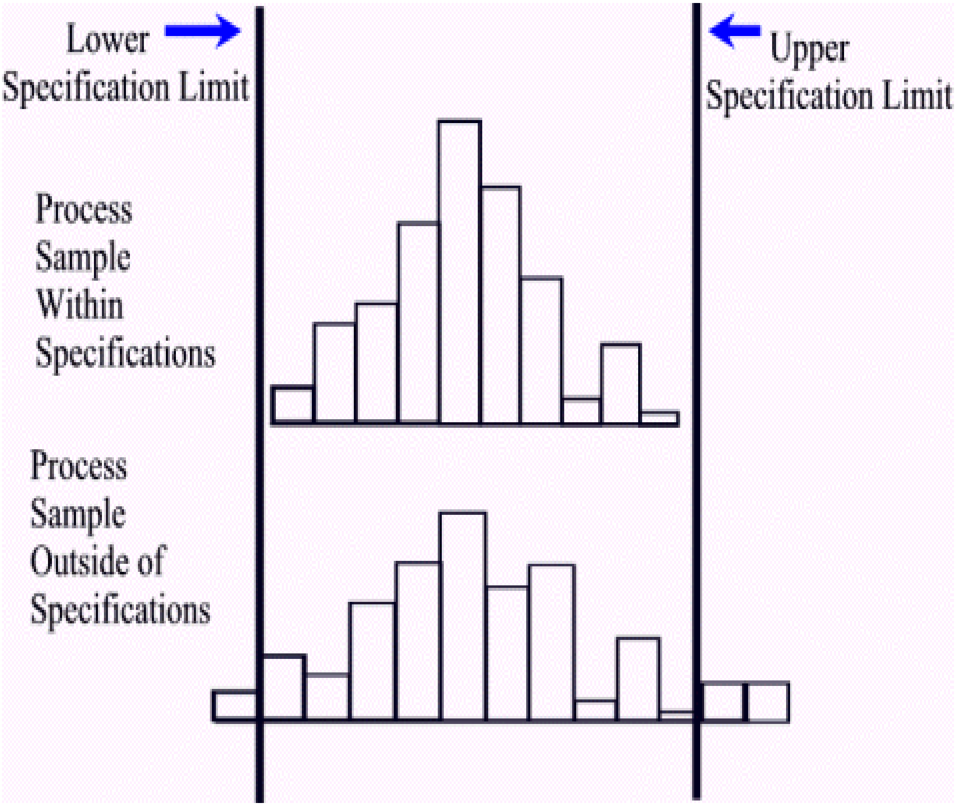
Analysis :

Once the histogram is developed, you can analyze the data with regard to customer expectations (specifications).

You can see from the following graphic that the first histogram of a process sample falls within the specifications,

while the second has a portion of the histogram outside of the specifications.

The second histogram has too much dispersion, or variability, to meet customer expectations. The indication is that action must be taken to make the output more consistent, or some number of defects will be produced.

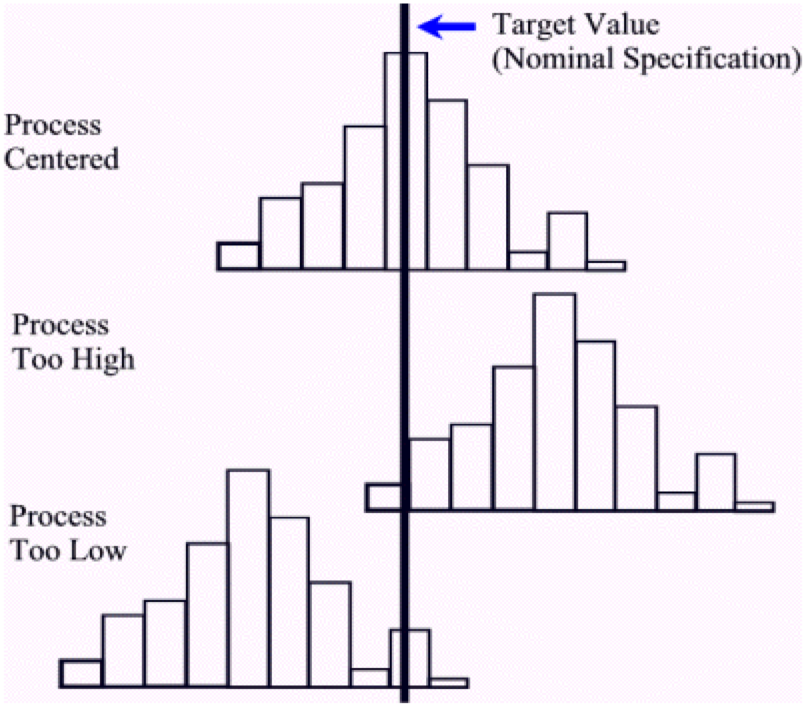


Analysis :

After assessing dispersion, or process spread, you can also analyze process centering. A process output distribution that is narrow enough to fall between the upper and lower specifications must also be centered in order to do so.

Often times it is much easier to center a process than to reduce its spread, or dispersion.

Centering may be a function of machine or tool settings, whereas the reduction of variability may require multiple actions to address multiple root causes.



Conclusion :

The histogram tool is a common tool for understanding data and the characteristics of data. Knowing how to correctly read a histogram graph can greatly assist process improvement efforts. Because of a histogram's common use it also makes an excellent graphic for representing data during presentations

Example:

Collect about 50 observations. Let on observation be denoted by X.

For example, consider the 50 readings of weight of 6R05 type Jars at Plastics Department.

394.62	394.65	394.45	394.15	394.35
393.8	394.42	394.1	394.45	394.5
393.85	394.44	394.25	394.21	394.45
394.35	394.77	394.45	394.6	394.1
394.68	394.20	394.6	394.2	394.90
394.66	394.25	394	394.45	394.15
394.59	394.12	394.15	394.7	394.40
394.85	394.56	394.53	394.65	394.45
394.17	394.40	394.25	394.5	394.91
394.5	394.43	394.12	394.25	394.53

.2. Find the smaller Xs and larger X_L in each row as follows :

Row	Xs	X_L
1	394.15	394.65
2	393.8	394.5
3	393.85	394.45
4	394.1	394.77
5	394.2	394.9
6	394	394.66
7	394.12	394.7
8	394.45	394.85
9	394.17	394.91
10	394.12	394.53

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3. From what is shown as maximum and minimum in each line, find out the minimum for all the readings.

$X \ max = 394.91; \qquad X \ min = 393.80$

4. Compute the range as

$R = X \ max - X \ min$

$R = 394.91 - 393.80 = 1.11$

5. Read the number of classes or groups from the following table :

No. of Observations(N)	Recommended No. of classes or groups (K)
$\leq$ 50	6
51 - 100	7
101 - 200	8
201 - 500	9
501 - 1000	10

Here N = 50 K = 6

6. Calculate the approximate width of class intervals as (R+W) / K where R is the range

K is the number of classes.

W is the least count

Let this denoted by 'C'

$R = 1.11$

$W = 0.01$

$K = 6$

$C = (R + W) / K$

$= (1.11 + 0.01)/6 = 0.19$

Lower limit of first class

$= X \text{ min} - 0.5\, W$

$= 393.80 - 0.5 \times 0.01$

$= 393.80 - 0.005$

$= 393.795$

Upper limit of first class

$= 393.795 + C$

$= 393.795 + 0.19 = 393.985$

Therefore, First class is 393.795 - 393.985

7. .Thus the classes are :

393.795 - 393.985

393.986 - 394.175

394.176 - 394.365

394.366 - 394.555

394.556 - 394.745

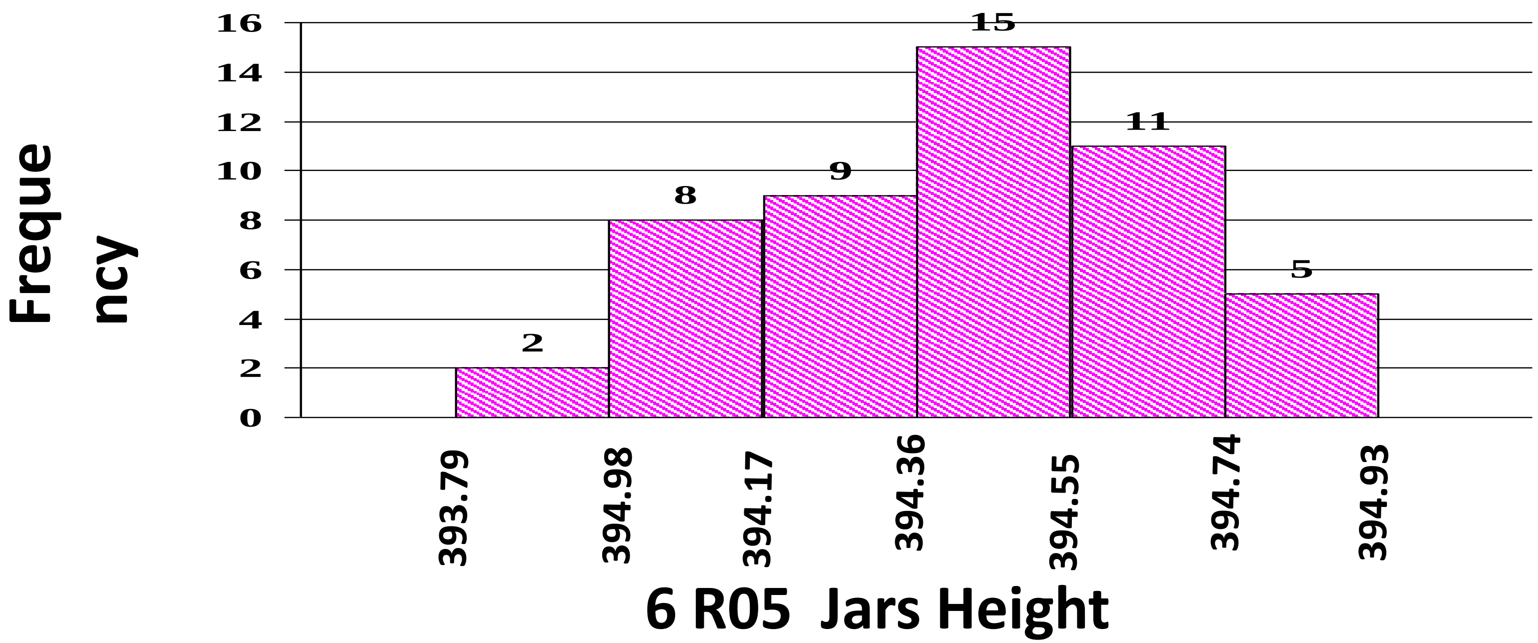
394.746 - 394.935

8. Read the observations in an order and for each observation put a mark against the class interval containing that value. Count the total no. of tally marks to give the frequency of that class. This gives the frequency table.

CLASS	TALLY	FREQUENCY
393.795 - 393.985	I I	2
393.985 - 394.175	~~IIII~~ III	8
394.175 - 394.365	~~IIII~~ IIII	9
394.365 - 394.555	~~IIII~~ ~~IIII~~ IIII	15
394.555 - 394.745	~~IIII~~ ~~IIII~~ I	11
394.745 - 394.935	~~IIII~~	5

9. To draw the Histogram for the above frequency table proceed as follows :

- Take a graph paper and represent Plastic Jar height on the X-axis and frequency on the Y-axis by choosing a suitable scale.
- Mark the classes on the X-axis with class intervals as base whose height is equal to the frequency. The resulting diagram is the HISTOGRAM



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CONTROL CHARTS

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1. PURPOSE OF CONTROL CHARTS :

There are 3 reasons for using a control chart

- .It is used to monitor a process to determine if the process is operating only with chance cause of variation, if it is not ,then process is out of control ,then control charts can be used to identify assignable cause and correct the process
- The purpose of drawing a control chart is to detect any changes in the process that would be evident by any abnormal points listed on the graph from the data collected. If these points are plotted in "real time", the operator will immediately see that the point is exceeding one of the contol limits, or is heading in that direction, and can make an immediate adjustment.
- It is used to estimate the parameters of a process(mean,variation)of a process.By these output of the process can be predicted.

1. CONTROL CHARTS FOR VARIABLES :

For variables data, the control chart for sample averages and sample ranges provides a powerful technique for analyzing process data.

- X - R CHART
- INDIVIDUAL(X) - MOVING RANGE CHART

The underlying distribution for this Variable control chart is Normal Distribution with mean and Standard deviation.

XBAR R- CHART

P D C A

Purpose:

$\overline{X}$ and R charts for any process with a subgroup size greater than one. Typically, it is used when the subgroup size falls between two and ten,

The range chart examines the variation within a subgroup

The $\overline{X}$ chart examines the variation between subgroups

Application:

- When you begin improving a system, use them to assess the system's stability
- After the stability has been assessed, determine if you need to stratify the data. You may find entirely different results between shifts, among workers, among different machines, among lots of materials, etc
- X-bar and R charts used to analyze the results of process improvements. Here you would consider how the process is running and compare it to how it ran in the past.
- use X-bar and R charts for standardization. This means you should continue collecting and analyzing data throughout the process operation. If you made changes to the system and stopped collecting data, you would have only perception and opinion to tell you whether the changes actually improved the system. Without a control chart, there is no way to know if the process has changed or to identify sources of process variability.

Data collection:

- A total of atleast 50 measurements(Here for ex: 15 samples of 4 each) should be collected
- Divide the data into sub groups, it is recommended the subgroups be of 4 or 5 data points each. The number of samples is represented by the letter " n " and the number of subgroups is represented by the letter " k ".

Analysis :

- Calculate and enter the average for each subgroup.by using formulae

$$\bar{X} = \frac{\text{Sum of individual measurements}}{\text{Number of individual measuremnts}}$$

- Calculate and enter the range for each subgroup

RANGE= (Largest Value in each Subgroup)- (Smallest Value in each Subgroup)

- Calculate the grand mean of the subgroup's average.

$$\bar{R} = \frac{\text{Average of each subgroups}}{\text{Number of individual Subgroups}}$$

- Calculate the overall mean, or $\bar{\bar{X}} = \frac{\text{Total the mean value of each subgroup}}{\text{Number of subgroups}}$
- Calculate the upper control limit (UCL) and lower control limit (LCL) for the averages of the subgroups.

UCL = $\bar{\bar{X}} + A_2 \bar{R}$ and **LCL** = $\bar{\bar{X}} - A_2 \bar{R}$ **CL** = $\bar{\bar{X}}$

- Calculate the upper control limit and lower control limit (LCL) for the ranges

UCL = $D_4 \bar{R}$ and **LCL** = $D_3 \bar{R}$ **CL** = $\bar{R}$

Conclusion :

Interpreting the X-bar &R chart:

- The control limits on the X-bar chart are derived from the average range, so if the Range chart is out of control, then the control limits on the X-bar chart are meaningless
- Whenever a single point falls outside the 3 sigma control limits, a lack of control is indicated. Since the probability of this happening is rather small, it is very likely not due to chance.
- Whenever at least 2 out of 3 successive values fall on the same side of the centerline and more than 2 sigma units away from the centerline a lack of control is indicated. Note that the third point can be on either side of the centerline
- Whenever at least 4 out of 5 successive values fall on the same side of the centerline and more than one sigma unit away from the centerline, a lack of control is indicated. Note that the fifth point can be on either side of the centerline.
- Whenever at least 8 successive values fall on the same side of the centerline, a lack of control is indicated.

$\overline{X}$ moving Range chart

Purpose:: X mR chart is best when there are single observations per time due to slow production rate, difficult and costly inspection period & outcomes are measured on an interval scale

Used when data is measured individually rather than in sample sets due to various constraints / reasons

Application:

Applied in medical field EX: Patients' case mix or risk factors do not change over the time periods. Since these charts often monitor the same patient over time, there is little need to measure severity of the patient as this is unlikely to change in short time periods

Data collection:

Control limits in $\overline{X}$mR chart are calculated from moving range (mR). A range is based on the absolute value of consecutive differences in observations

- Count the number of time periods, n.
- One sample is taken from the process (called subgroup is=1)
- Calculate the absolute value of the difference of every consecutive value, call this moving range.
- Add the moving ranges and divide by "n" minus one to get the average moving range

Analysis :

Calculate the overall mean of moving ranges

$$\overline{\overline{X}} = \frac{Total\ the\ mean\ value\ of\ moving\ average}{Number\ of\ subgroups - 1}$$

Calculate and enter the range for each subgroup

RANGE= (Largest Value in each Subgroup)- (Smallest Value in each Subgroup)

Calculate the grand mean of the subgroup'sRange average.

$$\overline{R} = \frac{Average\ of\ each\ subgroup}{Number\ of\ individual\ subgroups}$$

Calculate the upper control limit (UCL) and lower control limit (LCL) for the averages of the subgroups.

UCL = $\overline{\overline{X}}$+ E2$\overline{R}$ and LCL =$\overline{\overline{X}}$- E2 $\overline{R}$ CL=$\overline{\overline{X}}$

Calculate the upper control limit and lower control limit (LCL) for the ranges

UCL = D4$\overline{R}$ and LCL = D3$\overline{R}$ CL =$\overline{R}$

Conclusion :

Interpreting the X-bar &MR chart:

- Whenever a single point falls outside the 3 sigma control limits, a lack of control is indicated. Since the probability of this happening is rather small, it is very likely not due to chance.
- Whenever at least 2 out of 3 successive values fall on the same side of the centerline and more than 2 sigma units away from the centerline a lack of control is indicated. Note that the third point can be on either side of the centerline
- Whenever at least 4 out of 5 successive values fall on the same side of the centerline and more than one sigma unit away from the centerline, a lack of control is indicated. Note that the fifth point can be on either side of the centerline.
- Whenever at least 8 successive values fall on the same side of the centerline, a lack of control is indicated.

ATTRIBUTE CONTROL CHARTS

2. CONTROL CHART FOR ATTRIBUTES :

Many quality Characteristics are measured on a quantitative scale. In such cases, we classify the product as good or bad; acceptable, not acceptable; pass, reject etc. or we may count defects in a product. Data obtained in this case are called attributes. Control charts for Attributes are called Attribute Control Charts.

There are three types of control charts used with attribute data.

- p-chart(fraction defective chart)- For variable sample size
- np-chart - For constant sample size(number defective chart)
- c- chart (defects per unit)
- U-chart(Average defects per unit)

Note : A ‘defective’ item may have more than one defect

A ‘defect’ may or may not make an item defective.

P Chart :

Purpose:

- This chart would be appropriate to use where there is a large quantity produced and a certain amount of defectives is unavoidable. However, the proportion of defectives should be watched, controlled and reduced
- Generates a (binomial) proportion control chart.

Application:

- The p-chart is used to control the level of defectives produced by a process. It is used with attribute inspection where products are classified as good/bad, clean/unclean, tight/loose, etc., and no measurements are recorded.
- Since a p chart is used when the subgroup size varies, the chart plots the proportion or fraction of items rejected, rather than the number rejected

Data collection:

- A total of atleast 25 or 30 measurements should be collected
- Observe proportion of defective items, ‘p’

Analysis :

- Calculate central line is at Average Proportion of defectives per sample

$$\overline{P} = \frac{number\ of\ defectives}{Total\ parts\ inspected}$$

N is number of items in each subgroup

- CL= $\overline{P}$
- LCL= $\overline{P} - 3\sqrt{\frac{\overline{P}(1-\overline{P})}{n}}$
- UCL= $\overline{P} + 3\sqrt{\frac{\overline{P}(1-\overline{P})}{n}}$

Draw in the Control Limits and plot the number of proportion of defective items

Conclusion:

- Connect the dots and observe the chart to determine if there are any points out of the control limits
- when these plot points fall outside the UCL or LCL, that some form of change must occur on the assembly or manufacturing line. Further, the cause needs to be investigated and have proper action taken to prevent it from happening again called preventative action, and continuous improvement in the Quality world

n p - CHART

np Chart :

Purpose:

This chart would be appropriate to use Where to plot Actual number of non-conforming items per sample is recorded

Application:

- The np-chart is used to control the level of defectives produced by a process. It is used with attribute inspection where products are classified as good/bad, clean/unclean, tight/loose, etc., and no measurements are recorded.
- Since a np chart is used when the subgroup size Fixed, these chart plots the number rejected per sample

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Data collection:

- Collect the data recording the number inspected (N) and the number of defective products (Np).
- Divide the data into subgroups. Usually, the data is grouped by date or by lot numbers.
- The subgroup size (N) should be over 50, and it is strongly recommended you stick with the constant sample size of 100 for subgroups
- Record the number of defectives on a chart or spreadsheet, along with the subgroup size

Analysis :

- Calculate central line is at Average Proportion of defectives per sample

$$CL = N\overline{P} = \overline{d} = \frac{number\ of\ defectives}{Total\ parts\ inspected}$$

- The LCL is at LCL = $\overline{d} - 3\sqrt{\overline{d}(1-\overline{d})}$
- The UCL is at UCL = $\overline{d} + 3\sqrt{\overline{d}(1-\overline{d})}$
- Draw in the Control Limits and plot the number of defective parts listed in our chart .

Conclusion:

- Connect the dots and observe the chart to determine if there are any points out of the control limits
- when these plot points fall outside the UCL or LCL, that some form of change must occur on the assembly or manufacturing line. Further, the cause needs to be investigated and have proper action taken to prevent it from happening again called preventative action, and continuous improvement in the Quality world

P chart VS NP chart :

- P CONTROL CHART is similar to the NP CONTROL CHART. The distinction is that the P CONTROL CHART plots the percentage of defectives while the NP CONTROL CHART plots the number of defectives. The NP CONTROL CHART is typically used for equal sample sizes and P CONTROL CHART is typically used for unequal sample sizes.

C- CHART

C Chart :

P D C A

Purpose:

The C- chart is used where the quality of products is controlled by controlling the number of defects per unit. A certain number of defects may be tolerable, but the number of defects per unit should be watched, controlled and reduced.
It is used to plot number of defects per unit

Application:

It can be drawn in below applications

- No. of defects per 100 feet of wire
- No. of Print mistakes in a sheet of paper
- No. of defects in PCB boards

Data collection:

- Collect the data recording the number inspected (N) and the number of defects products
- Divide the data into subgroups. Usually, the data is grouped by date or by lot numbers.
- The subgroup size (N) should be over 50,
- Record the number of defects on a chart or spreadsheet, along with the subgroup size

Analysis :

- Calculate central line is at Average Proportion of defectives per sample

$$CL = \overline{C} = \frac{Total\ number\ of\ defects}{Total\ number\ of\ units}$$

- The LCL is at LCL = $\overline{C} - 3\sqrt{\overline{C}}$
- The UCL is at UCL = $\overline{C} + 3\sqrt{\overline{C}}$
- Draw in the Control Limits and plot the number of defective parts listed in our chart .

Conclusion:

- Connect the dots and observe the chart to determine if there are any points out of the control limits
- when these plot points fall outside the UCL or LCL, that some form of change must occur on the assembly or manufacturing line. Further, the cause needs to be investigated and have proper action taken to prevent it from happening again called preventative action, and continuous improvement in the Quality world

U- CHART

U Chart :

P D C A

Purpose:

The U-chart is used to control the average number of nonconformities per unit.
The u –chart is concerned about the number of non conformities that might be expected to be found on product per unit basis
u-chart differs from the c-chart in that it accounts for the possibility that the number or size of inspection units for which nonconformities are to be counted may vary.

Application:

It can be used in diverse areas
Examples:

- Monitoring the number of nonconformities per lot of raw material received where the lot size varies
- Monitoring the number of new infections in a hospital per day
- Monitoring the number of accidents for delivery trucks per day

Data collection:

- Collect the data recording the number inspected (N) and the number of Non conformities found per unit
- Divide the data into subgroups. Usually, the data is grouped by date or by lot numbers.
- The subgroup size (N) should be over 50.
- Record the number of defectives on a chart or spreadsheet, along with the subgroup size

Analysis :

- Calculate central line is at Average Proportion of defectives per sample

$$CL = \overline{U} = \frac{total\ number\ of\ defects\ in\ all\ samples}{sum\ of\ items\ in\ all\ samples}$$

- The LCL is at LCL = $\overline{U} - 3\sqrt{\frac{\overline{U}}{n}}$

- The UCL is at UCL = $\overline{U} + 3\sqrt{\frac{\overline{U}}{n}}$

- Draw in the Control Limits and plot the number of defects parts listed in our chart .

Conclusion:

- Connect the dots and observe the chart to determine if there are any points out of the control limits
- Once the control limits have been established for the U chart, these limits may be used to monitor the per unit number of nonconformities (defects) of the process going forward. When a point is outside these established control limits it indicates that the per unit number of nonconformities of the process is out-of-control. An assignable cause is suspected whenever the control chart indicates an out-of-control process.

The U Chart versus the C Chart:

The C chart is used when a single unit will be examined for nonconformities at each time point. The U chart is used when a number of units will be sampled at each time point, and a per unit average number of nonconformities will be obtained.

6.CAUSE AND EFFECT DIAGRAM

Identification of Possible Causes

P D C A

Purpose:

Cause and Effect Diagrams help you to think through causes of a problem thoroughly.

- A cause-and-effect analysis generates possible causes of problems.
- This tool provides a means of generating ideas about why the problem is occurring and possible effects of that cause.

Application:

- It allows problem solvers to broaden their thinking and look at the overall picture of a problem
- It can reflect either causes that block the way to the desired state or helpful factors needed to reach the desired state.

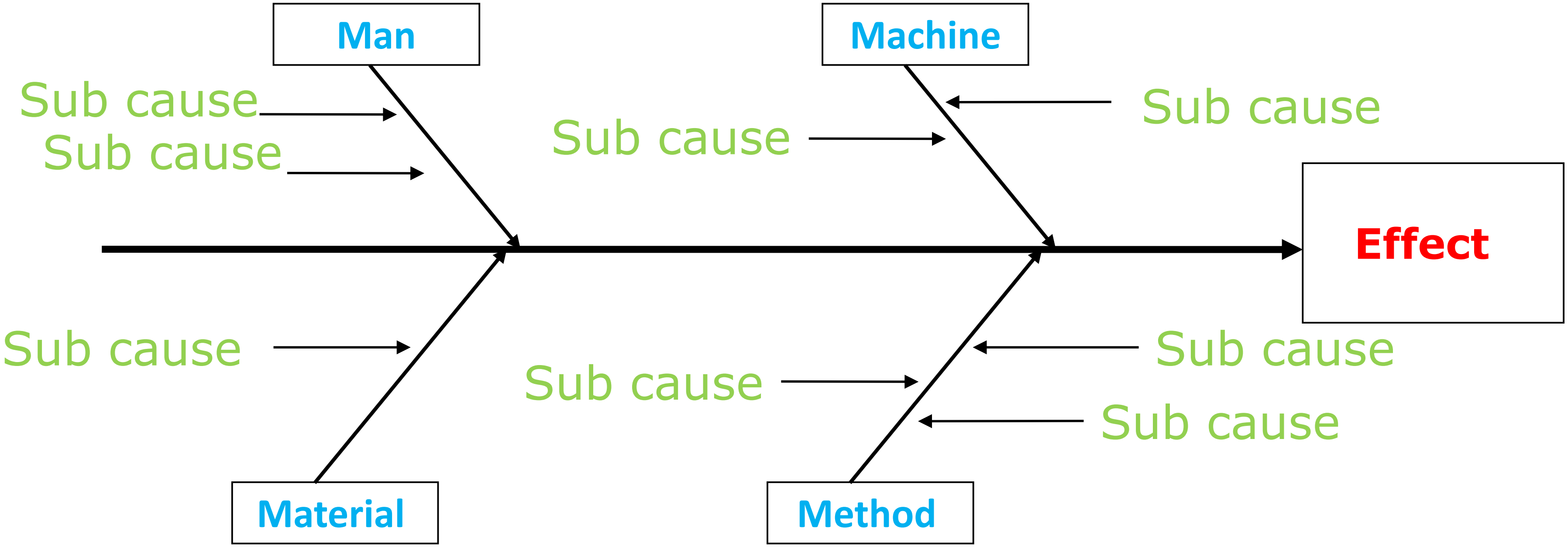
There are Three Types of cause & Effect Diagrams

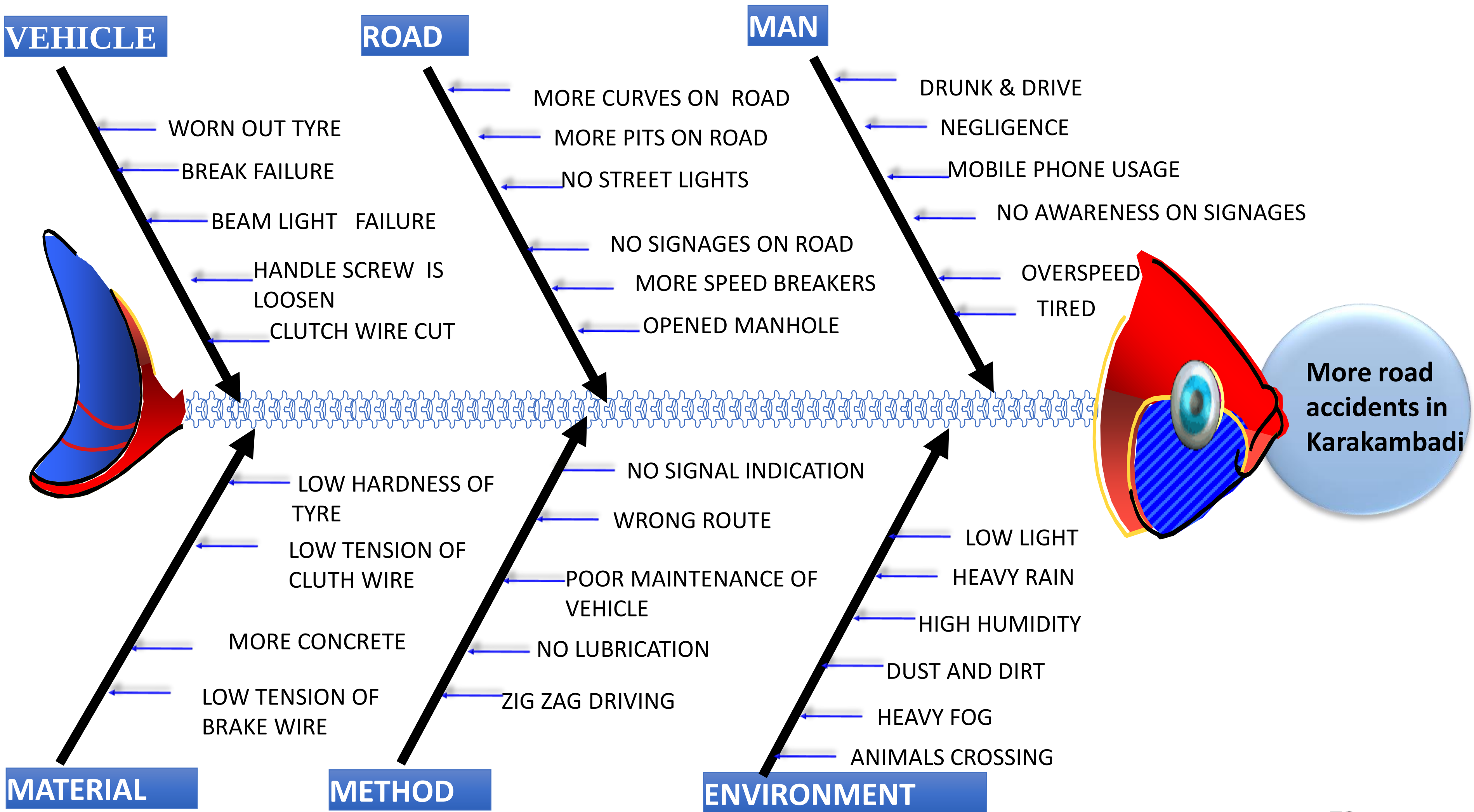
- Cause Enumeration
- Dispersion Analysis
- Production Process Classification

- Dispersion Method is simple method where the causes are dispersed under Man, Machine, Method & Material Headers
- Cause Enumeration is a method where the causes are listed down based on the Effect selected
- Production Process Classification is a method where all the causes are listed down in the Process Selected

Data collection:

Cause & effect diagram




VEHICLE
ROAD
MAN
WORN OUT TYRE
BREAK FAILURE
BEAM LIGHT FAILURE
HANDLE SCREW IS LOOSEN
CLUTCH WIRE CUT
MORE CURVES ON ROAD
MORE PITS ON ROAD
NO STREET LIGHTS
NO SIGNAGES ON ROAD
MORE SPEED BREAKERS
OPENED MANHOLE
DRUNK & DRIVE
NEGLIGENCE
MOBILE PHONE USAGE
NO AWARENESS ON SIGNAGES
OVERSPEED
TIRED
More road accidents in Karakambadi
LOW HARDNESS OF TYRE
LOW TENSION OF CLUTH WIRE
MORE CONCRETE
LOW TENSION OF BRAKE WIRE
NO SIGNAL INDICATION
WRONG ROUTE
POOR MAINTENANCE OF VEHICLE
NO LUBRICATION
ZIG ZAG DRIVING
LOW LIGHT
HEAVY RAIN
HIGH HUMIDITY
DUST AND DIRT
HEAVY FOG
ANIMALS CROSSING
MATERIAL
METHOD
ENVIRONMENT

Techniques

5. Brainstorming

Brain Storming

P D C A

Brainstorming is a *group creativity technique* designed to generate a large number of *ideas* for the solution to a *problem*

Mr. Alex Osborn of USA developed this technique in 1950s to solve advertising and marketing problems.

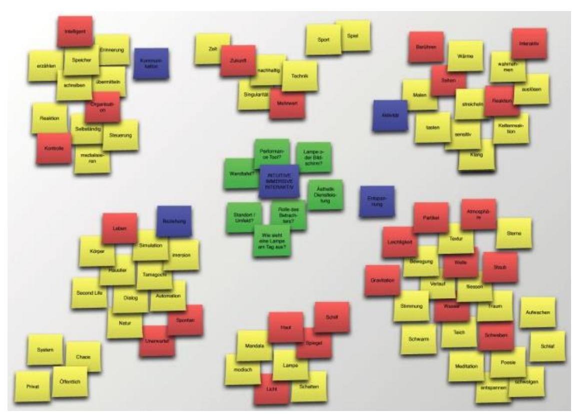
It is used effectively and frequently at variou stages of problem solving.

Two types of thinking is there , one is LOGICAL & another is CREATIVE. We to use both types of thinking whenever using brainstorming.

Brain Storming

➢ Brainstorming Methods

- ✓ Free wheeling or Unstructured
- ✓ Slip Method
- ✓ Round Robin or Structured process



Mr. J.P. Guilford who conducted research on the creative behavior, identified Five key elements concerning Human ability to creative.

1. FLUENCY

As we look for quantity over quality in Brainstorming, generally generating more ideas within a given time is important. It is found that more the quantity effective & useful ideas emerge.

2. FLEXIBILITY

This is the ability of a mind to move from one area to another quickly. In this aspect , the process of thinking helps. Another gain is that , in a group, people think divergently. When we listen to others, it opens up new avenues for our thinking. We call this <u>hitch-hiking</u> process.

Flexibility is measured by the no. of categories of ideas generated.

3. ORIGINALITY

Thinking without any barrier & away from unconventional methods lead to originality in people.

4. AWARENESS

This is the ability to look into the future i.e. beyond the immediate facts, what can the need of future be?

5. DRIVE

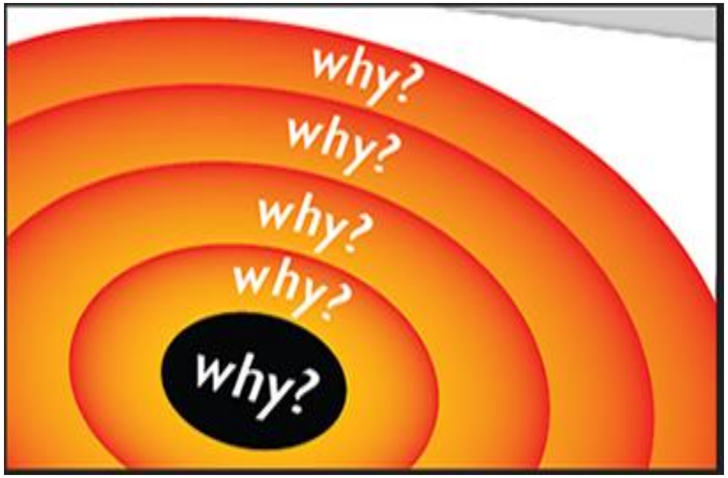
This is a willingness to contribute to achieve the end goal without fear or failure.

6. Why-Why analysis

Why – Why Analysis

P D C A

- **Tool used: Why why analysis**



The technique was originally developed by ***Sukichi Toyoda*** and was later used within ***Toyota*** Motor Corporation during the evolution of their manufacturing methodologies.

Described the 5 whys method as "the basis of Toyota's scientific approach . . . by repeating why five times

Why – Why Analysis

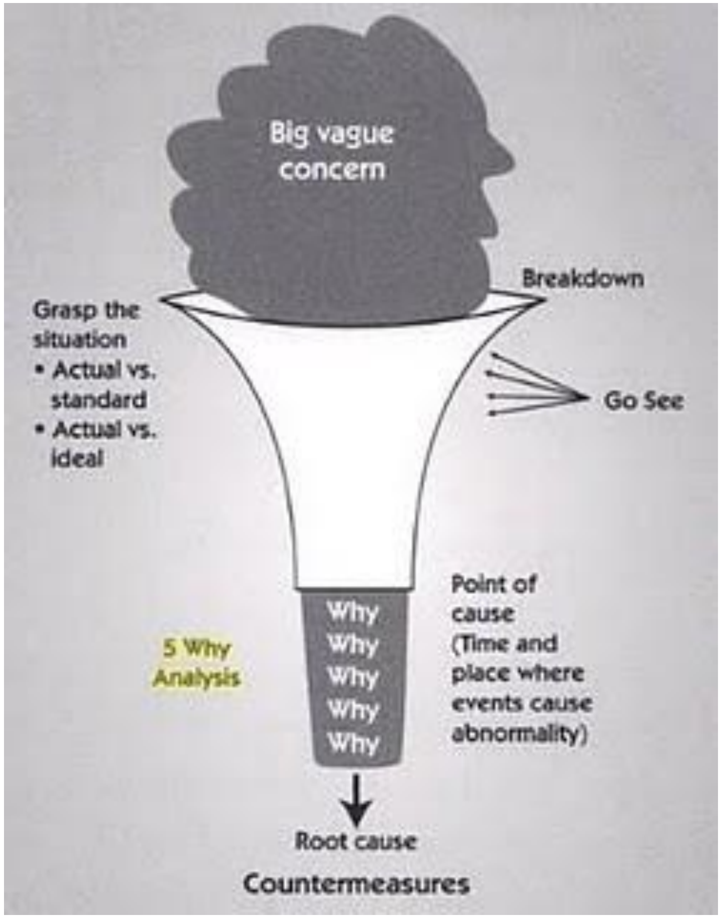
P D C A

➢ **Tool used: Why why analysis**

5 whys technique is used to understand/analyse the true root cause of a problem

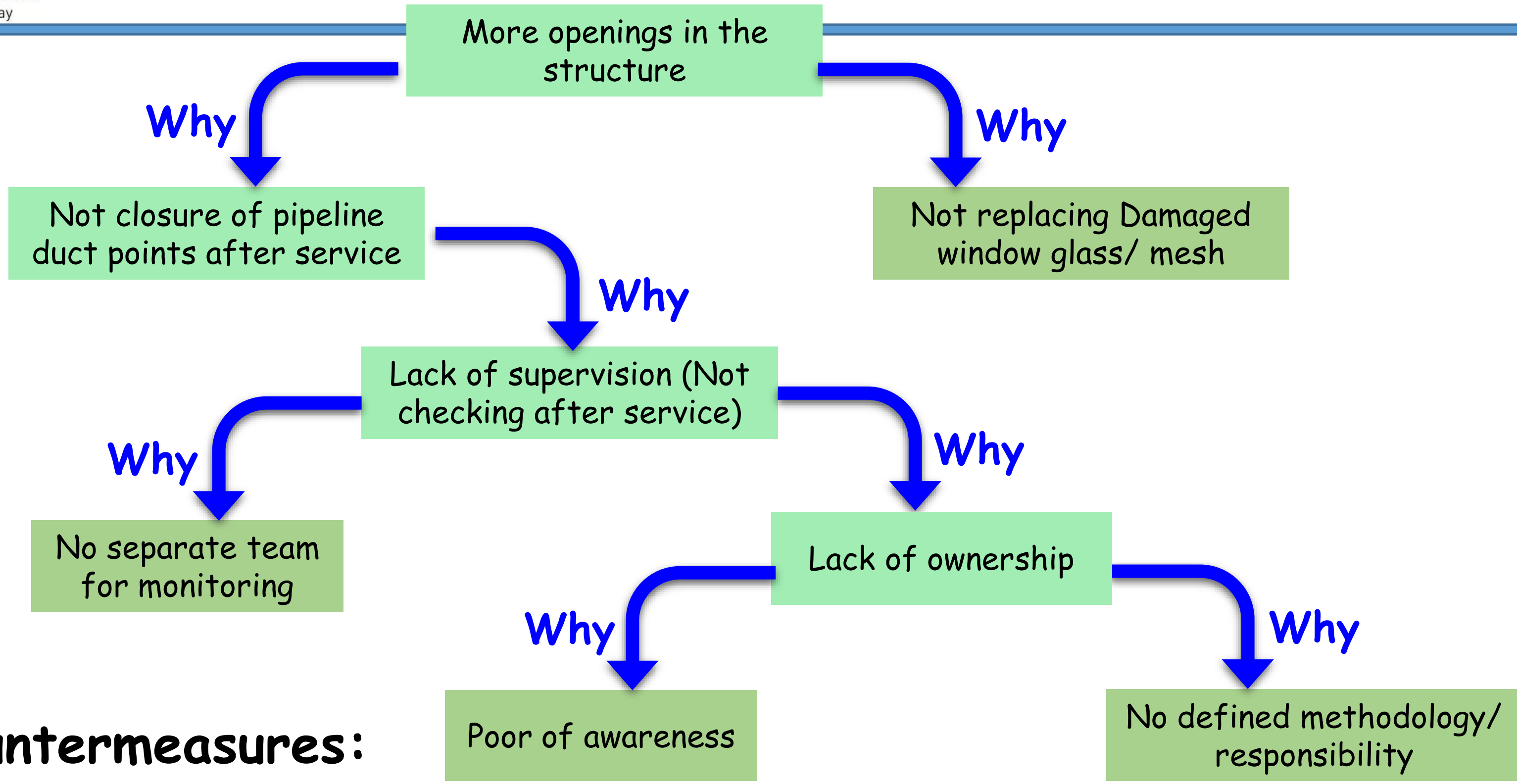
- ✓ quick and simple to do.
- ✓ most effective when brainstorming in a small group.
- ✓ can be used for any problem or issue

Although it is called the 5 Whys technique we get root cause



Root Cause Analysis

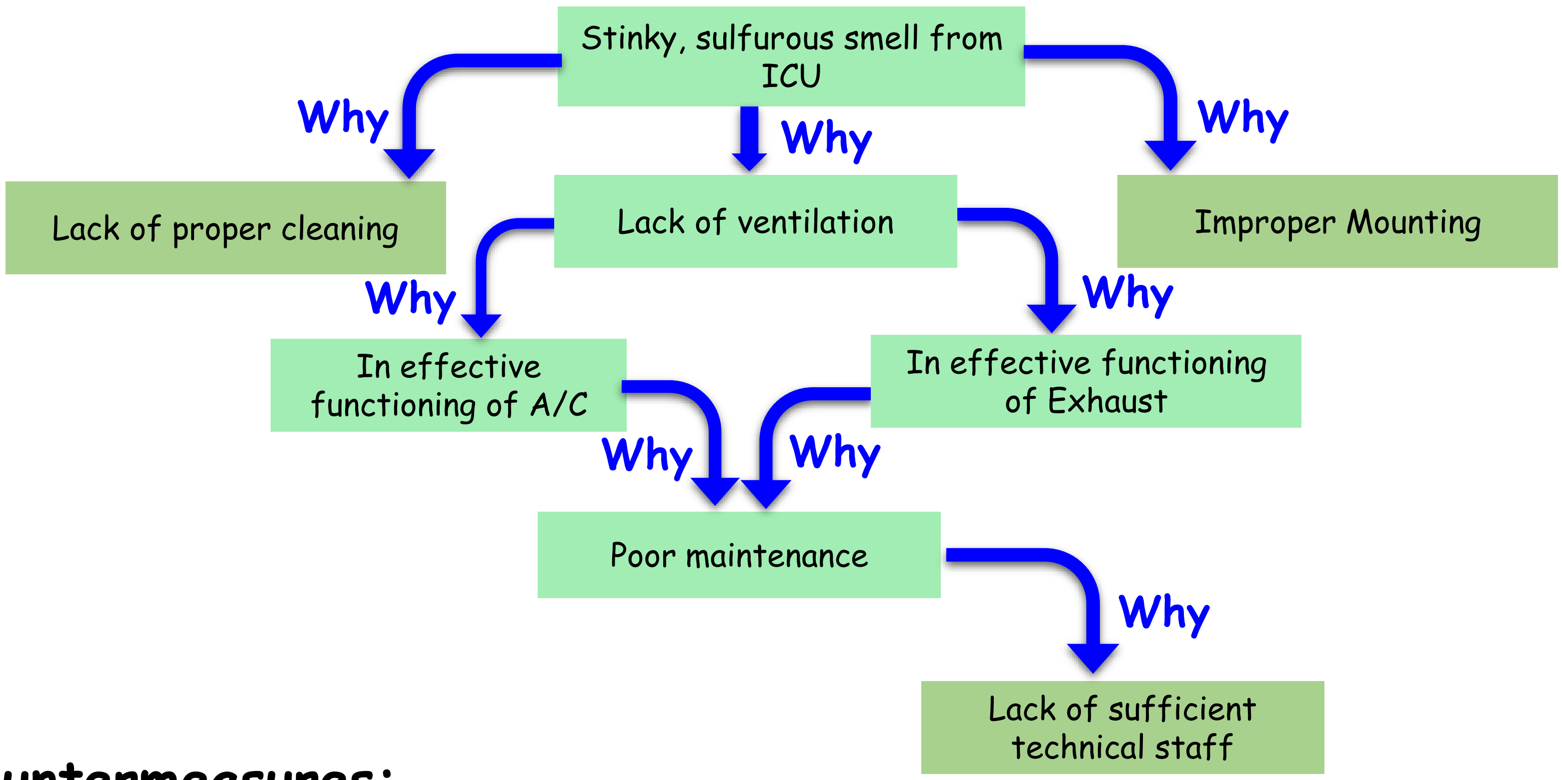
P D C A



Countermeasures:

- Establish separate cell for monitoring audit/ surveillance of service activities.
- To train the staff on behavioural change
- To define set of roles and responsibilities
- To close all existing openings (Restoring structure after service, to be made part of service agreement) and also set frequency for building maintenance
- To repair/replace existing mesh with stainless steel mesh

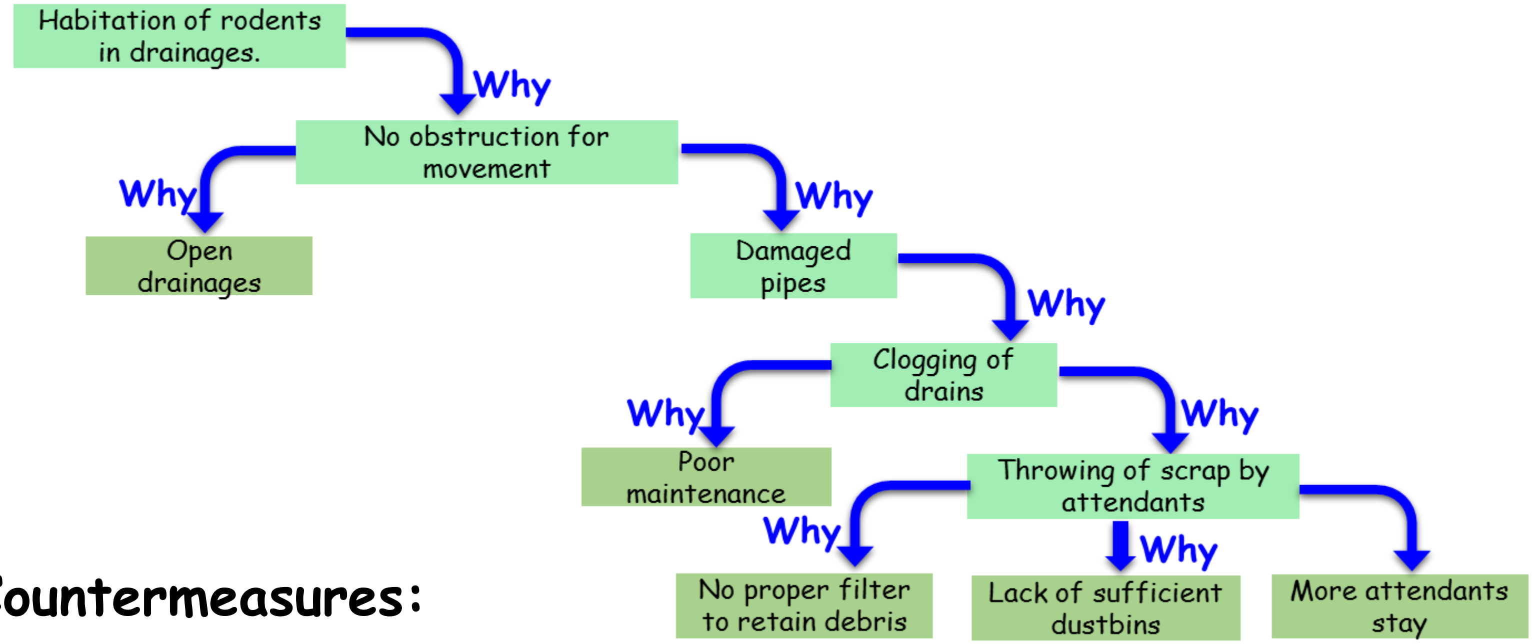
Root Cause Analysis



Countermeasures:

- To maintain A/C & Exhaust through Annual Maintenance Contract (AMC)
- To fix A/C without any gaps
- To use specified branded chemicals for effective cleaning

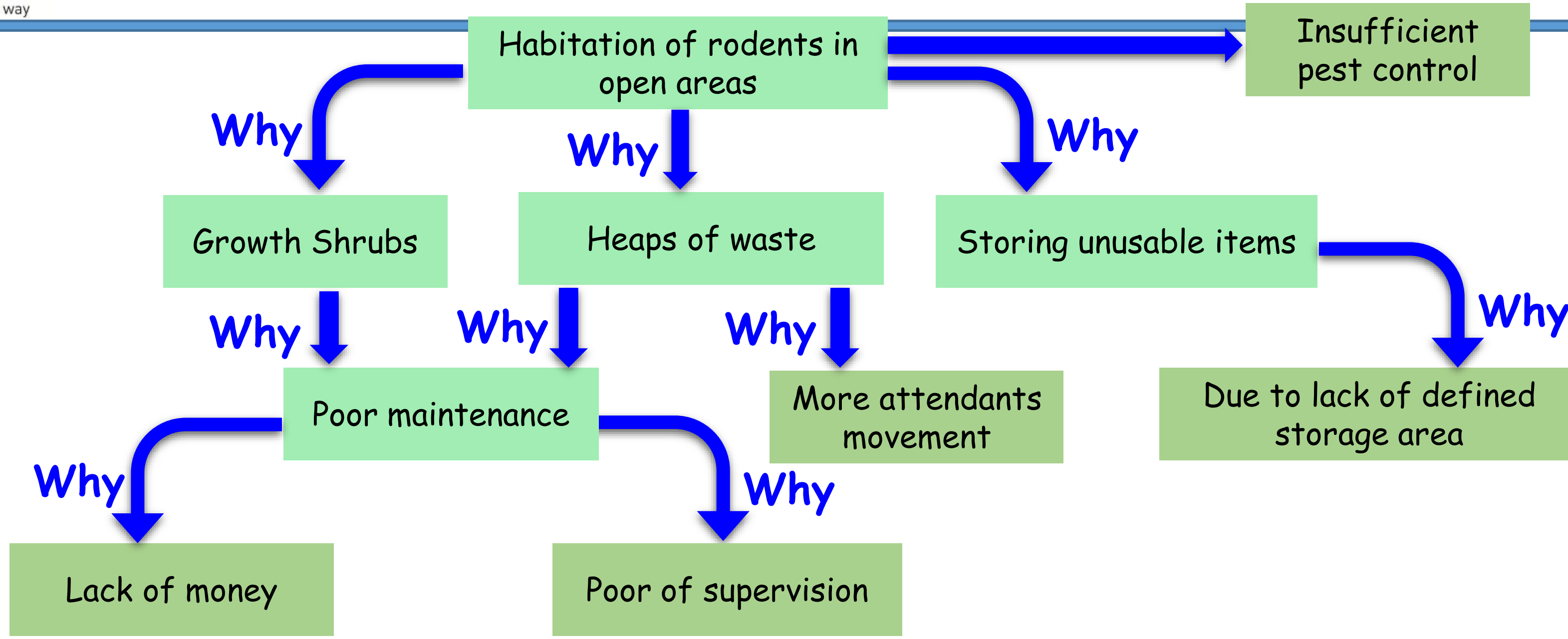
Root Cause Analysis



Countermeasures:

- Provide closed drainages around ICU & Wards
- To identify and display list of sanitation activities that are to be done by service provider
- To provide sufficient grouted dustbins(Closed lid) with colour codes
- To set and follow dustbin strategy along with predefined frequency of removal
- Two levels of security to restrict attendants entry and food into ward
- To provide metallic jally at pipe ends
- To modify existing drainage lines such that pipes are connected to drainages

Root Cause Analysis



Countermeasures:

- To develop greenery in open areas (Invite NGO's/ Industries to adopt these areas)
- Maintenance cell to monitor and ensure surroundings are maintained as per requirement
- To provide security control on number of attendants
- To clear open areas and provide separate area to store un usable items (To create centralised rectification and scrap handling area)
- To have daily pest control

7. FLOW DIAGRAM

Purpose:

Flow Diagram is a graphical or a pictorial way to defect a process. With the help of a flow diagram we can show a process sequence

Application:

- Stratification is the basis for other tools like Pareto analysis, and it is used in conjunction with other tools such as scatter diagrams, histograms, or box plots to make them more powerful.

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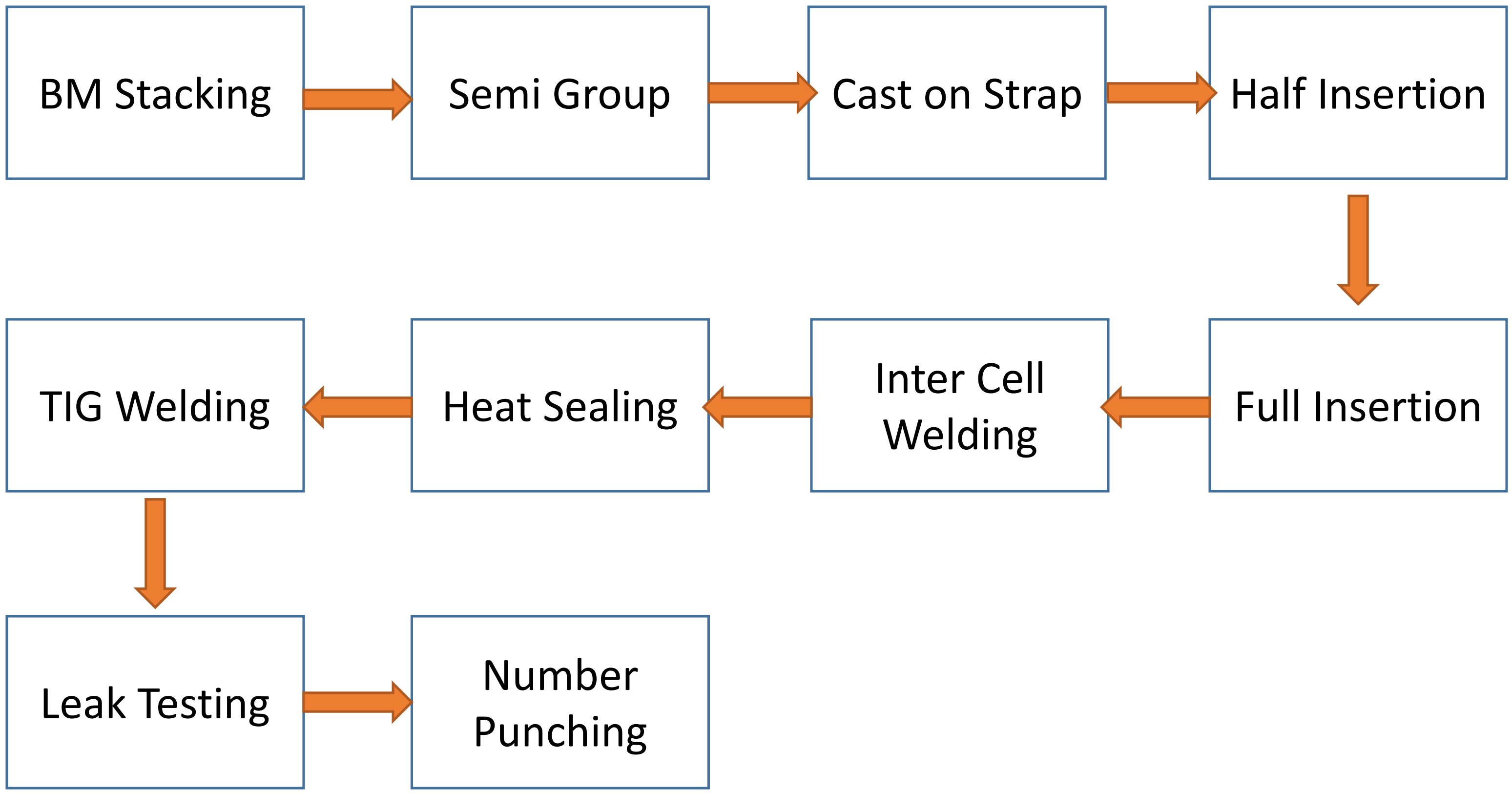
TYPES OF FLOW DIAGRAM

1) High level Flow Diagram

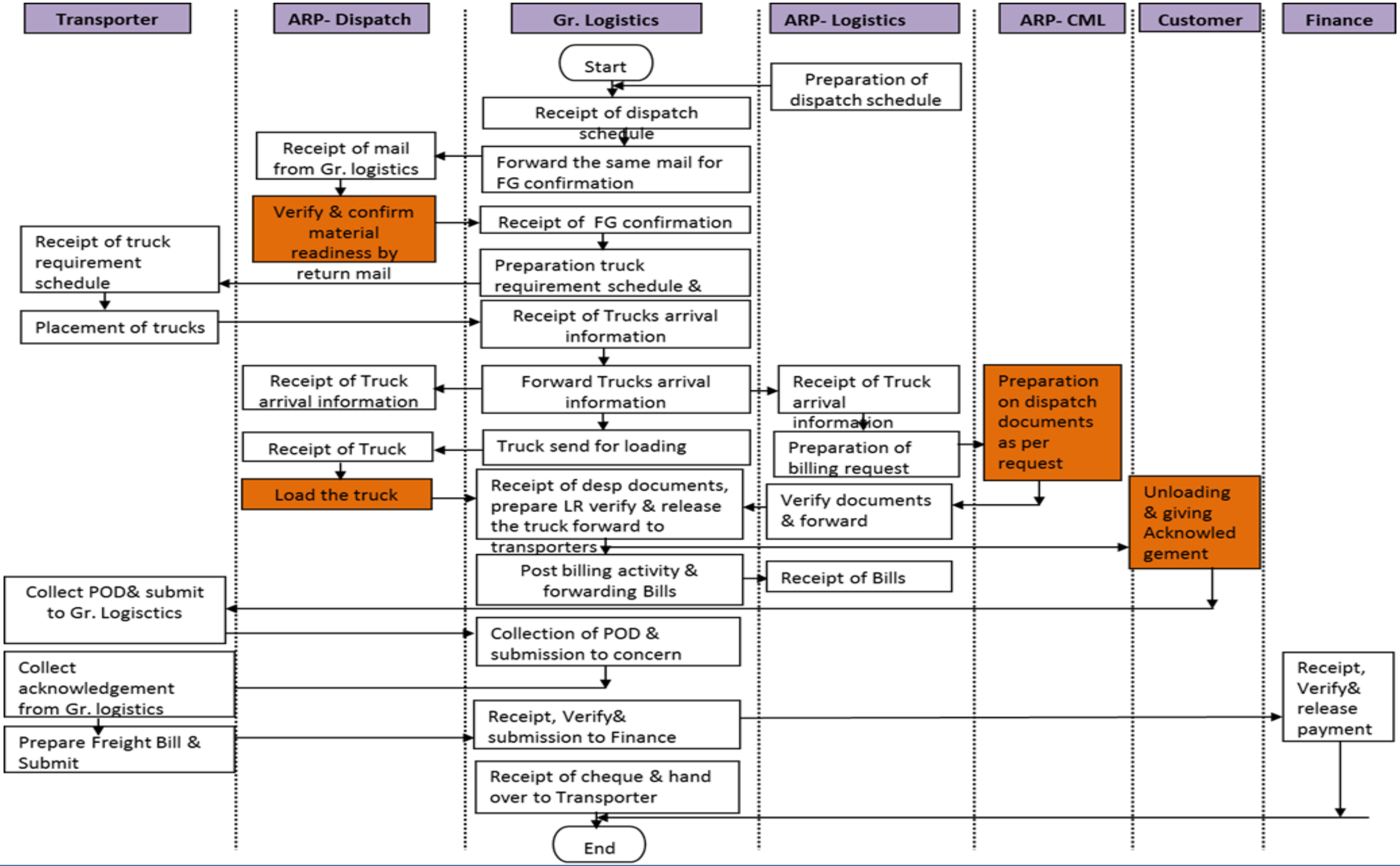
2) Matrix Flow diagram

3) Detailed Flow diagram

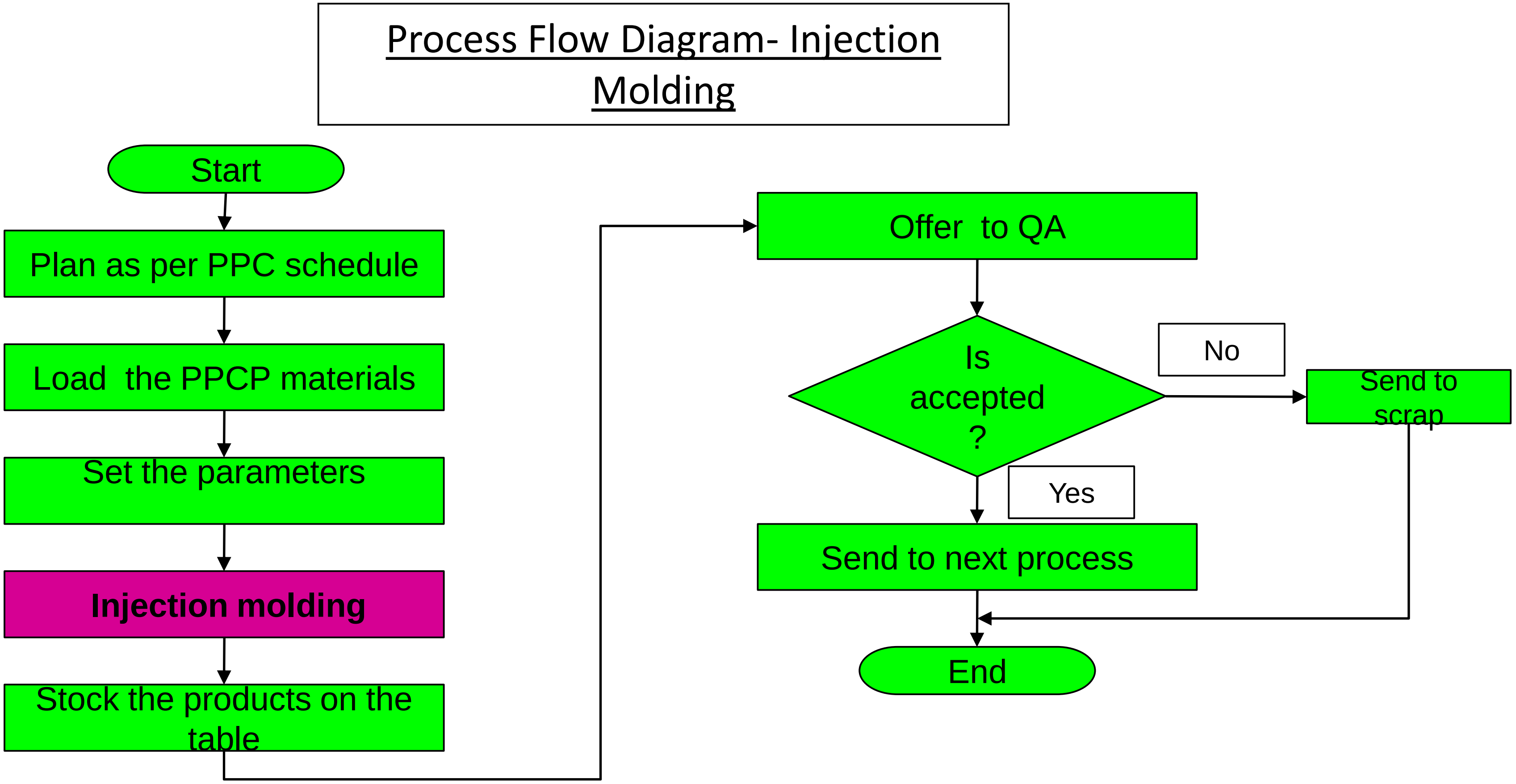
High level Flow Diagram : This is making the diagram of the total process a broad way. Here details are avoided.



Matrix Flow Diagram : Flow diagram drawn taking in to consideration the actual procedure of material procurement/CFT.

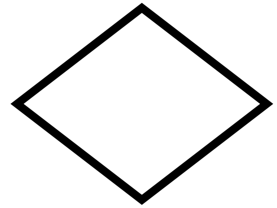


Detailed Flow Diagram : This is making the diagram of the total process in detail. Detailed flow diagrams clarify or give better understanding of the process.

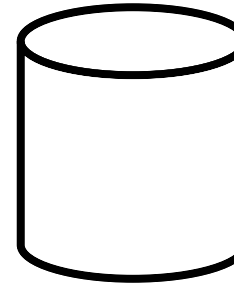


Activity

Decision

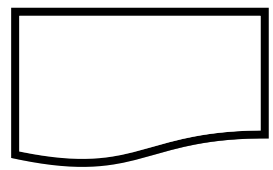


Data Base

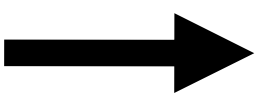


Terminator (Start/ End)

Document symbol



Flow lines



Connector