STATISTICAL QUALITY CONTROL

Introduction: Quality is the determining factor the success of any product or service large resource are committed in every organization to ensure quality

Definition: It is defined as customer satisfaction in general and fitness for use in particular. Both the external consumer who buy the product and services and the internal consumers that is, all divisions or departments of the business organization are equally interested in the quality.

Statistical quality control: The process of applying statistical principles to solve the problem of controlling the quality control of a product or service is called statistical quality control.

Quality elements: a) Quality design b) Quality conformance

a) Quality design: Quality of design refers to product feature such as performance, reliability durability, ease of use, serviceability

b) Quality conformance: Quality conformance means whether the product meets the given quality specification or not

Inspection: The process of measuring the out put and comparing it to check whether it meets the given specified requirements or not, is called inspection.

Inspection Methods: The following are the methods of inspection based on merits

1) Incoming inspection: In this method, the quality of the goods and services arriving into the organization is inspected. This ensures that the material suppliers adhere to the given specifications with this defective material cannot enter into the production process. This focuses on the vendor's quality and ability to supply acceptable raw materials.

2) Critical point inspection: Inspecting at the critical points of a product manufacture gives valuable insight into the completely functional process. At the points of manufacture that involve high costs or which offer no possibility for repair or rework, inspection is crucial further operation depend on these results critical point inspection helps to drop the defective production, and thereby, facilitate avoiding unnecessary further expenditure on them.

3) Process inspection: This is also called patrolling inspection or floor inspection or roving inspection. Here the inspector goes around the manufacturing points in the shop floor to inspect the goods produced on random sample basis from time to time.

4) Fixed inspection: It provides for a centralized and independent where work is brought for inspection from time to time. This method is followed where the inspection equipment cannot be moved to the points of productions.

5) Final inspection: This is centralized inspection making use of special equipment. This certifies the quality of the goods before they are shipped.

Elements of statistical Quality Control: The technique under SQC can be divided in to two parts a) Process control b) Acceptance sampling

a) Process control: Process control is a technique of ensuring the quality of the products during the manufacturing process itself. If a process consistently produces items with acceptable or tolerable range of specification. It is said to be statically under control. Process control is achieved through control charts. Process control aims to control and maintain the quality of the products in the manufacturing process.

Statistical control charts: A control chart compares graphically the process performance data to computed statistical control limits. These control limits act as limit lines on the chart control chats are the tools to determine whether the process is under control or not.

The quality of the production process may be affected by chance cause or assignable cause.

Chance cause: such causes, which may or may not affect the manufacturing process are called chance cause, chance cause cannot even be identified. It is not possible to always maintain the given specification.

Assignable Cause: Assignable causes affect the quality of the production process. These causes can be identified and specified. Causes such as change in the labour shift, power fluctuations, or excessive tool wear are said to be assignable causes as they affect the quality of manufacturing process in different ways.

Process capability: Process capability refers to the ability to achieve measurable results from a combination of machines, tools, methods, materials and people engaged in production.

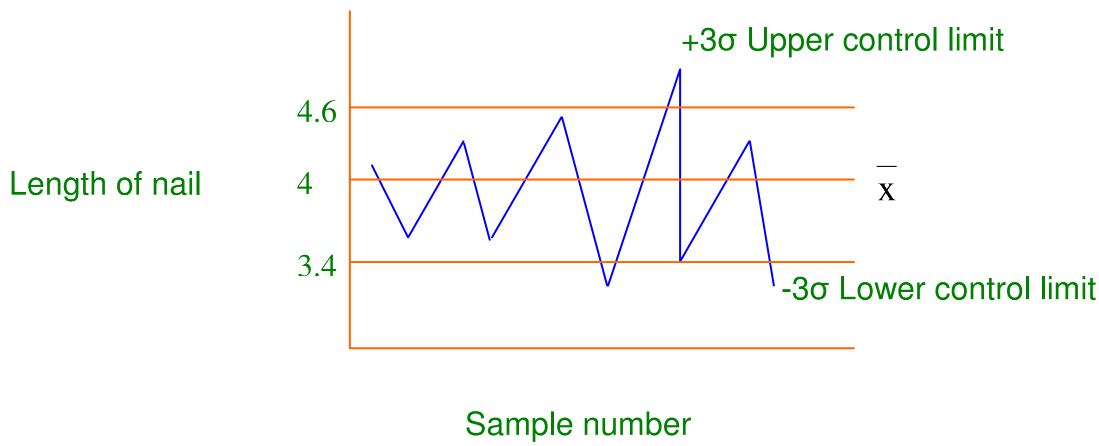
Confidence limits and control limit:

Confidence limit: It indicate the range of confidence level. A confidence level refers to the probability that the value of measurement or parameter, such as length of screw, is correct.

Ex: If a component is required with measurement of 50 mm. across, then the buy accept all components measuring between 48 mm and 52 mm across, considering a five percent confidence level.

Control limit: Control limits are found in the control charts. There are two control limits 1) Upper control limit (UCL) and 2) Lower control limit (LCL). These are determined based on the principles of normal distribution

Ex: In a pilot investigation of the length of the nails produced in the shop floor, it is found that the mean length $\overline{X}$ is cm, the S.D 3σ, the measure of variability of the nails produced 0.2 cm. How do you construct the control chart for this data.



Control charts for variables: A variable is one whose quality measurement changes from unit to unit. The quality of these variables is measured in terms of hardness, thickness, length, and so on. The control charts for variables are drawn using the principles of normal distribution. There are two types of control charts for variables $\overline{x}$ and R chart.

$\overline{X}$ and R Chart: The $\overline{X}$ chart is used to show the process variations based on the average measurement of samples collected. It shows more light on diagnosing quality problem when read along with R chart. It shows the erratic or cyclic shifts in the manufacturing process. It can also focus on when to take a remedial measure to set right the quality problems. However, collecting data about all the variables involves a large amount of time and resources.

The R chart is based on the range of the items in the given ample. It highlights the changes in the process variability. It is a good measure of spread or range. It shows better results when read along with the $\overline{X}$ chart.

For $\overline{x}$ charts: UCL = $\overline{\overline{x}} + A_2\overline{R}$ When $\overline{\overline{x}}$ = Mean of Means

LCL = $\overline{\overline{x}} - A_2\overline{R}$ $\overline{R}$ = Mean of sample range

A_2= Constant

For R chart: UCL = $D_4\overline{R}$ D_4, D_3 are constants

LCL = $D_3\overline{R}$

$\overline{R}$ is the average of sample ranges (Ranges is the difference between the maximum variable and minimum variable)

EX: Construct $\overline{x}$ and R charts from the following information and state whether the process is in control for each of the following $\overline{x}$ has been computed from a sample of 5 units drawn at an interval of half an hour from an ongoing manufacturing process.

Samples	1	2	3	4	5	6	7	8	9	10
$\overline{x}$	24	34	35	39	26	29	13	34	37	29
R	23	39	14	5	20	17	21	11	40	10

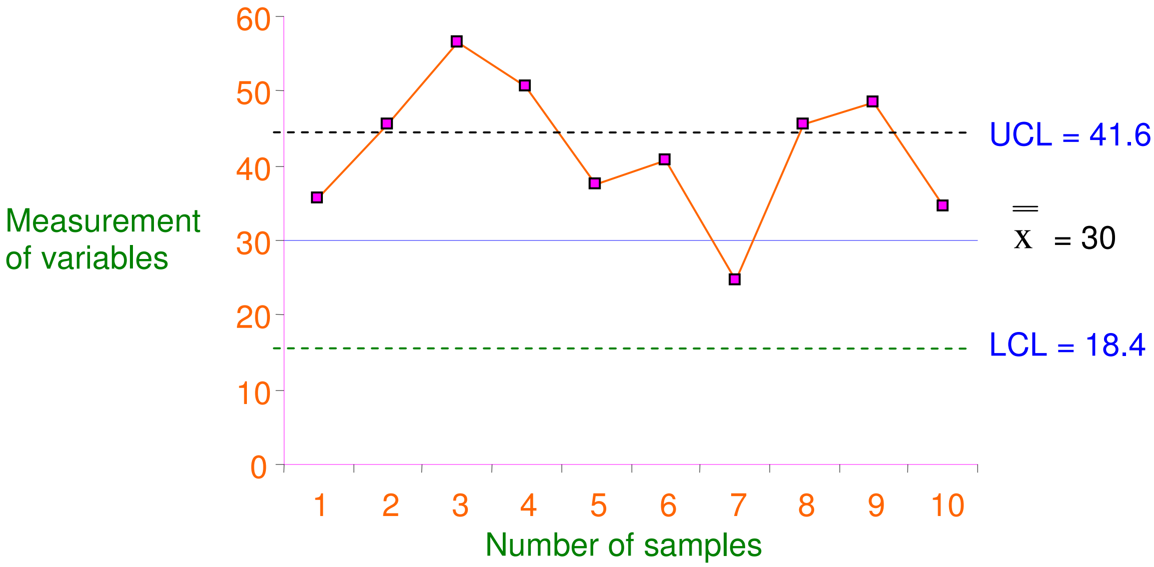
Solution: The mean of means $\overline{\overline{x}} = \frac{\sum \overline{x}}{n} = \frac{300}{10} = 30$

$\overline{R}$ is calculated as $\overline{R} = \frac{\sum R}{n} = \frac{200}{10} = 20$

$\overline{x}$ Chart: $\overline{x}$ chart UCL and LCL compute at sample size 5 A_2 table value is 0.58

UCL= $\overline{\overline{x}} + A_2\overline{R}$ = 30 + (0.58x20) =41.6

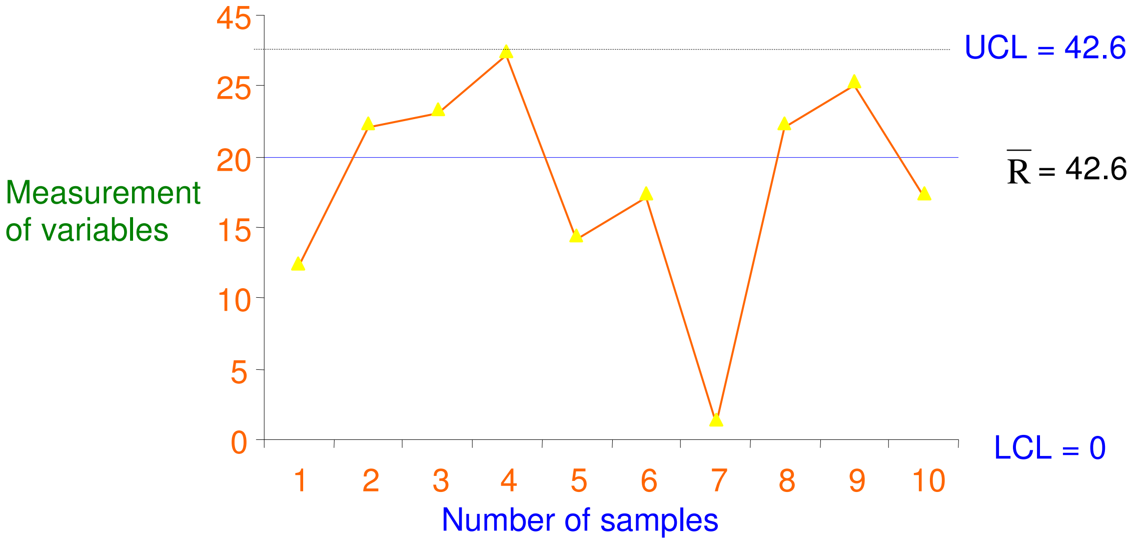
LCL = $D_3\overline{R}$ = 30 – (0.58x20) = 18.4


60
50
40
30
20
10
0
Measurement of variables
UCL = 41.6
$\bar{\bar{x}}$ = 30
LCL = 18.4
1 2 3 4 5 6 7 8 9 10
Number of samples

R Chart: R chart UCL and LCL compute at sample size 5, D_4 table value is 2.11 and D_3 table value is 0

$$UCL = D_4\overline{R} = 2.11 \times 20 = 42.2$$

$$LCL = D_3\overline{R} = 0 \times 20 = 0$$



Therefore 3, 7 points the process is out of control.

Control charts for attributes: The quality of attributes can be determined on the basis of 'Yes' or 'No', 'Go' or 'No go'. In other words, in case of a mirror glass, even if there is one scratch it is not considered to be a quality mirror, in such a case quality is decided base on whether the mirror has any scratch or not.

The control charts for attributes are 'C' chart and 'P' charts

'C' Chart: 'C' chart is use where there a number defects per unit. This control charts controls the number of defects per unit. Here the sample size should be constant. This calculate as below.

$$UCL = \bar{c} + 3\sqrt{\bar{c}} \quad \text{and} \quad LCL = \bar{c} - 3\sqrt{\bar{c}}$$

Where the $\bar{c} = \dfrac{\textit{Total number of defects in all the samples}}{\textit{Total number of samples inspected}}$

Ex:

Sample Number	No. of defects	Sample Number	No. of defects
1	5	11	4
2	4	12	6
3	9	13	7
4	7	14	3
5	8	15	5
6	9	16	3
7	4	17	3
8	5	18	1
9	2	19	7
10	6	20	2

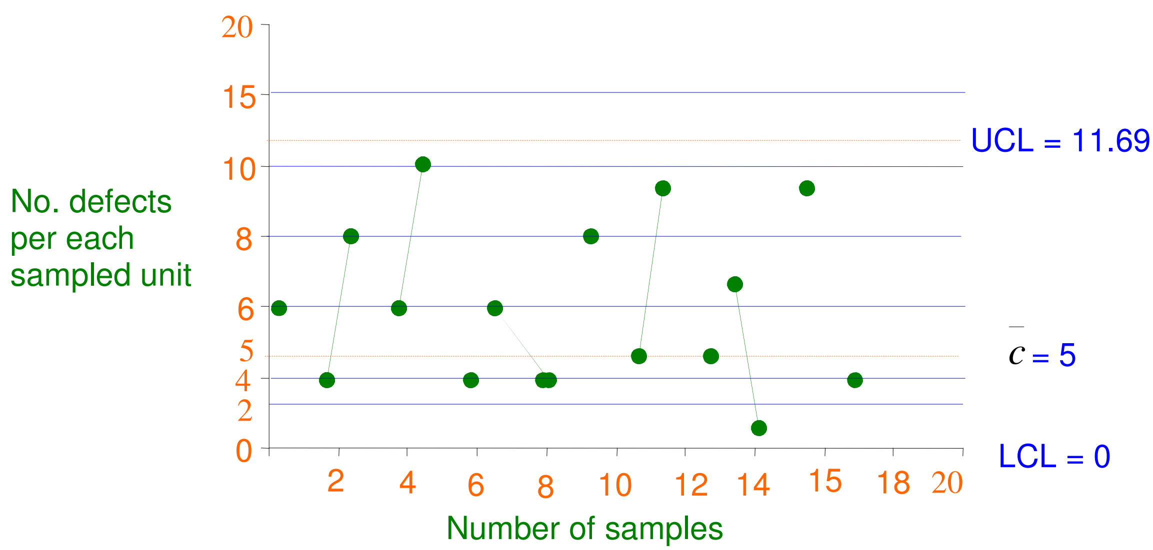
Total number of defects = 100

$$\bar{c} = \frac{100}{20} = 5$$

$$UCL = \bar{c} + 3\sqrt{\bar{c}} = 5 + 3\sqrt{5} = 11.69$$

$$LCL = \bar{c} - 3\sqrt{\bar{c}} = 5 - 3\sqrt{5} = 0$$

LCL = 0 means, LCL got negative value, take it as equal to zero



'P' Chart: 'P' Chart is used where there is date about the number of defectives per sample. It is also called fraction defective chart or percentage defectives chart. Here each item is classified on 'go or no go' basis that is good or bad. Hence if the sample size is larger, the results could be better.

UCL =

LCL =

Where average defective ($\bar{p}$) = $\frac{Total\ no.\ of\ defective\ found}{Total\ no.\ of\ pieces\ inspected}$

'n' = Number of pieces inspected per day

Ex: For each of the 14 days a number of magnets used in electric relays are inspected and the number of defectives is recorded. The total number of magnets tested is 14,000. The following are the particular of the number of defectives found every day.

Day number	Number of defective	Day number	Number of defective
1	100	8	120
2	50	9	60
3	150	10	140
4	200	11	50
5	150	12	70
6	50	13	40
7	80	14	40

Solution:

Total number of defectives = 14000

The average sample size(n) per day= 14000/14 days = 1000

Percentage of defective per day = $\frac{Total\ no.\ of\ defective\ found\ per\ day}{Total\ no.\ of\ pieces\ inspected\ per\ day}$

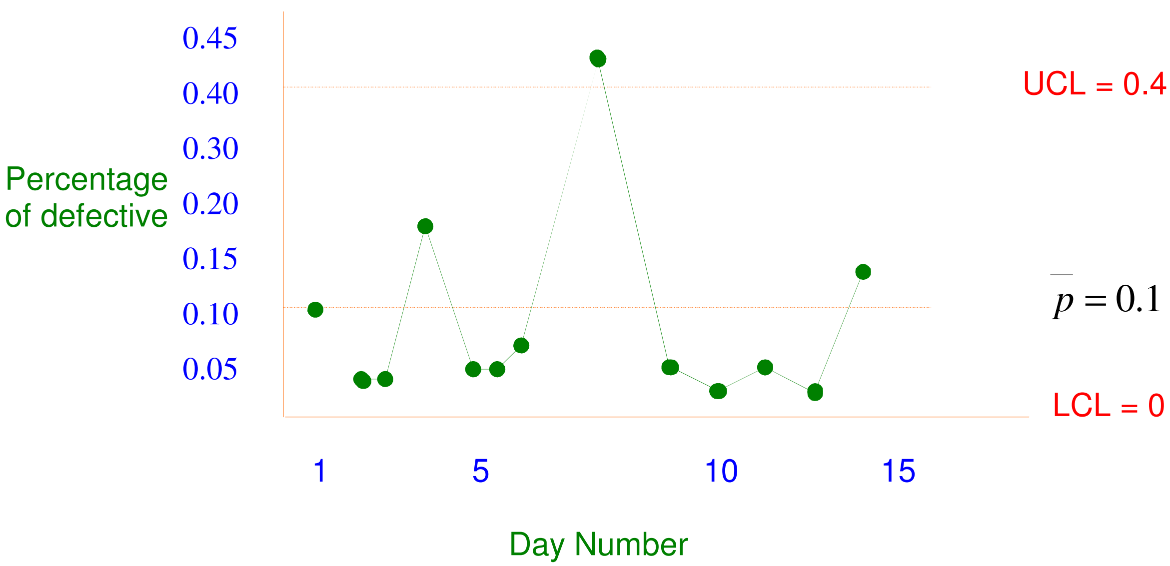
Day number	Percentage of defectives	Number of defective	Percentage of defectives	Day number	Number of defective
1	100/1000=0.10	100	120/1000=0.12	8	120
2	50/1000 =0.05	50	60/1000 =0.06	9	60
3	150/1000=0.15	150	140/1000=0.14	10	140
4	200/1000=0.20	200	50/1000 =0.05	11	50
5	150/1000=0.15	150	70/1000 =0.07	12	70
6	50/1000 =0.05	50	40/1000 =0.04	13	40
7	80/1000 =0.08	80	140/1000=0.14	14	40

$$(\bar{p}) = \frac{Total\ no.\ of\ defective\ found}{Total\ no.\ of\ pieces\ inspected}$$

1400/14000 = 0.1

$$UCL = 0.1 + 3\sqrt{\frac{0.1(1-0.1)}{1000}} = 0.4$$

$$LCL = 0.1 - 3\sqrt{\frac{0.1(1-0.1)}{1000}} = 0$$

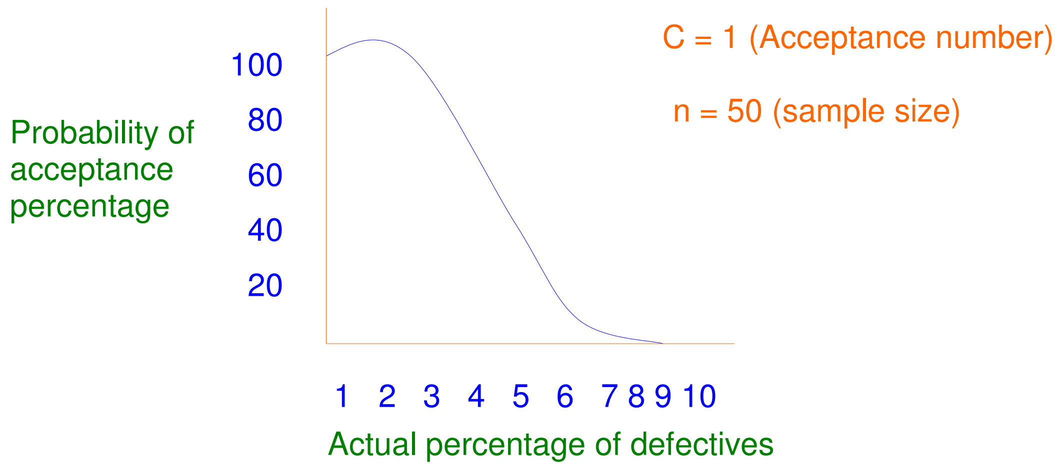


Acceptance Sampling: Acceptance sampling is a technique of deciding whether to accept the whole lot or not based on the number of defectives from a random drawn sample.

It is widely use in buying food products, such as rice, wheat etc. Before buying the random samples drawn from the bags of say rice are tested. If the quality of sample drawn looks good or free from defects then according to the requirement the entire bag or part of it can be brought

The process of acceptance sampling through operating characteristic curve (OCC)

Operating characteristic curve (OCC): The graphical relationship between percentage defective in the lots being submitted for inspection and the probability acceptance is termed as "operating characteristic of a particular sampling plan"



It gives a clear picture about the probability of acceptance of lot for various values of percent defectives in the lot. The probability of acceptance of a lot is high for low values of actual percentage decrease and it is low for high values of actual percentage defectives.

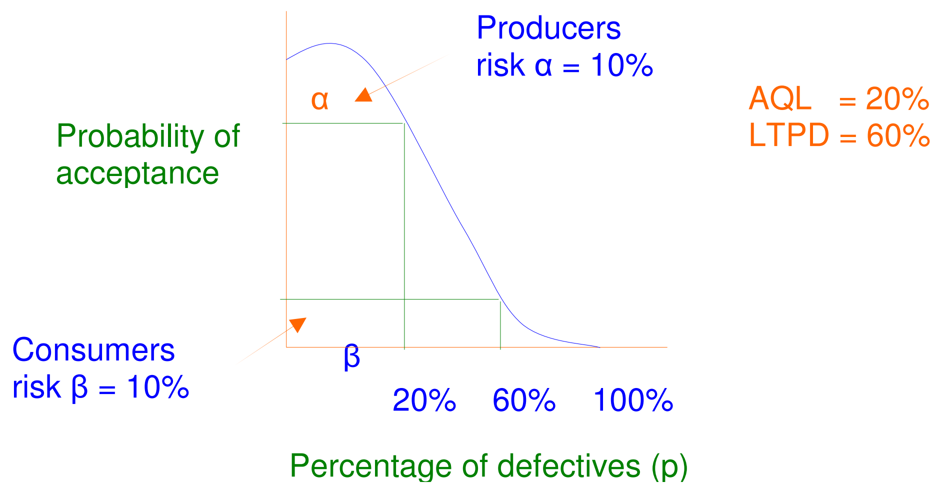
Construction of OC curve: To develop a sampling plan for acceptance sampling, an appropriate O.C curve must be selected to construct an OC curve an agreement has to be reached between the producer and the consumer on the following four point.

1) Acceptable quality level (AQL): This is the maximum proportion of defectives that will make the lot definitely acceptable.

2) Lot tolerance percentage defective (LTPD): This is the maximum proportion of defectives that will make the lot definitely unacceptable.

3) Producers risk (α): This is the risk, the producer is willing to take that lots of the quality level AQL will be rejected, even though, they are acceptable usually α = 5%

4) Consumer risk (β): This is the risk, the consumer is willing to take that lots of the quality level LTPD will be accepted, event though, they are actually unacceptable usually β = 10%.



Sampling plans: Based on the number of samples drawn for taking accept/ reject decisions, the sampling methods are used. There are four methods of acceptance samplings.

1) Single sampling plan: A lot is accepted or rejected on the basis of a single sample drawn from that cost

2) Double sampling plan: If it is not possible to decide the fate of the lot on the basis of first sample, a second sample is drawn and the decision is taken on the basis of the combined results of first and second sample.

3) Multiple sampling plan: A lot is accepted or rejected based upon the result obtained from several samples (of parts) drawn from the lot.

4) Sequential sampling plan: (Item by item analysis)

Sequential sampling involves increasing the sample size by one part at a time till the sample becomes large enough and contains sufficient number of defectives to decide intelligently whether to accept or reject the lot.