STAT PASS

A.C Sir

Statistical Quality Control

- What is S.Q.C

It is the term used to describe set of statistical tools or methods used by qualitative professionals

Use of S.Q.C

It is use to analyse the quality problems and solve them.

Advantages of S.Q.C

(1) It gives an early warning of defects. It provides a means of detecting errors at inception

(2) ~~Reword and~~ Rework and scrap are minimized.

Definition of Quality:

Quality is defined by ISO 8402 on 1986 as " The totality of features an characteristics of a product of service that bear on its ability to satisfy ~~sat~~ stated or implied needs"

Quality refers to the sum of the attributes or properties that describe a product.

Attributes

An attribute refers to the quality of a characteristics. The theory of attributes deals with qualitative types or characteristics that are calculated by using qualitative measurements

Methods and Philosophy of Statistical Process Control (SPC)

Basic ~~SP~~ SPC can be applied in any process, It's 7 major tools are →

(1) Histogram or Stem and leaf plot

10, 12, 14, 17, 22, 26, 29, 30, 39, 42, 43, 53, 54, 56

stem	leaf
1	0 2 4 7
2	2 6 9
3	0 9
4	2 8 3
5	3 4 6

(2) pareto sheet
(3) check "
(4) cause and effect diagram
(5) Defect concentration
(6) scatter diagram
(7) control chart

Dr. A Shewart called the father of S.Q.C analysis developed the concepts of S.Q.C for the purpose of controlling quality Shewart developed charting techniques and statistical procedure for controlling in process manufacturing of RS. his statistical procedures are based on the concept of IID random variables. (Independent and identically distributed R.variables (random))

In probability theory and statistic a Collection of random variable is independent and identically distributed it each R.V has the same prob dist as the others. And all are mutually independent. Based on this concept he distinguish between chance causes, producing random variation intrinsic of the process and assignable causes, one should look for an take requiring corrective actions.

What is quality control?

→ Quality control means those activities which ensure that quality creation each perform in such a manner that the resulting product will perfrom it's intended functions.

What is S.Q.C?

→ S.Q.C reffers to the use of statistical methods in the monitory

Stages of quality control:—

1) Input → raw materials, parts and supplies → Acceptancy test → Quality of inputs

2) Conversion → Production process → control chart → monitoring quality of semifinist product

3) Output → Goods and services → Acceptancy test → quality of outputs

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Chance cause of variation:

chance causes are reason for minor variation in the quality characteristic that are inspected.
variation i.e random in nature. this type of variation can not be completely eliminated unless there is a major change in the equipment or material used in the process.

Assignable cause: variation that is not random. It can be eliminated or reduced by investigating the problem finding the cause.

General theory of control charts:

[See Book]

Advantages of S.Q.C: [~~Prewrite~~]

Process and Product control: [Definitions only and distinguish, Example]

One aspect of SQC, called process control. It is concerned with controlling the quality of goods in the process of of production. process control detects whether the production process is going on at ~~dessign~~ desired level. Its aim is to control the manufacturing process so that the ~~items~~ items in the
Pr... ...defective...

entire output ~~ou~~ over a long period is not excessively large. This is achieved largely through control chart devices.

Again there is another type of problem, called product control, which is concerned with the inspection of goods already produced so that lots of manufactured goods do not contain excessively large proportion of defective items. Product control, also known as lot control, is achieved through sampling inspection plan. It should be carefully noted that process control and product control are different problems, because, even when the process is in control, an individual lot of products may contain large proportion of ~~of dete~~ defective items.

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Chance Causes of variation / (Random Causes):-
Chance Causes are reasons for minor variations in the quality characteristics that are inspected. This cause do not cause the item to be rejected as the variations are within the tolerance limit. The variation due to this Causes ~~are~~ is beyond the control of human hand and can not be prevented or eliminated under any circumstance. One has got to allow for variation within the stable pattern.

Assignable Causes of variation / (Preventable ca

This causes are external to the process and cause large variation in quality characteristics making items liable to the rejected. This causes major variation in quality characterist This include ware and tear of machine parts improper raw materials and negligency of operations. When it is known that improper size result of an assignable cause. It is possible to stop detect the cause and rectify it.

■ Difference between two Causes :-

Chance Cause	Assignable Cause
1) Consists of many individual causes	1) Consist of just a few individual causes
2) Chance variation can not economically be eliminated, from a process.	2) The presence of assignable variation ~~eliminated~~ can be detected and action to eliminate the causes if really economically justified.
3) Any one chance cause results in only a small amount of variation	3) Any one assignable cause results in only large amount of variation.
4) Example - Some typical chance cause of variations are - a) Slite vibration of a machine, b) lack of human perfection in reading instruments	4) Some typical assignable causes of variations are a) negligency of operators b) defective raw materials

and setting controls c) voltage fractuations and variations in temparature.	c) faulty equipment

▪ Process Control :-

Process control detects whether the process is going on at desire level. It's aim is to control the manufactering process so that the proportion of defective items in the entire output over a long period is not excessively large. This is achieved largely through control chart devices. ~~Again~~

▪ Product Control :-

There is another type of problem Called product control which is Concerned with the inspection of goods already produced. so that lots of manufactured goods do not contain excessively large proportion of defective items. This is also known as lot Control

Techniques of S.Q.C

- Product Control
  - Variable
  - Attribute
- Process Control
  - Variable
    - $\bar{X}$ bar chart
    - R chart
    - σ chart
  - Attribute
    - C. chart
    - np chart
    - p chart

Control Limits :-

These are limits of sampling variation of a statistical measure such that if the production process is under control, the values of the measure calculated from different rational subgroups will lie withing these limits. Points falling outside control limits indicate that the process is not operating under a system of chance causes that is assignable causes of variation are present, which ~~must~~ be eliminated.

Tolerance limits :-

These are limits of variation of a quality measure of the product between which atleast a specified proportion of the product is expected to lie (with a given probability) provi the process is in a state of statistic quality control.

Example :- we may claim with a probabil of 0.99 that atleast 90 % of the products will have dimentions between some stated limits

Rational Sub-groups :-

The fundamendal idea in Shewart Control chart technique is the divison of manufactured products into a number of sub-groups is called Rational sub grou

Control chart (Dr. W.A. Shewart, 1924) :-

Central line :- Indicating the level of process or desire standard.

upper Control limit (UCL) :- Indicating the upper lim of tolerance

Lower Control Limit (LCL) :- Indicating the lower limit of tolerance

Control chart is concieved and introduced by Shewart is a simple pictorial device for detecting unnatural patterns of variation in data resulting from predicting process.

Major Parts of a Control chart

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4 Parts → 1) Quality scale
2) Plotted ~~scale~~ samples
3) Sample numbers
4) The horizontal lines

A control chart generally includes the following four major parts.

1) Quality scale :- This is a vertical scale. The scale is marked according to the quality characteristics (either in variable or in attributes of each sample)

2) plotted samples :-
The qualities of individual items of a sample are not shown on a control chart. only the quality of the entire sample represented by a single value (a statistic) is plotted. The single value plotted on the

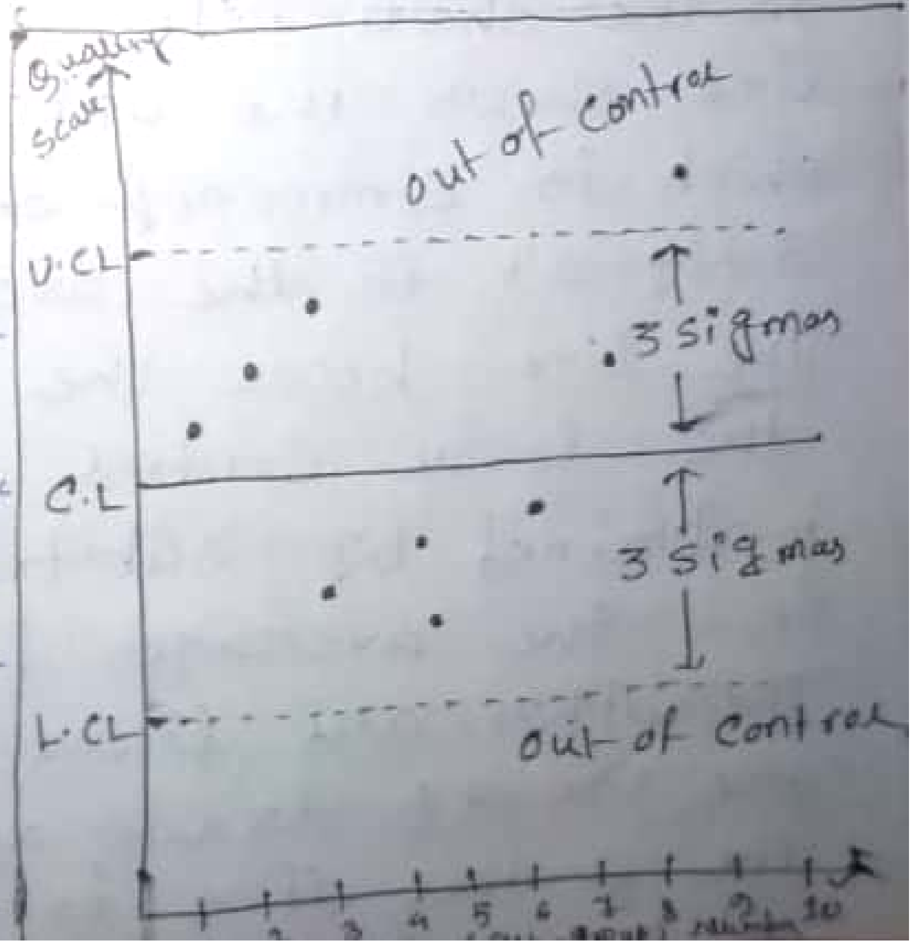

chart is in the form of a dot (Som
a small circle or a cross)

③ Sample (or Sub-group) Numbers:-

The sample plotted on a control chart are numbered individually and consecutively on a horizontal line. The line is usually placed at the bottom of the chart. The samples are also referred to as sub-groups are used in constructing a control chart.

④ The Horizontal Lines:-

The central line represents the average quality of the sample plotted on the chart. The line above the centre line shows the upper control limit (UCL) which is commonly obtained by adding 3 sigma's to the average, i.e Mean+3(S.D). The line below the central line is the lower control limit (L.C.L) which is obtained by substracting 3 sigmas from the average, i.e Mean − 3 (S.D). The upper and lower control limits are usually drawn as dotted lines and the central line is plotted as a bold line

The adjoining diagram (Pic-1) depicts the principle of Shewhart's Control chart. If t is the underline statistic then these values depend on the sampling distribution of t and given by UCL $= E(t) + 3 \cdot S.E(t)$ similarly LCL $= E(t) - 3 \cdot S.E(t)$

3-σ Control Limits or 3-σ Limits :-

3-σ limits were proposed by Dr. Shewart for his Control chart from various consideration, the main being probabilistic consideration. Consider a statistic $t = t(x_1, x_2, \cdots x_n)$ a function of the sample observations $x_1, x_2 \cdots x_n$

Let $E(t) = \mu_t$ and $Var(t) = \sigma_t^2$

If the statistic t is normally distributed then from the fundamental area property of the normal distribution, we have

$$P[\mu_t - 3\sigma_t < t < \mu_t + 3\sigma_t] = 0.9973$$

$$\Rightarrow P[|t - \mu_t| < 3\sigma_t] = 0.9973$$

$$\Rightarrow P[|t - \mu_t| > 3\sigma_t] = 0.0027$$

In other words the probability that a random value of t goes outside the 3-σ limit $\mu_t \pm 3\sigma_t$ is 0.0027

which is very small. Hence if 't' i
normally distributed the limits of
variation should be between $\mu_t + 3$
and $\mu_t - 3\sigma_t$ which are respective
termed as the UCL and LCL. If fo
ith sample the observed ~~statistic~~
be ti will be lies between the
and LCL. There is nothing to worr
as in such a case variation betw
samples is attributed to chance i.
in this case the process is in stati
control. It is only when any obs
ti falles outside the control limit
it is consider to be a danger signa
indicating that some assignable ca
has crept in which must be identi
and eliminated.

Tools for S.Q.C :-

The following four separate but
related techniques are the most imp
statistical tools for data analysis in quality control
of the manufactured products.

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1) Shewart's controe charts for variables
i.e for a characteristics which can be measured quantitatively. Many quality characteristic of a product are measurable and can be expressed in specific units of measurements. Such as diameter of a screw, pencil stand of steel pipe, etc. life of electric bulb etc. we used two types of charts for shewart's control chart.

a) charts for mean and range

b) " " " " S.D

2) P chart / shewart's control charts for fraction defectives
we will discuss about the fraction defectives in this chart.

3) Shewart's controe chart for the defects per unit / C-chart :-
The number of defective revets in an aircraft wings, The number of surface defects observed in a roll of quoted papers or a c-drop photographic film. we will draw the c-chart when the discrete variable of the product is given.

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Control charts for mean :-

When the process is in control, the distributions of the variable under consideration, x (say) in different rational sub-groups are identical.

Let μ and σ^2 be mean and variance of x. If independent random samples, each of size n, be drawn from the sub-groups, we have in each case,

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$E(\bar{x}) = \mu$, $\sigma_{\bar{x}} = \sigma/\sqrt{n}$

Now, the standard values of μ and σ may or may not be specified. According we shall discuss two types of control charts for mean.

Case (i) Standards given :-

If the standard values of μ and σ are specified as μ' and s' respectively then the chart for mean will be given by -

$$LCL = \mu' - 3\frac{\sigma'}{\sqrt{n}} = \mu' - A\sigma'$$

$$CL = \mu'$$

$$UCL = \mu' + 3 \cdot \frac{\sigma'}{\sqrt{n}} = \mu' + A\sigma'$$

where $A = 3/\sqrt{n}$

Case (ii) standards not given :-

If the values for μ and σ are unspecified then these are estimated from the sample observations.

Suppose, we have m samples and $\bar{x}_i$, s_i and R_i are respectively the mean, standard deviation and range of the ith sample, $i = 1(1)m$

Let $\bar{\bar{x}} = \frac{\sum_{i=1}^{m} \bar{x}_i}{m}$, $\bar{s} = \frac{\sum_{i=1}^{m} s_i}{m}$ .and $\bar{R} = \sum_{i=1}^{m}$

From these we get an estimate μ and alternative estimates of σ viz,

$$\hat{\mu} = \bar{\bar{x}}, \quad \hat{\sigma} = \frac{\bar{s}}{c_2} \text{ and } \frac{\bar{R}}{d_2}$$

where c_2 and d_2 are function of n

If the first estimate of σ is used along with the estimate of μ, the chart for $\bar{x}$ will be drawn up with

$$LCL = \bar{\bar{x}} - 3 \cdot \frac{\bar{s}}{c_2\sqrt{n}} = \bar{\bar{x}} - A_1 \bar{s}$$

$$CL = \bar{\bar{x}}$$

$$UCL = \bar{\bar{x}} + 3 \cdot \frac{\bar{s}}{c_2\sqrt{n}} = \bar{\bar{x}} + A_1 \bar{s}$$

where $A_1 = \frac{3}{c_2\sqrt{n}}$ and is tabulated for different values of n

Again, when the second estimate of σ is used, the Control chart for $\bar{x}$ will be based on

$$LCL = \bar{\bar{x}} - 3\frac{\bar{R}}{d_2\sqrt{n}} = \bar{\bar{x}} - A_2\bar{R}$$

$$CL = \bar{\bar{x}}$$

$$UCL = \bar{\bar{x}} + 3 \cdot \frac{\bar{R}}{d_2\sqrt{n}} = \bar{\bar{x}} + A_2\bar{R}$$

where $A_2 = \frac{3}{d_2\sqrt{n}}$ and is tabulated for different values of n.

$c_2 = \sqrt{2/n} \cdot \frac{\left(\frac{n-2}{2}\right)!}{\left(\frac{n-3}{2}\right)!}$ is a constant depending on n

Control chart for Range :-

we may note that for a normally distributed variable x with variance σ^2. $E(R) = d_2\sigma$ and $\sigma_R = D\sigma$ where d_2 and D are function of sample size n.

Case-1 standard given :-

Let the standard value of σ is given to be σ'. Hence the chart for range (R) will be constructed on the basis of the following :-

$LCL = d_2\sigma' - 3D\sigma' = D_1\sigma'$

$CL = d_2\sigma'$.

$UCL = d_2\sigma' + 3D\sigma' = D_2\sigma'$

Where $D_1 = d_2 - 3D$ and $D_2 = d_2 + 3D$.

The values D_1, D_2 and d_2 are tabulated for different values of n.

Case (ii) standard not given :-

when the standard value of σ is not specified, it is estimated by $\bar{R}/d_2$, $\bar{R}$ being the mean of sample ranges. Then R - chart will be drawn up with:

$$LCL = \bar{R} - 3\frac{D}{d_2}\bar{R} = D_3\bar{R}$$

$$CL = \bar{R}$$

$$UCL = \bar{R} + 3\frac{D}{d_2}\bar{R} = D_4\bar{R}$$

where $D_3 = 1 - \frac{3D}{d_2}$ and $D_4 = 1 + \frac{3D}{d_2}$

The values of the constanes D_3 and D_4 are available from tables for different values of n. Obviously R can not be negative. Hence in either case if LCL is found to be negative according to the above formula, then it is taken to be zero.

Control charts for fraction defective

Let p be the fraction defective in a sample of size n. For drawing p chart, we shall use following results:

$$E(p) = P \quad \text{and} \quad \sigma_p = \sqrt{\frac{P(1-P)}{n}}$$

where P is the population fraction defective.

case (i) : Standard given

Suppose the standard value of P is specified as P'. Then the control chart for p will consist of

$$LCL = P' - 3\sqrt{\frac{P'(1-P')}{n}} = P' - A\sqrt{P'(1-P')}$$

$$CL = P'$$

$$UCL = P' + 3\sqrt{\frac{P'(1-P')}{n}} = P' + A\sqrt{P'(1-P')}$$

where, $A = \frac{3}{\sqrt{n}}$

case (ii) Standard not given

Here, the value of the population fraction defective P is estimated by $\bar{p}$,

where, $\bar{p} = \frac{\sum_{i=1}^{m} p_i}{m}$, p_i being the fraction defective for the ith sample, $i = 1(1)m$

Hence, the control chart for fraction defective will be based on

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = \bar{p} - A\sqrt{\bar{p}(1-\bar{p})}$$

$$CL = \bar{p}$$

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = \bar{p} + A\sqrt{\bar{p}(1-\bar{p})}$$

Here also one should be note that p can never be negative. Hence, if LCL becomes negative according to the stated formulae, It is to be taken as zero.

Control chart for number defective:

If p denote the ~~faction~~ fraction defectives in a sample of size n, then np is the number of defectives

In the construction of np-chart we note that

$$E(np) = np \text{ and } \sigma_{np} = \sqrt{np(1-p)}$$

case(i) Standard given

If p' be the given standard value of p, then the np-chart will consist of

$LCL = np' - 3\sqrt{np'(1-p')}$

$CL = np'$

$UCL = np' + 3\sqrt{np'(1-p)}$

case(ii) standard not given

When the standard value p is not specified, it is estimated by $\bar{p}$ and the control chart will be constructed on the basis of

$$LCL = n\bar{p} - 3\sqrt{n\bar{p}(1-\bar{p})}$$

$$CL = n\bar{p}$$

$$UCL = n\bar{p} + 3\sqrt{n\bar{p}(1-\bar{p})}$$

clearly, np can never be negative ∴ Hence, in either case, if LCL, comes out negative, then it is taken to be zero.

control charts for number of defects

Before the construction of this chart we should note that defective and defect are two distinct terms. A defective is an item that fails to fulfil atleast one of the given specifications.

Thus one or more defects is seen in

any defective item. For example, a defective bolt in an aircraft containy some defecty.

Number of defects (c), in general is assumed to be distributed in Poisson form with parameter (λ).

For Poisson variable 'c' with parameter λ, $E(c) = \lambda$ and $\sigma_c = \sqrt{\lambda}$

Case (i) Standard given:

Let the standard value of λ is given to be c'. Hence the control chart for c will consist of

$LCL = c' - 3\sqrt{c'}$

$CL = c'$

$UCL = c' + 3\sqrt{c'}$

Case (ii) Standard not given

When no standard is given, λ is estimated by $\bar{c}$, where, $\bar{c} = \frac{\sum_{i=1}^{m} c_i}{m}$, c_i being number of defects of the ith sample,

$i = 1(1)m$. Then c-chart will be based on

$LCL = \bar{c} - 3\sqrt{\bar{c}}$

$CL = \bar{c}$

$UCL = \bar{c} + 3\sqrt{\bar{c}}$

one should note that 'c' cannot be negative according to stated formulae. it is taken to be zero.