Quality Control

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Overview

- Introduction
- Statistical Concepts in Quality Control
- Control Charts
- Acceptance Plans
- Computers in Quality Control
- Quality Control in Services

Introduction

- Pengendalian mutu adalah merupakan fungsi manajemen dalam memelihara kualitas dari produk sebagai dasar kebijakan perusahaan.
- Quality control (QC) includes the activities from the suppliers, through production, and to the customers.
- Incoming materials are examined to make sure they meet the appropriate specifications.
- The quality of partially completed products are analyzed to determine if production processes are functioning properly.
- Finished goods and services are studied to determine if they meet customer expectations.

Tujuan dari Pengendalian Mutu:

- Agar perusahaan dapat menghasilkan barang atau jasa yang baik (bermutu baik).
- Dicapainya produktivitas yang tinggi.
- Meningkatkan pemasaran.
- Ongkos produksi yang paling ekonomis.
- Memperbaiki proses yang salah.

Langkah-Langkah dalam Pengendalian Mutu

1. *Quality Consiusness*

   Menentukan ukuran kualitas yang akan dihasilkan mulai dari yang jelek sampai yang terbaik.

2. *Quality Responsibility*

   Produsen dan konsumen sama-sama berkepentingan mengontrol suatu produk yang dihasilkan perusahaan, untuk ini diperlukan koordinasi dalam pengerjaan produk sehingga dengan kerjasama tiap bagian dalam melaksanakan pekerjaan akan memelihara standar produk yang telah ditetapkan dan kemungkinan tercapainya tingkat ketelitian yang dikendalikan perusahaan.

3. *Quality Standar*

   Standar kualitas yang ditentukan perusahaan, digunakan sebagai ukuran perbandingan untuk menilai pengerjaan produk.

   Standar kualitas merupakan pedoman yang seragam bagi spesifikasi produk yang akan dijual.

4. *Operation Standar*

   Yaitu langkah untuk menetapkan suatu cara barang yang telah ditetapkan didalam suatu proses design yang dituangkan dalam flow diagram atau flow chart.

Langkah-Langkah dalam Pengendalian Mutu cont.

5. *Process Control*

   Proses kontrol berhubungan dengan langkah-langkah untuk melakukan inspelsi pada tahapan proses produksi pada waktu yang telah ditentukan dengan menggunakan cara dan peralatan yang telah ditetapkan.

6. *Cost Control*

   Biaya-biaya yang dikeluarkan untuk melakukan pengendalian mutu, perlu memperhatikan manfaat yang akan diperoleh.

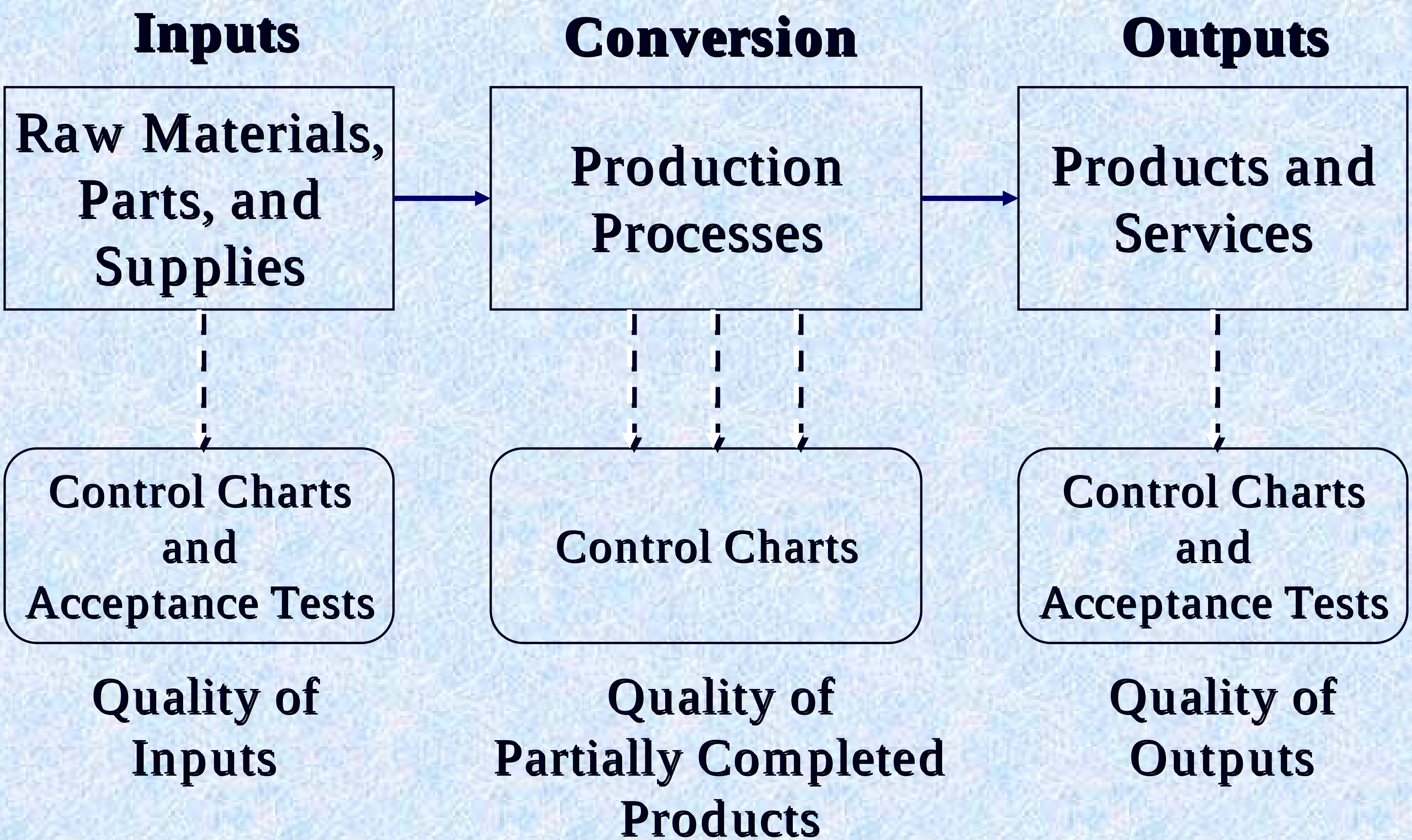
7. *Sampling*

   Merupakan cara penyajian produk untuk diperiksa, dan pada umumnya hanya bisa dilakukan untuk produk yang homogen.

8. *Market Research*

   Disini diteliti bagaimana tanggapan dan rekasi konsumen terhadap mutu barang yang akan dihasilkan oleh perusahaan dan sejauhmana keaktifan mengontrol mutu yang telah dilakukan, selain dari itu dengan market research akan diperoleh data tentang produk design

QC Throughout Production Systems



Services and Their Customer Expectations

- Hospital
  - Patient receive the correct treatments?
  - Patient treated courteously by all personnel?
  - Hospital environment support patient recovery?
- Bank
  - Customer’s transactions completed with precision?
  - Bank comply with government regulations?
  - Customer’s statements accurate?

Products and Their Customer Expectations

- Automaker
  - Auto have the intended durability?
  - Parts within the manufacturing tolerances?
  - Auto's appearance pleasing?
- Lumber mill
  - Lumber within moisture content tolerances?
  - Lumber properly graded?
  - Knotholes, splits, and other defects excessive?

Statistical Quality Control

- **Penggunaan metode statistika untuk mengumpulkan dan menganalisa data dalam mengawasi kualitas hasil produksi, teknik yang digunakan biasanya adalah control chart**

Kegunaan Control Chart:

1. Alat pembantu quality control
2. Mengurangi variasi dalam mutu
3. Mengurangi Biaya Pemriksaan
4. Besar variasi dapat diramalkan
5. Dasar untuk melakukan tindakan
6. Untuk menemukan kesalahan-kesalahan

Jenis Control Chart: X-Chart, R-Chart, I-Chart, C-Chart.

Sampling

- The flow of products is broken into discrete batches called lots.
- Random samples are removed from these lots and measured against certain standards.
- A random sample is one in which each unit in the lot has an equal chance of being included in the sample.
- If a sample is random, it is likely to be representative of the lot.

Sampling

- Either attributes or variables can be measured and compared to standards.
- Attributes are characteristics that are classified into one of two categories, usually defective (not meeting specifications) or nondefective (meeting specifications).
- Variables are characteristics that can be measured on a continuous scale (weight, length, etc.).

Size and Frequency of Samples

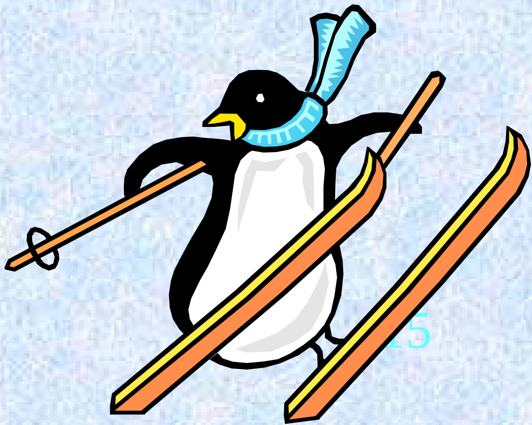
- As the percentage of lots in samples is increased:
  - the sampling and sampling costs increase, and
  - the quality of products going to customers increases.
- Typically, very large samples are too costly.
- Extremely small samples might suffer from statistical imprecision.
- Larger samples are ordinarily used when sampling for attributes than for variables.

When to Inspect During the Production Process

- Inspect before costly operations.
- Inspect before operations that are likely to produce faulty items.
- Inspect before operations that cover up defects.
- Inspect before assembly operations that cannot be undone.
- On automatic machines, inspect first and last pieces of production runs, but few in-between pieces.
- Inspect finished products.

Central Limit Theorem

- The <u>central limit theorem</u> is: *Sampling distributions can be assumed to be normally distributed even though the population (lot) distributions are not normal*.
- The theorem allows use of the normal distribution to easily set limits for control charts and acceptance plans for both attributes and variables.



Sampling Distributions

- The sampling distribution can be assumed to be normally distributed unless sample size (n) is extremely small.
- The mean of the sampling distribution ($\bar{\bar{x}}$) is equal to the population mean (μ).
- The standard error of the sampling distribution ($\sigma_{\bar{x}}$) is smaller than the population standard deviation (σ_x) by a factor of 1/ $\sqrt{n}$

Control Charts

- Primary purpose of control charts is to indicate at a glance when production processes might have changed sufficiently to affect product quality.
- If the indication is that product quality has deteriorated, or is likely to, then corrective is taken.
- If the indication is that product quality is better than expected, then it is important to find out why so that it can be maintained.
- Use of control charts is often referred to as <u>statistical process control</u> (SPC).

Constructing Control Charts

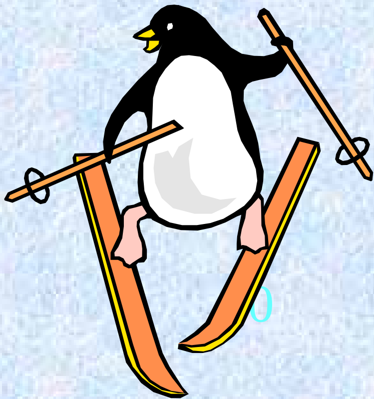
- Vertical axis provides the scale for the sample information that is plotted on the chart.
- Horizontal axis is the time scale.
- Horizontal center line is ideally determined from observing the capability of the process.
- Two additional horizontal lines, the lower and upper control limits, typically are 3 standard deviations below and above, respectively, the center line.

Constructing Control Charts

- If the sample information falls within the lower and upper control limits, the quality of the population is considered to be in control; otherwise quality is judged to be out of control and corrective action should be considered.
- Two versions of control charts will be examined
  - Control charts for attributes
  - Control charts for variables

Control Charts for Attributes

- Inspection of the units in the sample is performed on an attribute (defective/non-defective) basis.
- Information provided from inspecting a sample of size n is the percent defective in a sample, p, or the number of units found to be defective in that sample divided by n.



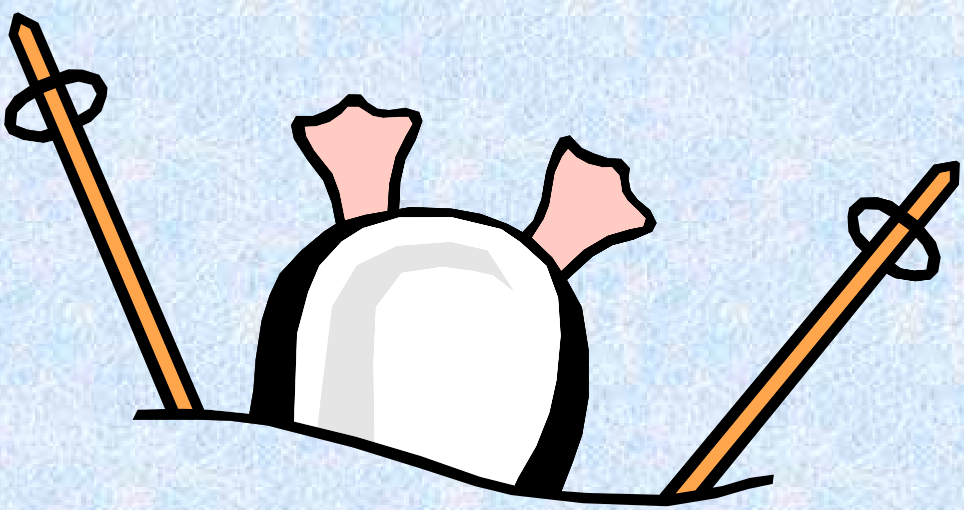
Control Charts for Attributes

- Although the distribution of sample information follows a binomial distribution, that distribution can be approximated by a normal distribution with a
  - mean of $\bar{p}$
  - standard deviation of $\sqrt{\bar{p}(100 - \bar{p})/n}$
- The 3σ control limits are

$$\bar{p} \; +/- \; 3\sqrt{\bar{p}(100 - \bar{p})/n}$$

Example: Attribute Control Chart

Every check cashed or deposited at Lincoln Bank must be encoded with the amount of the check before it can begin the Federal Reserve clearing process. The accuracy of the check encoding process is of upmost importance. If there is any discrepancy between the amount a check is made out for and the encoded amount, the check is defective.



Example: Attribute Control Chart

Twenty samples, each consisting of 250 checks, were selected and examined. The number of defective checks found in each sample is shown below.

4	1	5	3	2	7	4	5	2	3
2	8	5	3	6	4	2	5	3	6

Example: Attribute Control Chart

The manager of the check encoding department knows from past experience that when the encoding process is in control, an average of 1.6% of the encoded checks are defective.

She wants to construct a *p* chart with 3-standard deviation control limits.

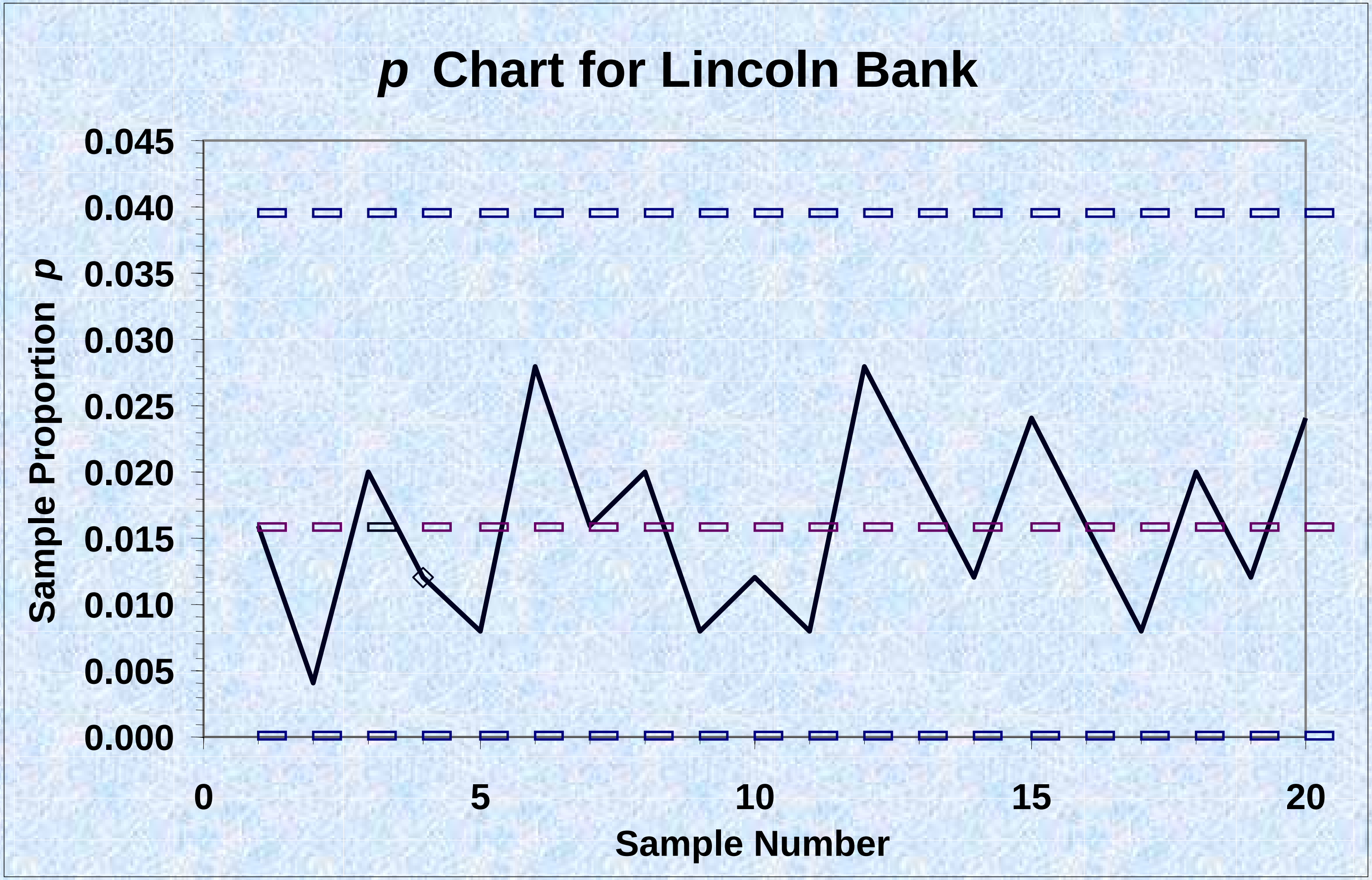
Example: Attribute Control Chart

$$\sigma_{\bar{p}} = \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = \sqrt{\frac{.016(1-.016)}{250}} = \sqrt{\frac{.015744}{250}} = .007936$$

$$\text{UCL} = p + 3\sigma_{\bar{p}} = .016+3(.007936) = .039808 \text{ or } 3.98\%$$

$$\text{LCL} = p - 3\sigma_{\bar{p}} = .016-3(.007936) = -.007808 = 0\%$$

Example: Attribute Control Chart



Control Charts for Variables

- Inspection of the units in the sample is performed on a variable basis.
- The information provided from inspecting a sample of size n is:
  - Sample mean, $\bar{x}$, or the sum of measurement of each unit in the sample divided by n
  - Range, R, of measurements within the sample, or the highest measurement in the sample minus the lowest measurement in the sample

Control Charts for Variables

- In this case two separate control charts are used to monitor two different aspects of the process's output:
  - Central tendency
  - Variability
- Central tendency of the output is monitored using the $\bar{x}$-chart.
- Variability of the output is monitored using the R-chart.

$\bar{x}$-Chart

- The central line is $\bar{\bar{x}}$, the sum of a number of sample means collected while the process was considered to be “in control” divided by the number of samples.
- The 3σ lower control limit is $\bar{\bar{x}}$ - AR
- The 3σ upper control limit is $\bar{\bar{x}}$ + AR
- Factor A is based on sample size.

R-Chart

- The central line is $\bar{R}$, the sum of a number of sample ranges collected while the process was considered to be "in control" divided by the number of samples.
- The 3σ lower control limit is $D_1\bar{R}$.
- The 3σ upper control limit is $D_2\bar{R}$.
- Factors D_1 and D_2 are based on sample size.

3σ Control Chart Factors for Variables

Sample Size n	Control Limit Factor for Sample Mean A	Control Limit Factor for Sample Range D_1	D_2
2	1.880	0	3.267
3	1.023	0	2.575
4	0.729	0	2.282
5	0.577	0	2.116
10	0.308	0.223	1.777
15	0.223	0.348	1.652
20	0.180	0.414	1.586
25	0.153	0.459	1.541
Over 25	$0.75(1/\sqrt{n})$	0.45+.001n	1.55-.0015n

Example: Variable Control Chart

Harry Coates wants to construct $\bar{x}$ and R charts at the bag-filling operation for Meow Chow cat food. He has determined that when the filling operation is functioning correctly, bags of cat food average 50.01 pounds and regularly-taken 5-bag samples have an average range of .322 pounds.

Example: Variable Control Chart

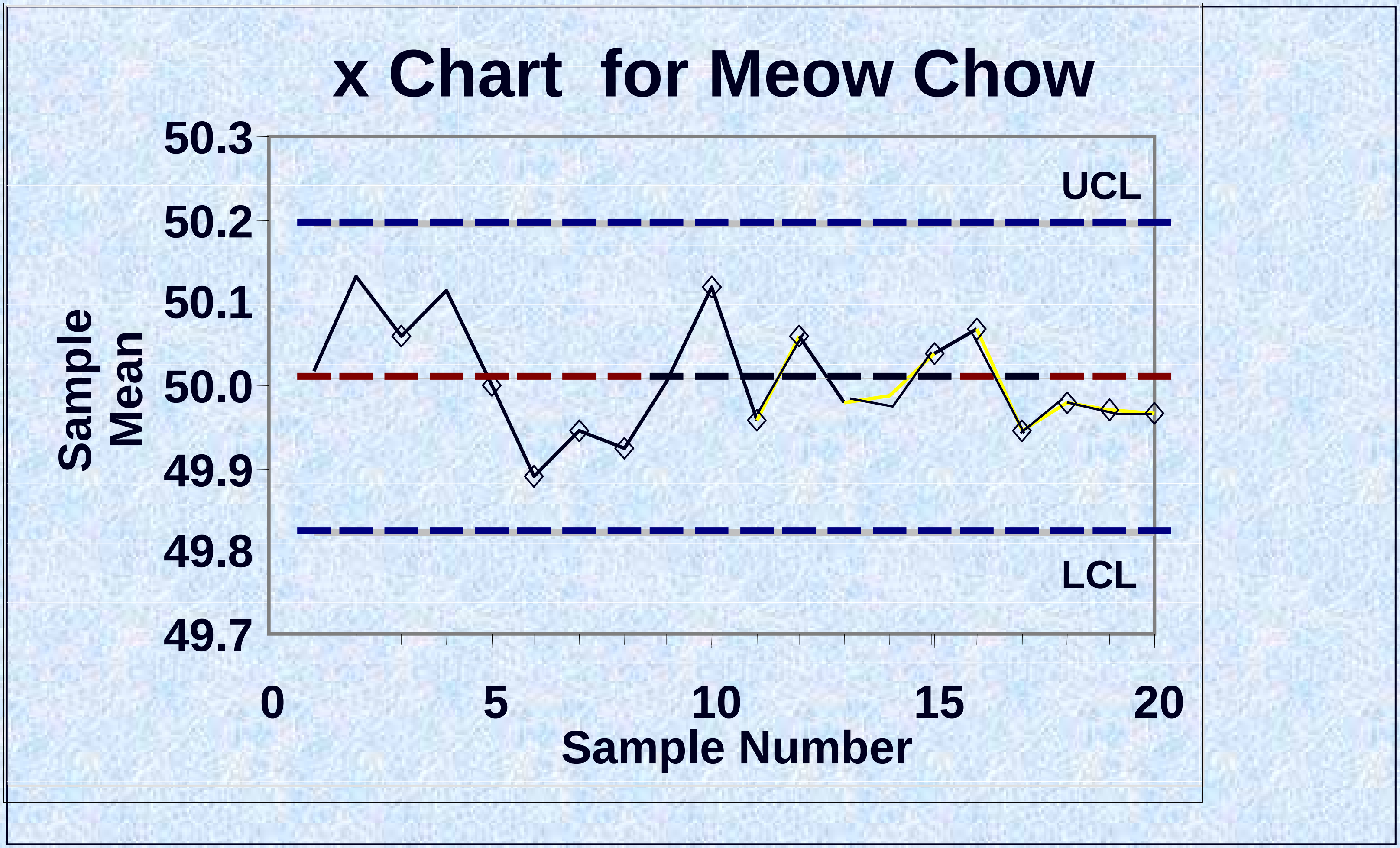
- Sample Mean Chart

$$\bar{\bar{x}} = 50.01, \quad \bar{R} = .322, \quad n = 5$$

$$UCL = \bar{\bar{x}} + A\bar{R} = 50.01 + .577(.322) = 50.196$$

$$LCL = \bar{\bar{x}} - A\bar{R} = 50.01 - .577(.322) = 49.824$$

Example: Variable Control Chart



Example: Variable Control Chart

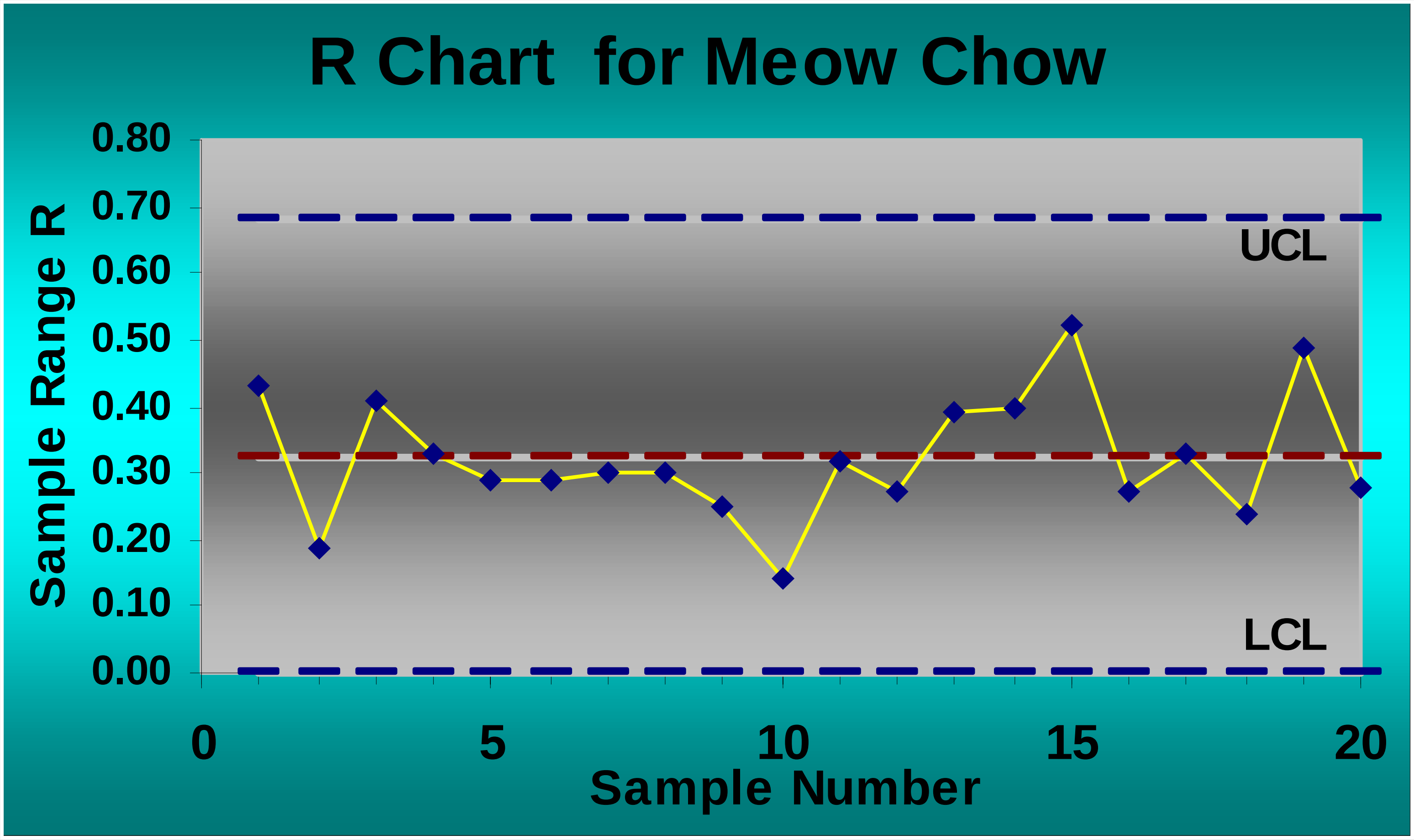
- Sample Range Chart

$$\bar{\bar{x}} = 50.01, \quad \bar{R} = .322, \quad n = 5$$

$$UCL = \bar{R}D_2 = .322(2.116) = .681$$

$$LCL = \bar{R}D_1 = .322(0) \qquad = \quad 0$$

Example: Variable Control Chart



Acceptance Plans

- Trend today is toward developing testing methods that are so quick, effective, and inexpensive that products are submitted to 100% inspection/testing
- Every product shipped to customers is inspected and tested to determine if it meets customer expectations
- But there are situations where this is either impractical, impossible or uneconomical
  - Destructive tests, where no products survive test
- In these situations, acceptance plans are sensible

Acceptance Plans

- An acceptance plan is the overall scheme for either accepting or rejecting a lot based on information gained from samples.
- The acceptance plan identifies the:
  - Size of samples, n
  - Type of samples
  - Decision criterion, c, used to either accept or reject the lot
- Samples may be either single, double, or sequential.

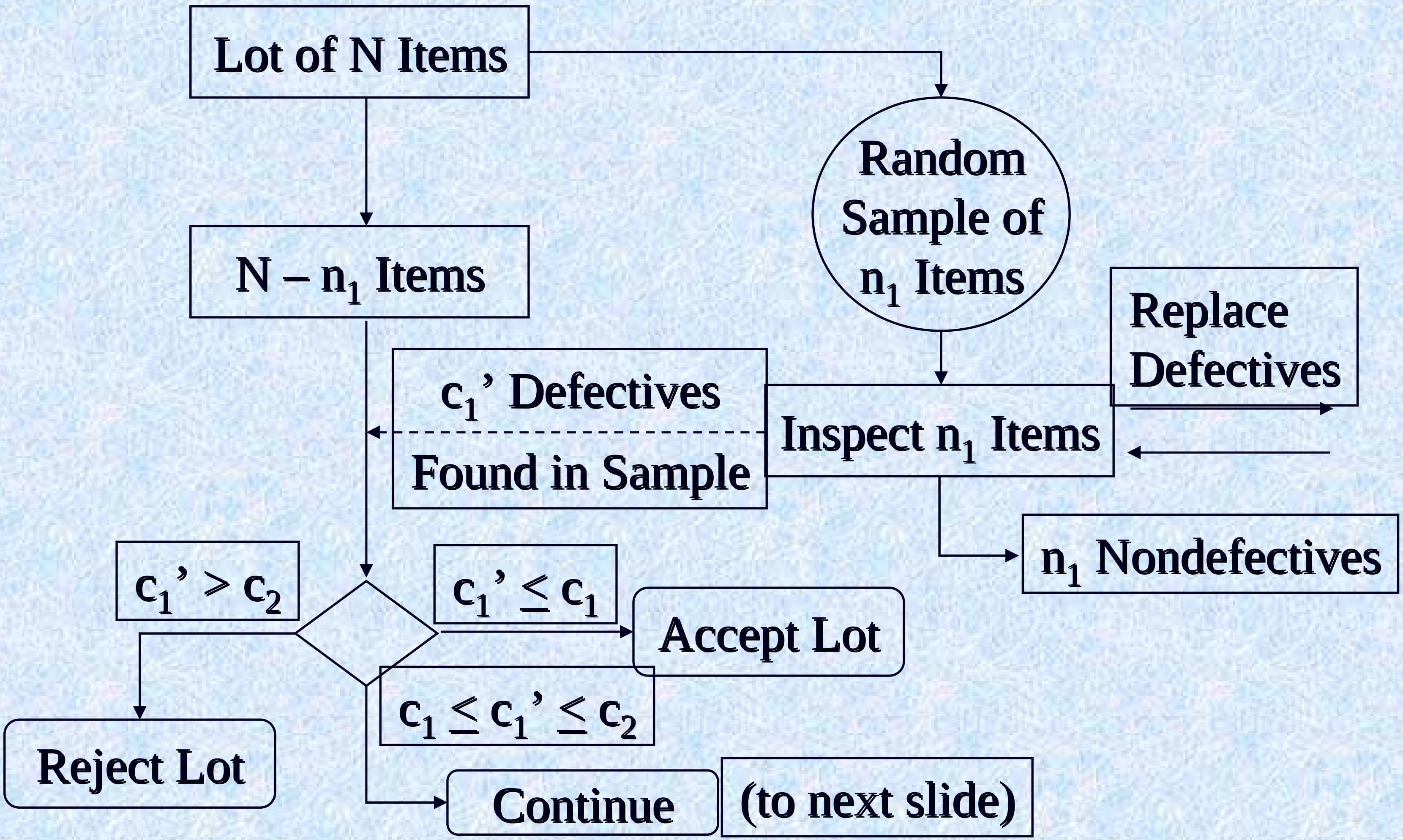
Single-Sampling Plan

- Acceptance or rejection decision is made after drawing only one sample from the lot.
- If the number of defectives, c', does not exceed the acceptance criteria, c, the lot is accepted.

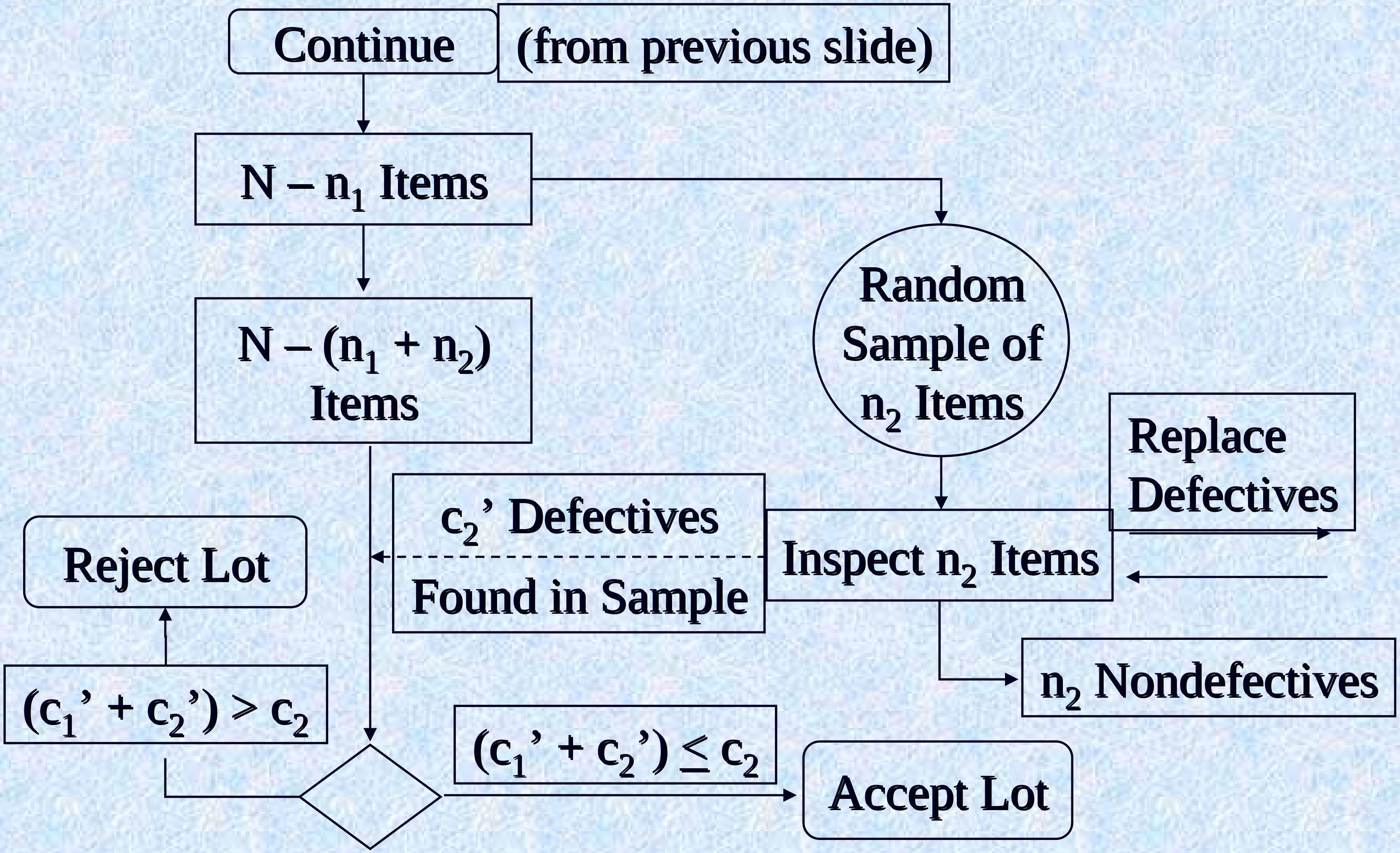
Double-Sampling Plan

- One small sample is drawn initially.
- If the number of defectives is less than or equal to some lower limit, the lot is accepted.
- If the number of defectives is greater than some upper limit, the lot is rejected.
- If the number of defectives is neither, a second larger sample is drawn.
- Lot is either accepted or rejected on the basis of the information from both of the samples.

Double-Sampling Plan



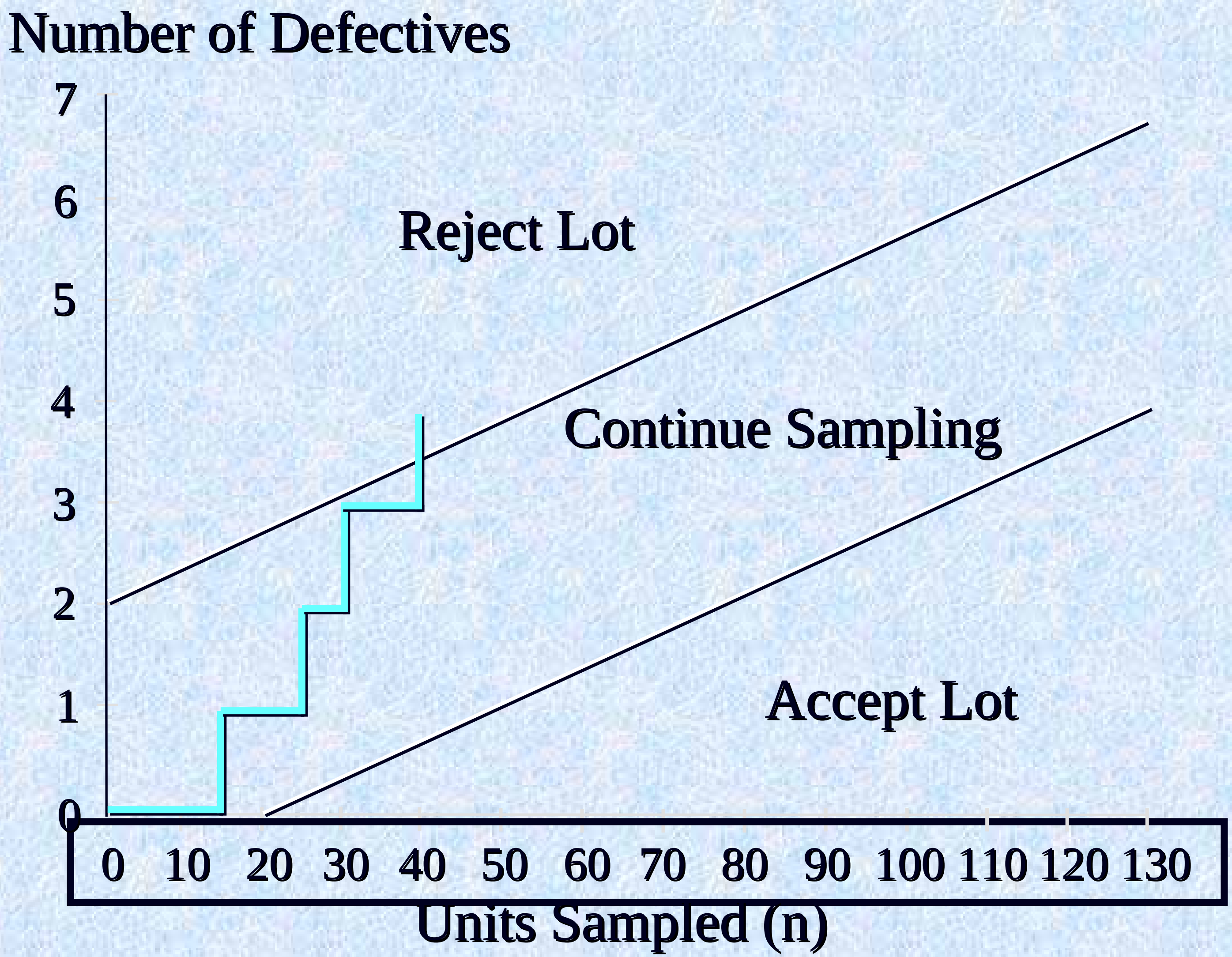
Double-Sampling Plan



Sequential-Sampling Plan

- Units are randomly selected from the lot and tested one by one.
- After each one has been tested, a reject, accept, or continue-sampling decision is made.
- Sampling process continues until the lot is accepted or rejected.

Sequential-Sampling Plan



Definitions

- <u>Acceptance plan</u> - Sample size (n) and maximum number of defectives (c) that can be found in a sample to accept a lot
- <u>Acceptable quality level (AQL)</u> - If a lot has no more than AQL percent defectives, it is considered a good lot
- <u>Lot tolerance percent defective (LTPD)</u> - If a lot has greater than LTPD, it is considered a bad lot

Definitions

- Average outgoing quality (AOQ) – Given the actual % of defectives in lots and a particular sampling plan, the AOQ is the average % defectives in lots leaving an inspection station
- Average outgoing quality limit (AOQL) – Given a particular sampling plan, the AOQL is the maximum AOQ that can occur as the actual % defectives in lots varies

Definitions

- <u>Type I error</u> - Based on sample information, a good (quality) population is rejected
- <u>Type II error</u> - Based on sample information, a bad (quality) population is accepted
- <u>Producer's risk (α)</u> - For a particular sampling plan, the probability that a Type I error will be committed
- <u>Consumer's risk (β)</u> - For a particular sampling plan, the probability that a Type II error will be committed

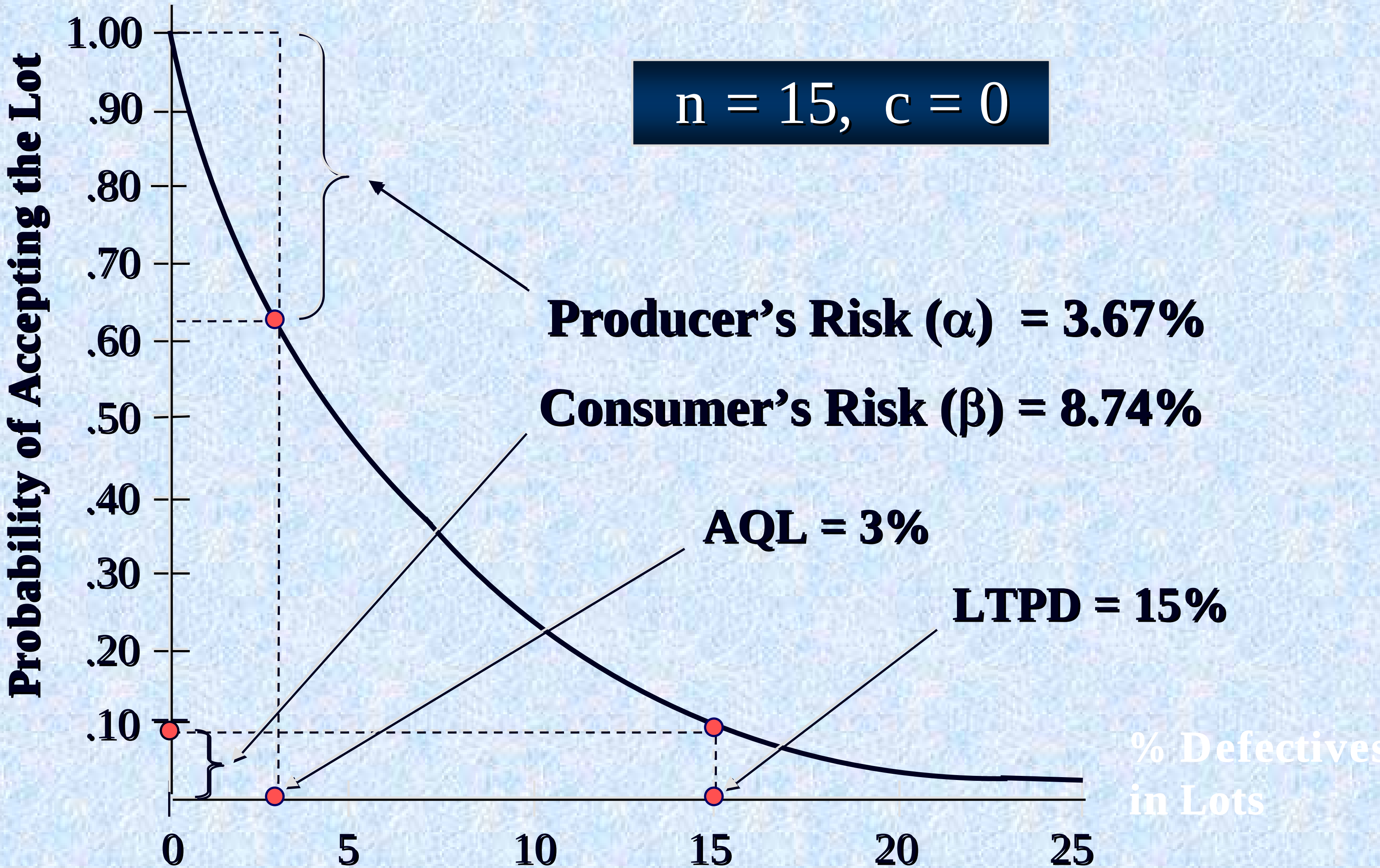
Considerations in Selecting a Sampling Plan

- Operating characteristics (OC) curve
- Average outgoing quality (AOQ) curve

Operating Characteristic (OC) Curve

- An OC curve shows how well a particular sampling plan (n,c) discriminates between good and bad lots.
- The vertical axis is the probability of accepting a lot for a plan.
- The horizontal axis is the actual percent defective in an incoming lot.
- For a given sampling plan, points for the OC curve can be developed using the Poisson probability distribution

Operating Characteristic (OC) Curve



OC Curve (continued)

- Management may want to:
  - Specify the performance of the sampling procedure by identifying two points on the graph:
    - AQL and α
    - LTPD and β
  - Then find the combination of n and c that provides a curve that passes through both points

Average Outgoing Quality (AOQ) Curve

- AOQ curve shows information depicted on the OC curve in a different form.
- Horizontal axis is the same as the horizontal axis for the OC curve (percent defective in a lot).
- Vertical axis is the average quality that will leave the quality control procedure for a particular sampling plan.
- Average quality is calculated based on the assumption that lots that are rejected are 100% inspected before entering the production system.

AOQ Curve

- Under this assumption,

$$AOQ = \pi[P(A)]/1$$

where: π = percent defective in an incoming lot

P(A) = probability of accepting a lot is obtained from the plan's OC curve

- As the percent defective in a lot increases, AOQ will increase to a point and then decrease.

AOQ Curve

- AOQ value where the maximum is attained is referred to as the average outgoing quality level (AOQL).
- AOQL is the worst average quality that will exit the quality control procedure using the sampling plan n and c.

Computers in Quality Control

- Records about quality testing and results limit a firm's exposure in the event of a product liability suit.
- Recall programs require that manufacturers
  - Know the lot number of the parts that are responsible for the potential defects
  - Have an information storage system that can tie the lot numbers of the suspected parts to the final product model numbers
  - Have an information system that can track the model numbers of final products to customers

Computers in Quality Control

- With automation, inspection and testing can be so inexpensive and quick that companies may be able to increase sample sizes and the frequency of samples, thus attaining more precision in both control charts and acceptance plans

Quality Control in Services

- In all services there is a continuing need to monitor quality
- Control charts are used extensively in services to monitor and control their quality levels