POLITEKNIK MALAYSIA
PORT DICKSON

QUALITY CONTROL
NOTE, QUESTION AND ANSWER

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QUALITY CONTROL

NOTE, QUESTION AND ANSWER

ACKNOWLEDGEMENT

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We hereby declare that this module is our original work. To the best of our knowledge it contains no materials previously written or published by another person. However, if there is any, due acknowledgement and credit are mentioned accordingly in the e-book.

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PREFACE

In the name of Allah, Most Gracious, Most Merciful. This book was written with the intention that His knowledge can be spread and utilized by all levels of readers, especially by students who take the Quality Control course.

Students who are less robust in basic statistical calculations, control chart construction and even sampling find this book suitable because it is written in an easy-to-understand form. Since the calculations and competencies of drawing graphs can be obtained through practice, some practice questions and answers are provided at the end of each chapter so that students can try and measure their understanding.

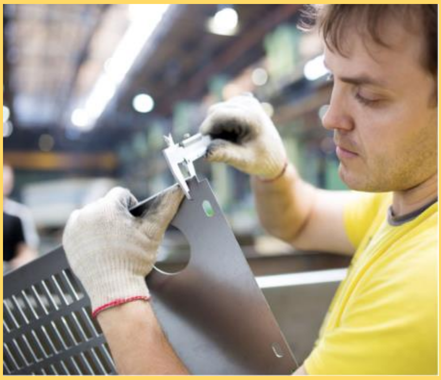
Finally, we would like to thank the staff of the Department of Mechanical Engineering for all the cooperation provided to make this book a success.

ABSTRACT

The E- Book entitled Quality Control: Notes, Question and Answer is a comprehensive and effective reference that prepares students to face the Quality Control exam regardless of polytechnic students or university students. This e-book contains notes, various types of questions and answers. The topics in this e-book are Basic Quality Concept, Control Chart for Variables, Control Chart for Attributes, Acceptance Sampling, Quality Cost and Tools and Technique for Quality Improvement.

Contents


Johnson&Johnson




QUALITY ASSURANCE
STANDARD
SYSTEM
MANAGEMENT
SERVICE
CONTROL
PROCESS
CUSTOMER

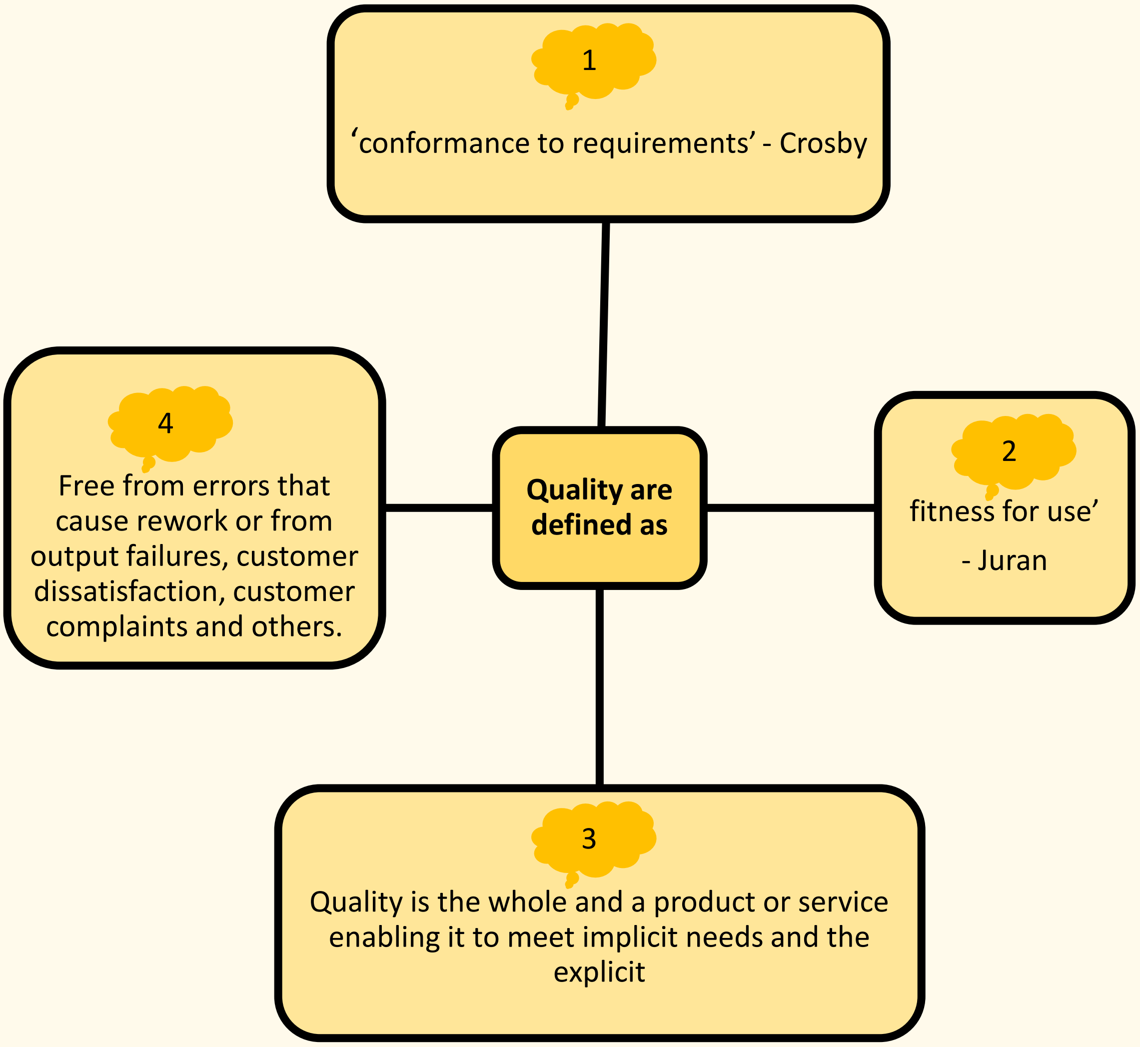
Topic 1

Basic Quality Concept

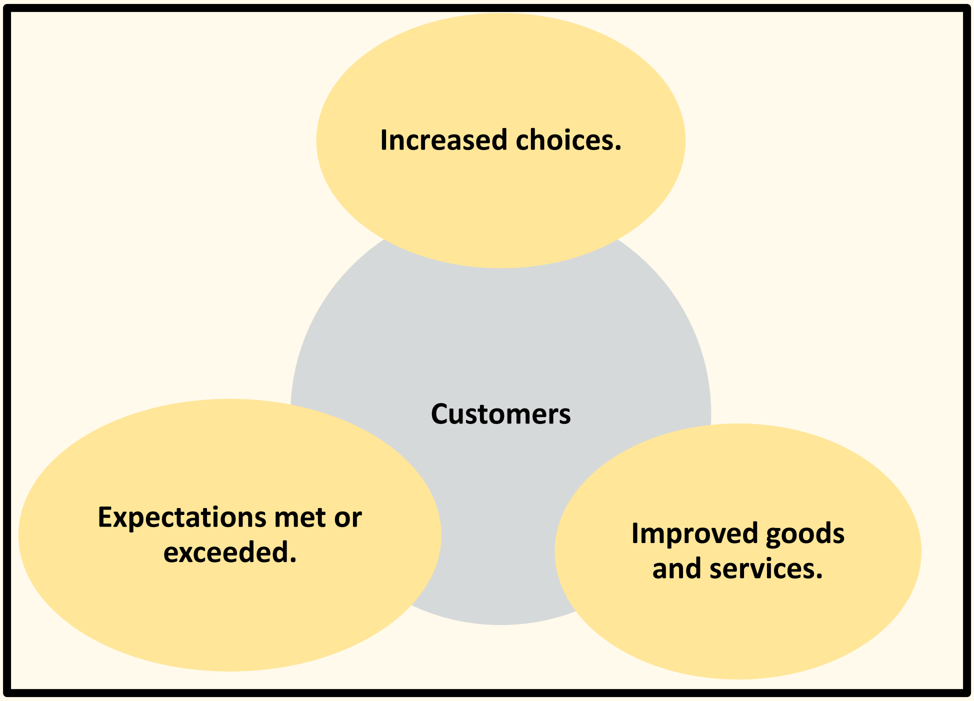
- 1.1 Quality Concept
- 1.2 Quality System Management
- 1.3 Basic Statistics In Quality Control
- Tutorial

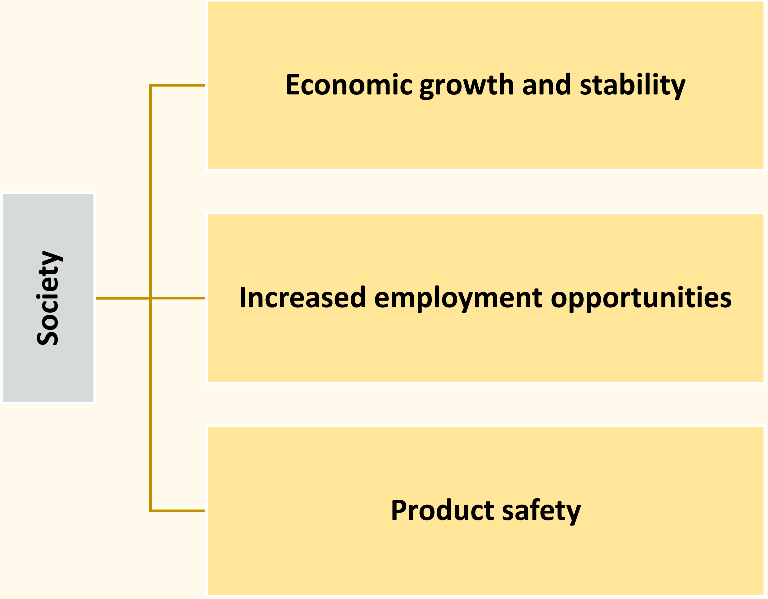
1.1 Quality Concept:

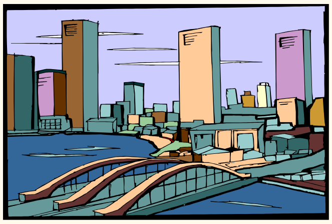
a) Definition

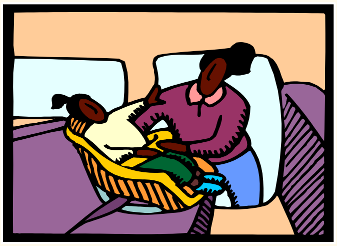


- ❑ **A Quality Approach Will Benefits**









c) Zero Defect

Zero Defects is an activity to minimize and reduce an errors or defect in a project or process. Phil Crosby states things to do right in the first time.

d) The important of external and internal customers

i. External Customers

- A person who pays and receives a product or service from an organisation.
- A business will lose it's profits when they provide a bad product or service.
- They can influence over the purchasing of product or service because they have choice.

ii. Internal Customers

- Can be within an organisation such as workers and departments.
- Many departments deal with customers within it's organisation.
- Internal customer satisfaction have similar important as external customer satisfaction. Both of them need a good quality of services.
- Internal customer do not have choices compare to the external customer.
- If a job is not acceptable to other departments, they cannot just split the employees and find others to complete the task.

e) Quality associated terms and concepts:

1

Quality Control

- Definition: Quality as adaption for use, i.e. in terms of product characteristics or services required by customers and guarantee of freedom from failure.
- This process ensures that the products and services produced meet the expectations of the customer.

2

Quality Assurance

- Definition: All appropriate activities or actions are taken to gain trust and guarantee the product or service customer satisfaction service.
- All systematic or planned actions that are carried out to provide reasonable assurance that an entity will meet quality requirements.

3

Total Quality Management

- Defined as handling the whole organisation quality system to excels on all extents of products and services.
- It requires organisation to emphasis on continual improvement or kaizen on a process or service improvement over a long term period.

4

Continuous Process Improvement

- Continuous improvement defined as an ongoing effort for a company to improve a product, service or process

Six sigma

- Six Sigma is a comprehensive approach to problem solving through the DMAIC method which ensures that all processes and products produced can satisfy customers.
- The purpose of this method is to improve performance and reduce errors.

1.2 Quality System Management:

a) The needs of quality system

To ensure the service provided by an organization can meet the requirements of customers, giving confidence to the company which can gain many customers, increase sales of goods and provide opportunities to increase various businesses.

b) Quality Management Principles

Principle 1- **Customer- Focused Organisation:** Every company will depend on their customers, therefore the management of the company must understand the needs of customers nowadays and in the future.

Principle 2- **Leadership:** A leader must be able to set common goals as well as run the company. They should also be able to create and maintain the company's interior so that employees become involved in the achievement of the company goals.

Principle 3- **Involvement of People:** All employees are very important as well as maximum involvement will provide many benefits for the company.

Principles 4- **Process Approach:** The results are achieved efficiently when the activities and resources are managed with the same process. This process is as a sequential integration of people, materials, methods, machines, methods, machines as well as equipment that is useful to produce value- added output for the customer.

Principles 5- **System Approach to Management:** The identification, understanding and management of the processes that are interrelated as a system, will contribute to all the effectiveness and efficiency of the company to achieve the goals of the company.

Principles 6- **Continual Improvement:** Continuous improvement in the company's performance in all areas should be a permanent destination for the company. In this case it is defined as a process that focuses on the effective improvement efforts as well as the efficiency of the company to meet goals.

Principle 7- **Factual Approach to Decision Making:** This effective decision is a decision based on the analysis of available data and information to eliminate the root causes of existing problems, so that all quality problems can be solved effectively and efficiently.

Principle 8- **Mutually Beneficial Supplier Relationships:** We know that companies with these suppliers are interdependent. When a relationship is mutually beneficial it will provide an increase in mutual ability in creating the added value that exists.

c. Basic concept and main terms in ISO 9000 series

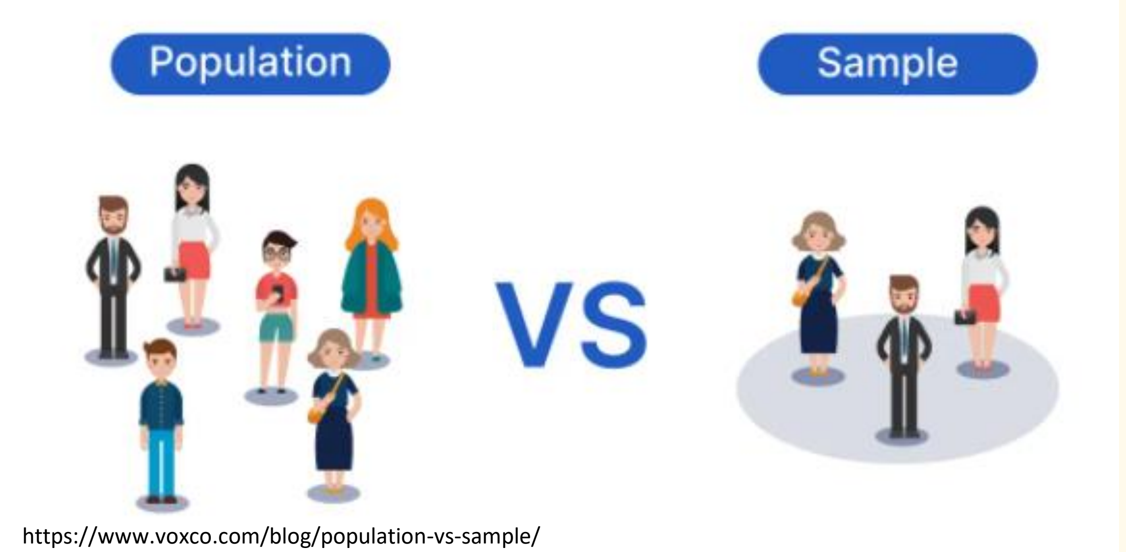
- **ISO 9000-** supporting documents that provide adopted terminology and definitions.
- **ISO 9001-** a quality management model that provides the minimum requirements for a quality system.
- **ISO 9004-** a supporting document that provides organisational guidelines for exceeding the minimum requirements through a process of continuous improvement.

1.3 Basic Statistic In Quality Control

Statistics:

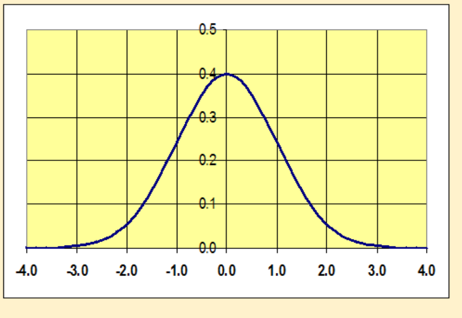
Is a disciplines related to the collection, organization, analysis, interpretation and presentation of data that are often used on scientific, industrial or social problems

- A **population** is a group of human beings who will be identified as well as having some specific and uniform characteristics.
  - for example, population consisting of Port Dickson Polytechnic students.
- A **sample** is the process of selecting elements in the population for the purpose of representing the population of a study.
  - for example, sample consisted of DTP Program students representing the entire population of the Department of Mechanical Engineering students.



https://www.voxco.com/blog/population-vs-sample/

Formula

	Ungroup Data	**Group Data**
Mean/ Average	$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$	$\bar{x} = \frac{\sum fixi}{\sum fi}$
Range	R= XH- XL	Range: last class upper boundary– first class lower boundary
Standard Deviation	$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$ @ S= $\sqrt{\frac{\sum x_i^2 - \frac{(\sum xi)^2}{n}}{n-1}}$	
Normal Distribution	Z = $\frac{x-\mu}{\sigma}$ 	

TUTORIAL

1. Define zero defect.

Answer:

Zero Defects is an activity to minimize and reduce an errors or defect in a project or process.

2. Define the Six Sigma and its concepts in manufacturing.

Answer:

Six Sigma is a data-driven procedure that delivers tools and methods to describe and assess each step of a process. It provides methods to develop efficiencies in a business structure, increase the quality of the procedure and increase the bottom-line profit.

- Eliminates defects during the manufacturing process
- Minimize manufacturing time product
- Reduce and save costs.

3. List THREE (3) benefits of quality implementation to the customers.

Answer:

- Increased choices.
- Improved goods and services.
- Expectations met or exceeded.

4. Explain TWO (2) differences between quality control (QC) and quality assurance (QA).

Answer

QC	QA
Product	Process
Line function	Staff function
Find defects	Prevent defects
Reactive	Proactive

5. Explain the following
   i. Quality Control (QC)
   ii. Quality Assurance
   iii. Continuous improvement
   iv. Total Quality Improvement.
   v. 100% inspection

Answer:

i. Quality as adaption for use, i.e. in terms of product characteristics or services required by customers and guarantee of freedom from failure.

ii. All appropriate activities or actions are taken to gain trust and guarantee the product or service customer satisfaction service.

iii. Continuous improvement defined as an ongoing effort for a company to improve a product, service or process

iv. Total quality improvement as handling the whole organisation quality system to excels on all extents of products and services.

v. 100 Percent Inspection is carried out as a whole or all units in the lot will be inspected.

7. List 3 advantages and 3 disadvantages ISO 9000.

Answer:

Advantages :

- Products and services are safe, reliable and good quality
- For business, they are strategic tools that reduce costs by minimising waste and errors and increasing productivity
- Help companies to access new markets, level the playing field for developing countries and facilitate free and fair global trade

Disadvantages

- The high cost of implementation
- The time required to write the manual
- The high volume of paperwork

8. A wireman testing the voltage of input line for a domestic firm and finds five readings: 114, 112, 120, 114, 115. Calculate the mean value.

Answer:

Step 1

$$x = \frac{1}{n} \Sigma xi$$

Step 2

$$x = \frac{114+112+120+114+115}{5}$$

$$= \frac{575}{5} = \underline{\underline{115}}$$

9. Following are 30 readings obtained in a hospital by a motion- and- time – a study by analyst who took five readings each day for 6 days.

Day	Duration of Operation Time (Min)				
1	165	164	171	162	170
2	159	174	173	158	182
3	186	174	181	168	176
4	177	185	181	180	175
5	175	169	161	163	156
6	168	165	175	167	180

Based on the data, identify a frequency distribution table consisting of the class data, class boundary, class midpoint and frequency. Construct histogram

Answer:

Step 1

Calculate the number of cell;

$k = 1 + 3.3 \log n$,

n = number of observed value

$= 1 + 3.3 \log 30$

$= 5.87 \approx 6$

Step 2

Range = 186 – 156=30

Step 3

Calculate the cell interval;

$= \text{Range}/k \quad = \frac{30}{6} = 5$

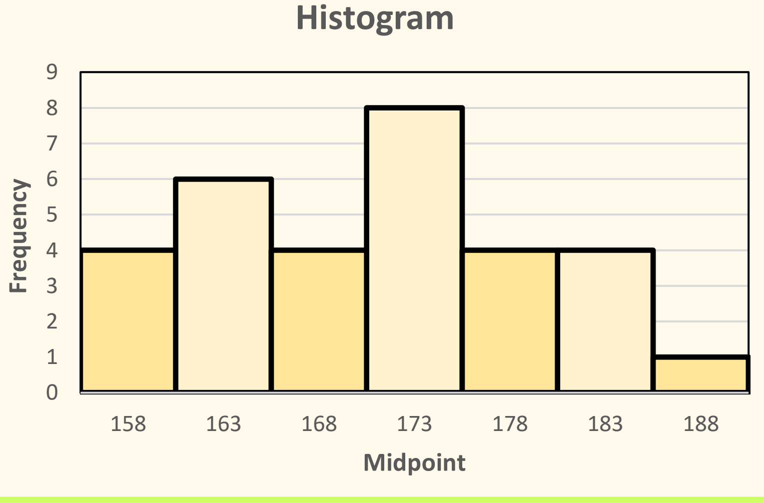
Step 4

Class	Tally Sheet
156 - 160	///
161 -165	//// /
166 -170	////
171 - 175	//// ///
176 -180	////
181 - 185	////
186 - 190	/

Step 5
Post the cell frequency

Class	Frequency
156 - 160	4
161 -165	6
166 -170	4
171 - 175	8
176 -180	4
181 - 185	4
186 - 190	1

Step 5 : Construct histogram



10. The height of 65 ladders in metres is dispersed as below:

Cell Midpoint, x	Frequency
3.5	6
3.8	9
4.1	18
4.4	14
4.7	13
5.0	5

Determine the range and sample standard deviation.

Answer:

Step 1

Cell Midpoint, x	**Frequency**	$fixi$	x^2	$\boldsymbol{fixi^2}$
3.5	6	21	12.25	73.5
3.8	9	34.2	14.44	129.96
4.1	18	73.8	16.81	302.58
4.4	14	61.6	19.36	271.04
4.7	13	61.1	22.09	287.17
5.0	5	25	25	125
	65	276.7		1189.25

Step 2

Calculate range

Range= 5.0 -3.5 = 1.5

Step 3

Calculate standard deviation

$$= \sqrt{\frac{\sum f_i x_i^2 - \frac{(\sum f_i x_i)^2}{\sum f_i}}{(\sum f_i)-1}} \qquad = \sqrt{\frac{\sum 1189.25 - \frac{276.7^2}{65}}{\sum 65-1}}$$

$= \sqrt{0.178}$

= 0.42

11. The population mean of a company's racing bicycles is 9.07 kg with a population standard deviation of 0.40 kg. If the distribution is approximately normal, determine the percentage of bicycles greater than 8.30 kg.

Answer:

Step 1

μ =9.07

σ = 0.40

X= 10.00

Step 2

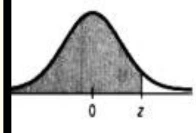
$Z > \frac{X-\mu}{\sigma}$

Step 3

$Z < \frac{10.00-9.07}{0.4} = 2.33$

Step 4

Table Z (cont.)
Areas under the standard Normal curve



	Second decimal place in z									
z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.[illegible]517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.[illegible]910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.[illegible]293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.[illegible]664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.[illegible]019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.[illegible]357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.[illegible]673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.[illegible]967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.[illegible]238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.[illegible]485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.[illegible]708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.[illegible]907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.[illegible]082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.[illegible]236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.[illegible]370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.[illegible]484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.[illegible]582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.[illegible]664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.[illegible]732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.[illegible]788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.[illegible]834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.986[illegible]	[illegible]	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	[illegible]	[illegible]	[illegible]	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952

Step 5

= 1- 0.9901 = 0.00099 X100= 0.99%

12. Using Table Z, determine the probability for Z value below, greater than Z = 1.0

Answer:

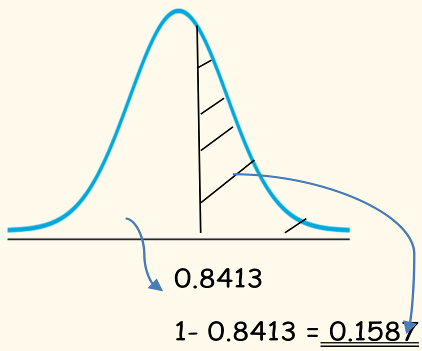
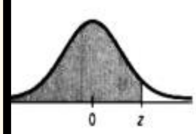


Table Z (cont.)
Areas under the standard Normal curve



	Second decimal place in z									
z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
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1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
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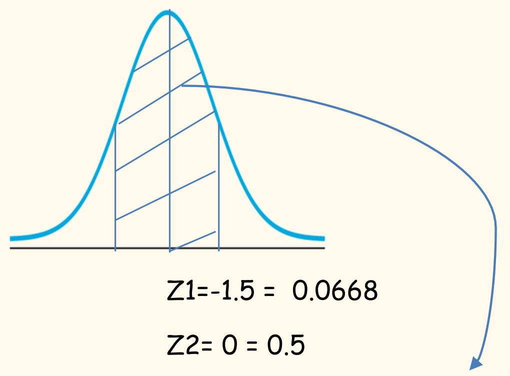
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952

Table A

13. Using Table A, determine the probability for Z value below, between Z = -1.5 and Z = 0

Answer:



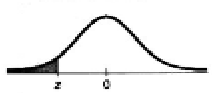
Z1=-1.5 = 0.0668

Z2= 0 = 0.5

Z3= 0.5 - 0.0668 = <u>0.4332</u>

A. Normal Distribution Table

Table Z
Areas under the standard Normal curve



$z = \frac{X_i - \mu}{\sigma}$

Second decimal place in z										
0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01	0.00	z
									0.0000†	−3.9
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	−3.8
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	−3.7
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	−3.6
0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	−3.5
0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	−3.4
0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	−3.3
0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	−3.2
0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0010	−3.1
0.0010	0.0010	0.0011	0.0011	0.0011	0.0012	0.0012	0.0013	0.0013	0.0013	−3.0
0.0014	0.0014	0.0015	0.0015	0.0016	0.0016	0.0017	0.0018	0.0018	0.0019	−2.9
0.0019	0.0020	0.0021	0.0021	0.0022	0.0023	0.0023	0.0024	0.0025	0.0026	−2.8
0.0026	0.0027	0.0028	0.0029	0.0030	0.0031	0.0032	0.0033	0.0034	0.0035	−2.7
0.0036	0.0037	0.0038	0.0039	0.0040	0.0041	0.0043	0.0044	0.0045	0.0047	−2.6
0.0048	0.0049	0.0051	0.0052	0.0054	0.0055	0.0057	0.0059	0.0060	0.0062	−2.5
0.0064	0.0066	0.0068	0.0069	0.0071	0.0073	0.0075	0.0078	0.0080	0.0082	−2.4
0.0084	0.0087	0.0089	0.0091	0.0094	0.0096	0.0099	0.0102	0.0104	0.0107	−2.3
0.0110	0.0113	0.0116	0.0119	0.0122	0.0125	0.0129	0.0132	0.0136	0.0139	−2.2
0.0143	0.0146	0.0150	0.0154	0.0158	0.0162	0.0166	0.0170	0.0174	0.0179	−2.1
0.0183	0.0188	0.0192	0.0197	0.0202	0.0207	0.0212	0.0217	0.0222	0.0228	−2.0
0.0233	0.0239	0.0244	0.0250	0.0256	0.0262	0.0268	0.0274	0.0281	0.0287	−1.9
0.0294	0.0301	0.0307	0.0314	0.0322	0.0329	0.0336	0.0344	0.0351	0.0359	−1.8
0.0367	0.0375	0.0384	0.0392	0.0401	0.0409	0.0418	0.0427	0.0436	0.0446	−1.7
0.0455	0.0465	0.0475	0.0485	0.0495	0.0505	0.0516	0.0526	0.0537	[illegible]	−1.6
0.0559	0.0571	0.0582	0.0594	0.0606	0.0618	0.0630	0.0643	0.0655	[illegible]	−1.5
0.0681	0.0694	0.0708	0.0721	0.0735	0.0749	0.0764	0.0778	0.0793	0.0808	−1.4
0.0823	0.0838	0.0853	0.0869	0.0885	0.0901	0.0918	0.0934	0.0951	0.0968	−1.3
0.0985	0.1003	0.1020	0.1038	0.1056	0.1075	0.1093	0.1112	0.1131	0.1151	−1.2
0.1170	0.1190	0.1210	0.1230	0.1251	0.1271	0.1292	0.1314	0.1335	0.1357	−1.1
0.1379	0.1401	0.1423	0.1446	0.1469	0.1492	0.1515	0.1539	0.1562	0.1587	−1.0
0.1611	0.1635	0.1660	0.1685	0.1711	0.1736	0.1762	0.1788	0.1814	0.1841	−0.9
0.1867	0.1894	0.1922	0.1949	0.1977	0.2005	0.2033	0.2061	0.2090	0.2119	−0.8
0.2148	0.2177	0.2206	0.2236	0.2266	0.2296	0.2327	0.2358	0.2389	0.2420	−0.7
0.2451	0.2483	0.2514	0.2546	0.2578	0.2611	0.2643	0.2676	0.2709	0.2743	−0.6
0.2776	0.2810	0.2843	0.2877	0.2912	0.2946	0.2981	0.3015	0.3050	0.3085	−0.5
0.3121	0.3156	0.3192	0.3228	0.3264	0.3300	0.3336	0.3372	0.3409	0.3446	−0.4
0.3483	0.3520	0.3557	0.3594	0.3632	0.3669	0.3707	0.3745	0.3783	0.3821	−0.3
0.3859	0.3897	0.3936	0.3974	0.4013	0.4052	0.4090	0.4129	0.4168	0.4207	−0.2
0.4247	0.4286	0.4325	0.4364	0.4404	0.4443	0.4483	0.4522	0.4562	[illegible]	−0.1
0.4641	0.4681	0.4721	0.4761	0.4801	0.4840	0.4880	0.4920	0.4960	[illegible]	−0.0

†For z ≤ −3.90, the areas are 0.0000 to four decimal places.

Z1

Z2

Topic 2

Control Chart For Variable

- 2.1 Source of Variation
- 2.2 Causes of Variation- Chance and Assignable
- Tutorial

2.1 Source of Variation

1. Equipment: Tool wear, electrical, fluctuations for welding
2. Material: Tensile strength, moisture content
3. Environment: Temperature, light, humidity
4. Operator: Method, SOP followed, motivation
5. Inspection: Inspector, inspection equipment

/http://nimsready.org/the-significance-of-machine-tool-analyses-to-precision-manufacturing

2.2 Causes of Variation- Chance & Assignable

Chance Variation

- Are unavoidable
- As long as fluctuate in natural/ expected/ stable pattern of chance causes of variation which are small-it is considered okay.
- This process is called statistical control

Example: Machine wear

Assignable Variation

- When causes of variation is large in magnitude; it can be identified
- State out of control
- Example: Body temperature- 36.5°C ~ 37.5°C. Example: Machine wear

Example: Defective material

Formula

Type of Control Chart and Control Limits			
	CL	UCL	LCL
$\bar{x}$ chart	$\bar{\bar{X}} = CL_x = \frac{\sum \bar{x}}{N}$	$\bar{\bar{x}} + A_2\bar{R}$	$\bar{\bar{x}} - A_2\bar{R}$
R chart	$\bar{R} = CL_R = \frac{\sum R}{N}$	$D_4\bar{R}$	$D_3\bar{R}$
$\bar{x}$ chart	$\bar{\bar{X}} = CL_x = \frac{\sum \bar{x}}{N}$	$\bar{\bar{x}} + A_3\bar{s}$	$\bar{\bar{x}} - A_3\bar{s}$
s chart	$\bar{s} = CL_s = \frac{\sum s}{N}$	$B_4\bar{s}$	$B_3\bar{s}$
Capability Index			
X and R charts		$\sigma_0 = \frac{\bar{R}}{d_2}$	
X and s charts		$\sigma_0 = \frac{\bar{s}}{c_4}$	

Type of Control Chart and Control Limits	
c_p	$\frac{USL - LSL}{6\sigma_o}$ • Cp$\leq 1 - process\ is\ capable$ • Cp$\geq 1 -\ process\ is\ capable$
Cp_k	$minimun \left\{ \frac{\mu - LSL}{3\sigma_O} - \frac{USL - \mu}{3\sigma_O} \right\}$ • $Cp_k \leq 1$ – process is not capable • $Cp_k \geq 1$ – process is capable

TUTORIAL

1. A quality supervisor at Teguh Micro Chip Sdn Bhd has collected 5 samples with 10 observations. Table 2.1 shown the sample data with D_3=0, D_4=2.11 and A_2=0.58, (Round off all the value up to 2 decimal points)

Table 2.1

Sample of Micro Chip in milligram										
N	**Observations**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	13.4	13.7	13.2	13.2	13.4	13.5	13.6	13.4	13.6	13.1
2	13.2	13.3	13.6	13.6	13.5	13.4	13.7	13.3	13.5	13.4
3	13.6	13.4	13.5	13.5	13.5	13.6	13.5	13.6	13.3	13.5
4	13.7	13.8	13.4	13.3	13.5	13.6	13.8	13.5	13.6	13.8
5	13.4	13.6	13.3	13.5	13.6	13.5	13.4	13.6	13.3	13.6

i. Complete the table above

Step1

Sample of Micro Chip in milligram		
N	**X bar**	**R**
1	13.41	0.6
2	13.45	0.5
3	13.5	0.6
4	13.6	0.5
5	13.48	0.3
	67.44	2.5

X bar

$$N_3 = \frac{13.6+13.4+13.5+13.5+13.5+13.6+13.5+13.6+13.3+13.5}{10}$$

= 13.5

$$N_4 = \frac{13.7+13.8+13.4+13.3+13.5+13.6+13.8+13.5+13.6+13.8}{10}$$

= 13.6

$$N_5 = \frac{13.4+13.6+13.3+13.5+13.6+13.5+13.4+13.6+13.3+13.6}{10}$$

= 13.48

Range

N_3 = 13.7 -13.1 = 0.6

N_4 = 13.8 – 13.3 = 0.5

N_5 = 13.6 – 13.3 = 0.3

ii. Determine the trial control limits using data in above.

Step 1

$\Sigma\bar{x}$ = 67.44

ΣR = 2.5

Step 2

$$\bar{\bar{X}} = CL_x = \frac{\sum \bar{x}}{N}$$

$$= \frac{67.44}{5} = 13.49$$

$$\bar{R} = CL_R = \frac{\sum R}{N}$$

$$= \frac{2.5}{5} = 0.5$$

Step 3

$\bar{\bar{X}} + A_2\bar{R}$

$= 13.49 + (0.308)0.5 = 13.64$

$\bar{\bar{X}} - A_2\bar{R}$

$= 13.49 - (0.308)0.5 = 13.34$

Step 4

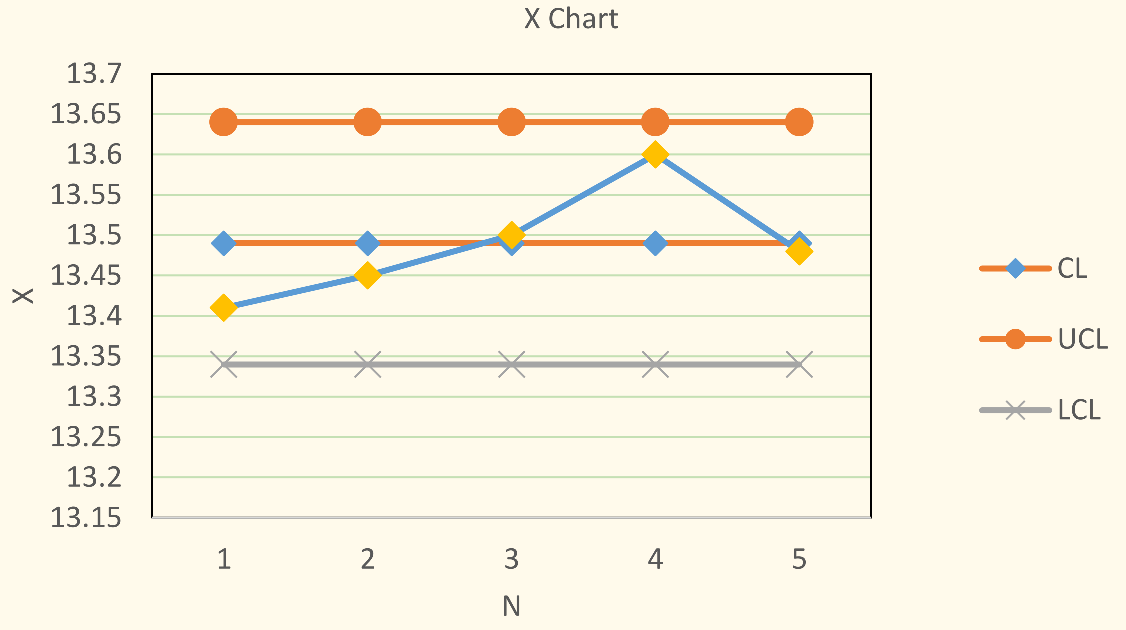
$D_4\bar{R}$

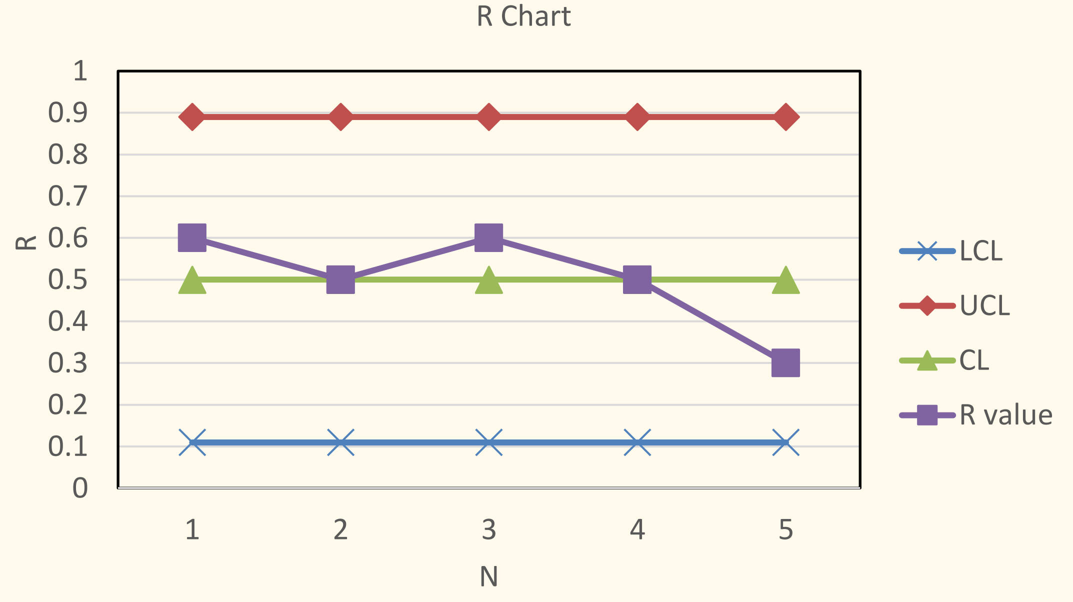
= 1.777(0.5) =0.89

$D_3\bar{R}$

=0.223 (0.5) = 0.11

Step 6: Plot graph





2. Table 2.2 is the X and R chart check sheet with the data on milk content in milliliters. The average and range for each subgroup has been determined. Assume that the process is in control,

Table 2.2

VARIABLES CONTROL CHART: DEP/ AREA: CHART ID:

Part ID:	Operation ID:	Characteristic: Milk Content
Check Method:	Nominal Value:	Tolerance: ± 0.20

		1	2	3	4	5	6	7	8	9	10
SAMPLE READINGS	1	.85	.75	.80	.65	.75	.60	.80	.70	.75	.60
	2	.65	.85	.80	.75	.70	.75	.75	.60	.85	.70
	3	.65	.75	.75	.60	.65	.75	.65	.75	.85	.60
	4	.70	.85	.70	.70	.80	.70	.75	.75	.80	.80
SUM, ∑X		2.85	3.20	3.05	2.70	2.90	2.80	2.95	2.80	3.25	2.70
AVERAGE,		.71	.80	.77	.68	.73	.70	.74	.70	.82	.68
RANGE, R		.20	.10	.10	.15	.15	.15	.15	.15	.10	.20

i. Calculate the control limits and center line in 3 decimal points.

Answer:

Step 1

$\Sigma\bar{x}$ = 7.33

ΣR = 1.45

Step 2

$$\bar{\bar{X}} = CL_x = \frac{\sum \bar{x}}{N}$$

$$= \frac{7.33}{10} = 0.733$$

$$\bar{R} = CL_R = \frac{\sum R}{N}$$

$$= \frac{1.45}{10} = 0.145$$

$$\bar{\bar{X}} + A_2\bar{R}$$

$$= 0.733 + (0.729)0.145 = 0.839$$

$$\bar{\bar{X}} - A_2\bar{R}$$

$$= 0.733 - (0.729)0.145 = 0.627$$

Step 3

$$D_4\bar{R}$$

= 2.282(0.145) =0.331

$$D_3\bar{R}$$

=0 (0.145) = 0

ii. If specification of the milk content is 0.75±0.20 ml, using the answers obtained above, compare the process capability index, C_p and C_{pk}.

Answer:

Step 1

USL= 0.75+0.20= 0.95

LSL= 0.75-0.20= 0.55

μ= 0.733

$$\sigma = \frac{R}{d_2} = \frac{0.145}{2.059} = 0.07$$

Step 2

$$Cp = \frac{USL - LSL}{6\sigma_0}$$

$$= \frac{0.95 - 0.55}{6(0.07)} = 0.952$$

Step 3

$$CP_k = \text{minimun}\left\{\frac{\mu - LSL}{3\sigma_O} - \frac{USL - \mu}{3\sigma_O}\right\}$$

$$= \text{minimum}\left\{\frac{0.733 - 0.55}{3(0.07)}, \frac{0.95 - 0.733}{3(0.07)}\right\}$$

=minimum (0.871, 1.033)

= 0.871

Cp and CPk is no capable because ≤ 1

3. The data below shows the study by the resistance in units of ohms of electrical components and simplify the control charts X and σ. Number of subgroup was 25 with a size of 6. Σ X = 2035 and Σσ = 18. Determine control limits and center line.

Answer:

Step 1

$$\bar{\bar{X}} = CL_x = \frac{\sum \bar{x}}{N}$$

$$= \frac{2035}{25} = 81.4 \text{ ohms}$$

Step 2

$$\bar{s} = CL_s = \frac{\sum s}{N}$$

$$= \frac{18}{25} = 0.72 \text{ ohms}$$

Step 3

$$\bar{\bar{X}} + A_3\bar{s}$$

$$= 81.4 + 1.287(0.72) = 82.33 \text{ ohms}$$

$$\bar{\bar{X}} - A_3\bar{s}$$

$$= 81.4 - 1.287(0.72) = 80.47 \text{ohms}$$

Step 4

$$B_4\bar{s}$$

$$= 1.970(0.72) = 1.42 \text{ ohms}$$

$$B_3\bar{s}$$

$$= 0.03(0.72) = 0.02 \text{ ohms}$$

4. Table 2.3 below shows data obtained from Bluegrass Horse Farm regarding on a measure of feed quality. Data were collected in subgroups sizes of 5 as shown. Draw $\overline{X}$ and s charts for these data.

Table 2.3

Subgroup Number	$\overline{X}$	***s***	**Subgroup Number**	$\overline{X}$	***s***
1	1.661	0.018	11	1.655	0.018
2	1.661	0.021	12	1.654	0.019
3	1.628	0.024	13	1.641	0.018
4	1.648	0.024	14	1.663	0.018
5	1.643	0.023	15	1.639	0.029
6	1.640	0.013	16	1.658	0.016
7	1.664	0.030	17	1.654	0.018
8	1.653	0.010	18	1.645	0.012
9	1.645	0.026	19	1.651	0.016
10	1.654	0.023	20	1.655	0.029

Answer:

Step 1

$\sum \overline{\boldsymbol{X}}$ = 33.012

$\sum \boldsymbol{R}$ = 0.405

$\overline{\overline{X}}$ = CL_x = $\frac{\sum \bar{x}}{N}$

= $\frac{33.012}{20}$ = 1.651

Step 2

$\bar{s}$=CL$_s$=$\frac{\sum s}{N}$

=$\frac{0.405}{20}$ =0.020

Step 3

$\bar{\bar{X}} + A_3\bar{s}$

$= 1.651 + 1.427(0.020)$

$= 1.68$

$\bar{\bar{X}} - A_3\bar{s}$

$= 1.651 - 1.427(0.020)$

$= 1.622$

Step 4

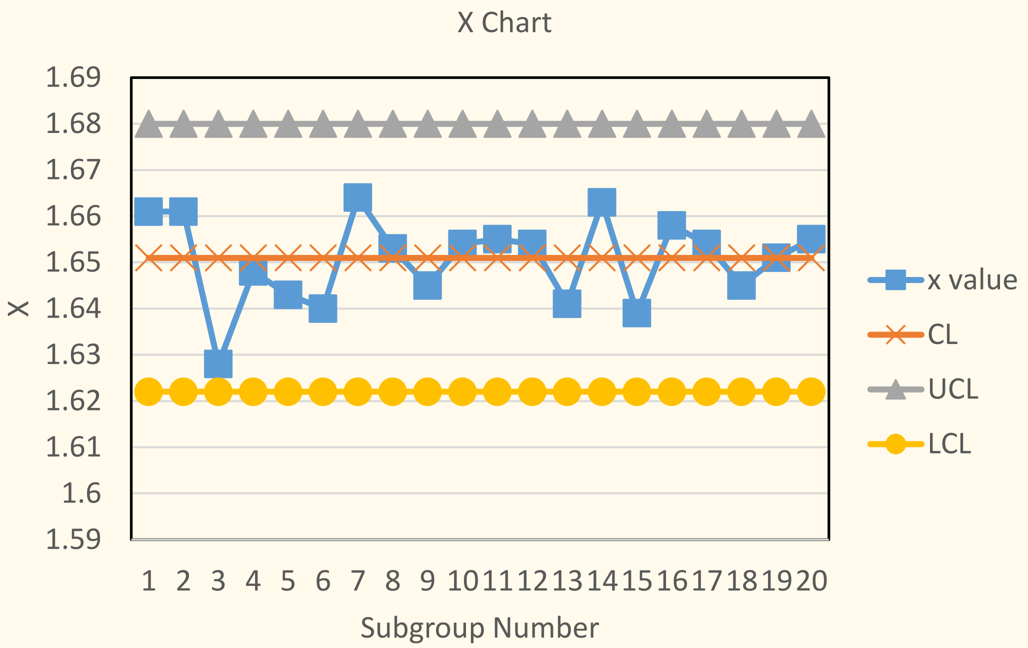
$B_4\bar{s}$

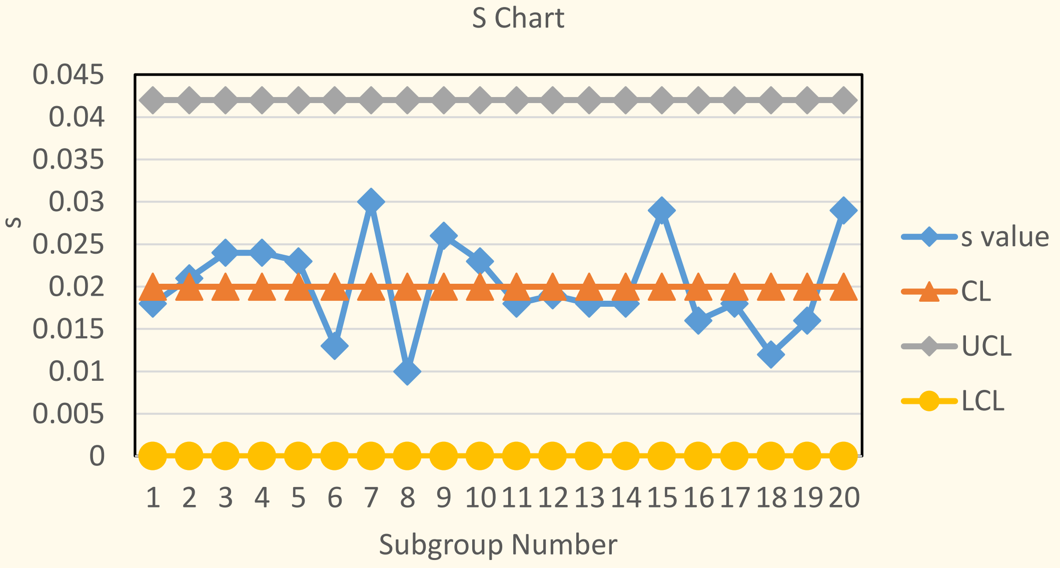
= 2.089(0.020)= 0.042

$B_3\bar{s}$

=0(0.020) =0

Step 5


X Chart
1.69
1.68
1.67
1.66
1.65
1.64
1.63
1.62
1.61
1.6
1.59
X
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Subgroup Number
x value
CL
UCL
LCL


S Chart
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
s
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Subgroup Number
s value
CL
UCL
LCL

5. The data below shows the resistance in units ohms of an electrical components and simplify the control charts X and . The number of subgroup is 25 with a size of 4. Σ X = 13798 and Σσ = 670. Determine control limits and center line.

Answer:

Step 1

$$\overline{\overline{X}} = \frac{\sum \overline{X}}{N}$$

= 13798/25 = 551.92 ohm.

$$\overline{\sigma} = \frac{\sigma}{N}$$

= 670/25 = 26.8 ohm

Step 2

$$UCL_{\overline{X}} = \overline{\overline{X}} + A_3\overline{\sigma}$$

= 551.92 + 1.628(26.8) =595.55 ohm

$$LCL_{\overline{X}} = \overline{\overline{X}} - A_3\overline{\sigma}$$

= 551.92 - 1.628(26.8) =508.29 ohm

Step 3

$$UCL_{\sigma} = B_4\overline{\sigma}$$

= 2.266(26.8) = 60.57 ohm

$$LCL_{\sigma} = B_3\overline{\sigma}$$

= 0 (26.8) = 0 ohm

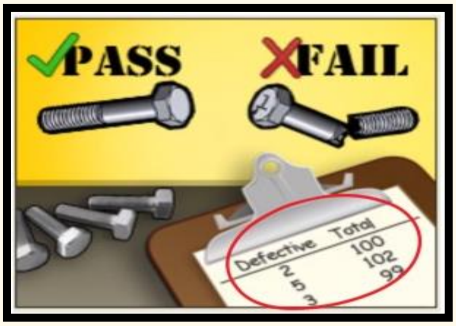
Topic 3

Control Chart for Attribute

- **3.1 Definition of Control Chart for Atributes**
- **3.2 Types of Control Charts**
- **3.3 Differences Between Control Chart for Variables and Control Chart for Attribute**
- **3.4 Advantages of using Control Chart for Attributes**
- **3.5 Defects and Defectives**
- **3.6 Types of Control Chart for Attributes**
- **Tutorial**

3.1 Definition:

- Many quality characteristics cannot be conveniently represented numerically.
- In such cases, each item inspected is classified as either **conforming** or **nonconforming** to the specifications on that quality characteristic.
- Quality characteristics of this type are called **attributes**.
- Examples: nonfunctional semiconductor chips, warped connecting rods, etc,.



3.2 Types of Control Chart

a) Control Chart for Variables

X and R charts: for sample averages and ranges.

X and s charts: for sample means and standard deviations.

Md and R charts: for sample medians and ranges.

X charts: for individual measures; uses moving ranges.

b) Control Chart for Attributes

***p* charts: proportion of units nonconforming.**

***np* charts: number of units nonconforming.**

***c* charts: count of nonconformities.**

***u* charts: count of nonconformities per unit.**

3.3 Differences between Control Chart for Variables and Control Chart For Attributes

Variables control charts

- Variable data are measured on a continuous scale.

  Example: time, weight, distance or temperature can be measured in fractions or decimals.
- Applied to data with continuous distribution

Attributes control charts

- Attribute data are counted and cannot have fractions or decimals. Attribute data arise when you are determining only the presence or absence of something, such as:
  - success or failure
  - accept or reject
  - correct or not correct.

    Example, a report can have four errors or five errors, but it cannot have four and a half errors.
- Applied to data following discrete distribution

3.4 Advantages of using Control Chart For Attributes

- Allowing quick summaries, that is, the engineer may simply classify products as *acceptable* or *unacceptable*, based on various quality criteria.
- Easily understood by managers who are unfamiliar with quality control procedures.

3.5 Defects and Defectives

Defects	Defective
a single nonconforming quality characteristic.	items having one or more defects.
Example: Consider a mechanical part gear	

3.6 Types of Control Chart for Attributes

p-chart- This chart shows the fraction of nonconforming or defective product produced by a manufacturing process.
It is also called the control chart for fraction nonconforming.

np chart- This chart shows the number of nonconforming. Almost the same as the *p* chart.

C chart- This shows the number of defects or nonconformities produced by a manufacturing process.

U chart- This chart shows the nonconformities per unit produced by a manufacturing process.

Formula

Type of Control Chart and Control Limits				
	p	***CL***	***UCL***	***LCL***
p chart	$\frac{np}{n}$	$\bar{p} = \frac{\sum np}{\sum n}$	$\bar{p} + 3\left(\sqrt{\frac{\bar{p}(1-\overline{p})}{n}}\right)$	$\bar{p} - 3\left(\sqrt{\frac{\bar{p}(1-\overline{p})}{n}}\right)$
	p_0	***CL***	***UCL***	***LCL***
np chart	$p_0 = \frac{\sum np}{\sum n}$	$\overline{np} = \frac{\sum np}{N}$	$\overline{np} + 3\left(\sqrt{\overline{np}\,(1-p_0)}\right)$	$\overline{np} - 3\left(\sqrt{\overline{np}\,(1-p_0)}\right)$
		CL	***UCL***	***LCL***
c chart		$c = \frac{\sum c}{N}$	$c + 3(\sqrt{c})$	$c + 3(\sqrt{c})$
	u	***CL***	***UCL***	***LCL***
u chart	$\frac{c}{n}$	$\bar{u} = \frac{\sum c}{\sum n}$	$\bar{u} + 3\left(\sqrt{\frac{\bar{u}}{n}}\right)$	$\bar{u} - 3\left(\sqrt{\frac{\bar{u}}{n}}\right)$

TUTORIAL

1. Data were collected in subgroup number of 8 as in following Table 3.1:

Table 3.1

Subgroup	Number Inspected	Number Nonconforming	p	UCL	LCL
Oct 30	2385	55	0.023		
Oct 31	1451	18	0.012		
Nov 01	1935	50	0.026	0.030	0.011
Nov 02	2450	42	0.017	0.028	0.012
Nov 03	2168	52	0.024	0.029	0.011
Nov 04	1941	47	0.024	0.030	0.011
Nov 05	1962	34	0.017	0.030	0.011
Nov 06	2244	29	0.013	0.029	0.011
TOTAL	**16536**	**327**			

i. Determine the center line and control limits for subgroup 30 Oct and 31 Oct. Show all related steps of calculation clearly.

ii. Build the p chart

Answer :

i. Center line and control limits for subgroup 30 Oct and 31 Oct.

Step 1

p = (np)/n

$$\bar{p} = C.L = \frac{\sum np}{\sum n} = 327/\ 16537 = 0.02$$

Step 2

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

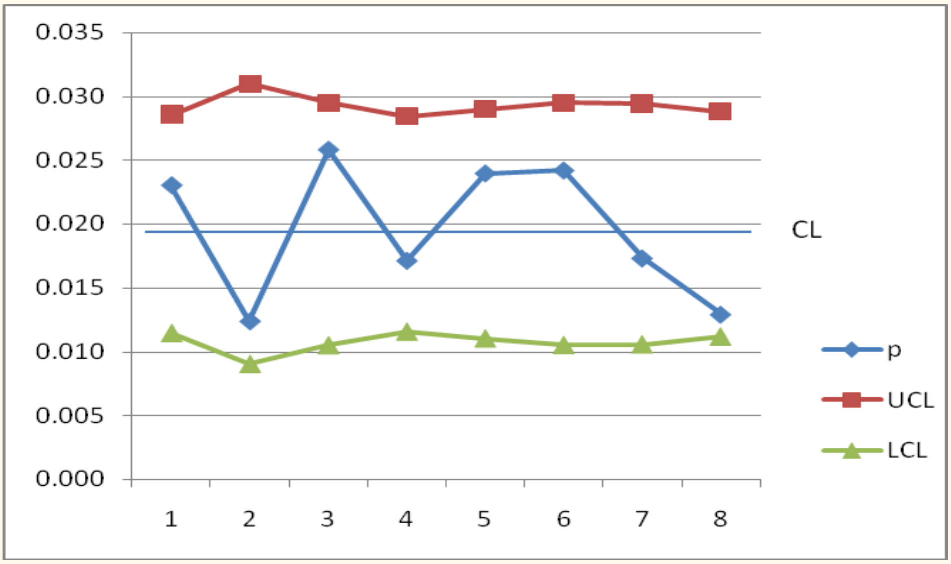
$$= 0.02 + 3\left(\sqrt{\frac{0.02(1-0.02)}{2385}}\right) = 0.029$$

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

$$= 0.02 - 3\left(\sqrt{\frac{0.02(1-0.02)}{2385}}\right) = 0.011$$

Subgroup	Number Inspected	Number Nonconforming	p	UCL	LCL
Oct 30	2385	55	0.023	0.029	0.011
Oct 31	1451	18	0.012	0.031	0.009
Nov 01	1935	50	0.026	0.030	0.011
Nov 02	2450	42	0.017	0.028	0.012
Nov 03	2168	52	0.024	0.029	0.011
Nov 04	1941	47	0.024	0.030	0.011
Nov 05	1962	34	0.017	0.030	0.011
Nov 06	2244	29	0.013	0.029	0.011
TOTAL	**16536**	**327**			

ii. Construct p chart



2. Determine:

   a) Trial central line and control limits

   b) Plot the chart

No. Sample	Number Inspected	Number Nonconforming (np)
1	10	3
2	10	4
3	10	2
4	10	5
5	10	3
6	10	3
7	10	2
8	10	2
9	10	4
10	10	3
		Σ= 31

Answer:

Step 1

$$p_o = \frac{\sum \text{np}}{\sum \text{n}}$$

$$p_o = \frac{31}{200}$$

$$p_o = 0.16$$

Step 2

$$CL = \overline{np} = \frac{\sum np}{N}$$

$$\overline{np} = \frac{31}{10}$$

$$\overline{np} = 3.1$$

Step 3

$$UCL = \overline{np} + 3\left(\sqrt{\overline{np}\,(1 - p_0}\right)$$

$$UCL = 3.1 + 3\left(\sqrt{3.1(1 - 0.16}\right)$$

$$UCL = 3.1 + 3\ (1.61)$$

$$UCL = 7.94\ \#$$

Step 4

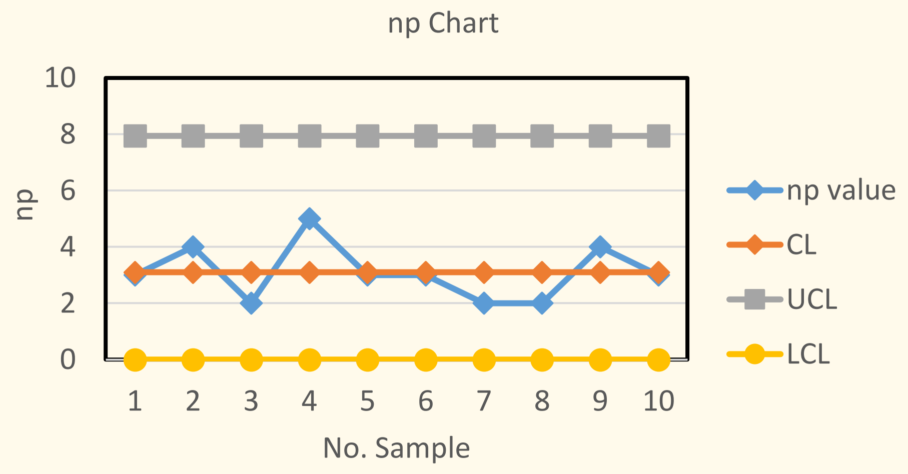
$$UCL = \overline{np} - 3\left(\sqrt{\overline{np}\,(1 - p_0}\right)$$

$$UCL = 3.1 - 3\left(\sqrt{3.1(1 - 0.16}\right)$$

$$UCL = 3.1 - 3\ (1.61)$$

$$UCL = -1.73 \approx \underline{0}\ \#$$

Step 5: Construct graph



3. Determine:

a) Trial central line and control limits

b) Plot the chart

No. Sample	Number Inspected	Number Nonconforming (np)	Fraction Nonconforming (P)
1	20	3	0.15
2	20	4	0.20
3	20	2	0.10
4	20	5	0.25
5	20	3	0.15
6	20	3	0.15
7	20	2	0.10
8	20	2	0.10
9	20	4	0.20
10	20	3	0.15

Answer:

Step 1

$$p = \frac{np}{n}$$

$\Sigma np = 31$
$\Sigma n = 200$

$$\bar{p} = \frac{\Sigma np}{\Sigma n}$$

$$\bar{p} = \frac{31}{200}$$

$$\bar{p} = 0.16$$

Step 2

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

$$= 0.16 + 3\sqrt{\frac{0.16(1-0.16)}{20}}$$

$$= 0.16 + 3\ (0.08)$$

$$= 0.41$$

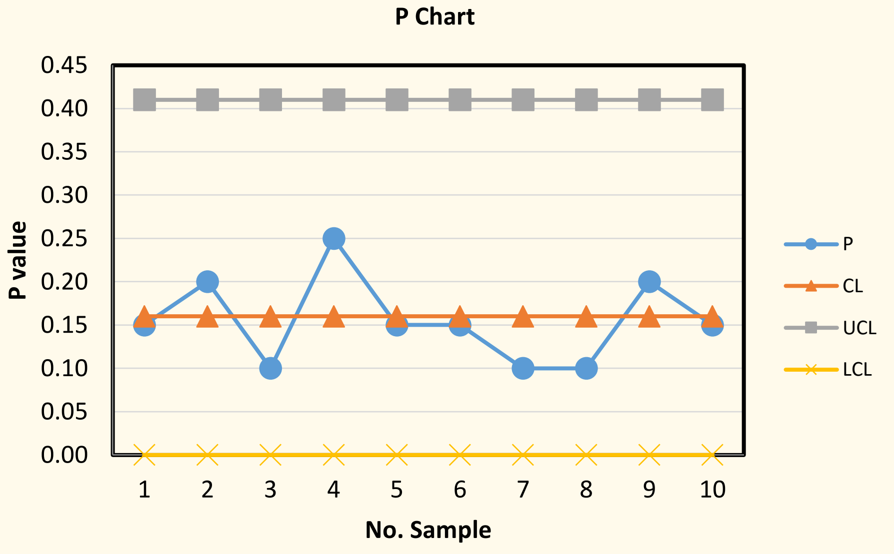
$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$= 0.16 - 3\sqrt{\frac{0.16(1-0.16)}{20}}$$

$$= 0.16 - 3\ (0.08)$$

$$= -0.09 \approx 0.00$$

Step 3



4. Calculate:

   a) Center line, UCL and LCL

   b) Plot the chart

Number, N	Count of Nonconformities, c	Number, N	Count of Nonconformities, c
1	19	11	16
2	17	12	14
3	14	13	28
4	16	14	16
5	15	15	12
6	13	16	20
7	14	17	10
8	16	18	12
9	11	19	10
10	20	20	17

Answer:

Step 1

$$\overline{c} = \frac{\sum c}{N}$$

$$\overline{c} = \frac{310}{20}$$

$$\overline{p} = 15.5$$

Step 2

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

$$UCL = 15.5 + 3\sqrt{15.5}$$

$$UCL = 15.5 + 3\,(3.94)$$

$$UCL = 27.31$$

Step 3

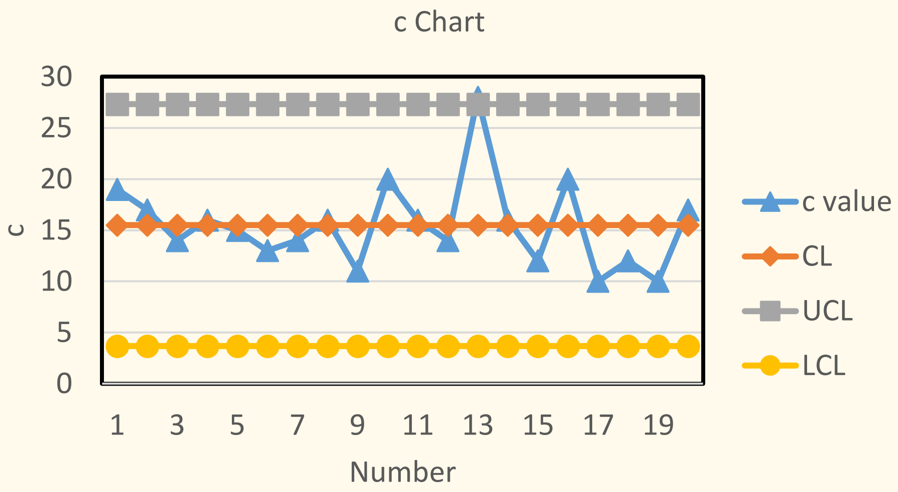
$$LCL = \overline{c} - 3\sqrt{\overline{c}}$$

$$LCL = 15.5 - 3\sqrt{15.5}$$

$$LCL = 15.5 - 3\,(3.94)$$

$$LCL = 3.68$$

Step 4: Construct graph



5. Determine :

   a) U

   b) UCL dan LCL

   c) Plot carta u

Subgroup Number	Subgroup Size	Total Nonconformities
1	5	18
2	5	13
3	5	11
4	5	15
5	5	21
6	10	15
7	10	13
8	10	16
9	10	25
10	10	12
Total		

Answer:

Step 1

$$u = \frac{c}{n}$$

Subgroup Number	Nonconformities per Unit, u	UCL	LCL
1	3.6		
2	2.6		
3	2.2		
4	3		
5	4.2		
6	1.5		
7	1.3		
8	1.6		
9	2.5		
10	1.2		

Σ=75 Σ= 159

$$\overline{u} = CL = \frac{\sum c}{\sum n} = 15/75 = 2.12$$

Step 2

$$UCL = \bar{u} + 3\left(\sqrt{\frac{\bar{u}}{n}}\right)$$

$$LCL = \bar{u} - 3\left(\sqrt{\frac{\bar{u}}{n}}\right)$$

Step 3

$$UCL_{1\text{-}5} = 2.123\ (\sqrt{\frac{2.12}{5}})=4.07$$

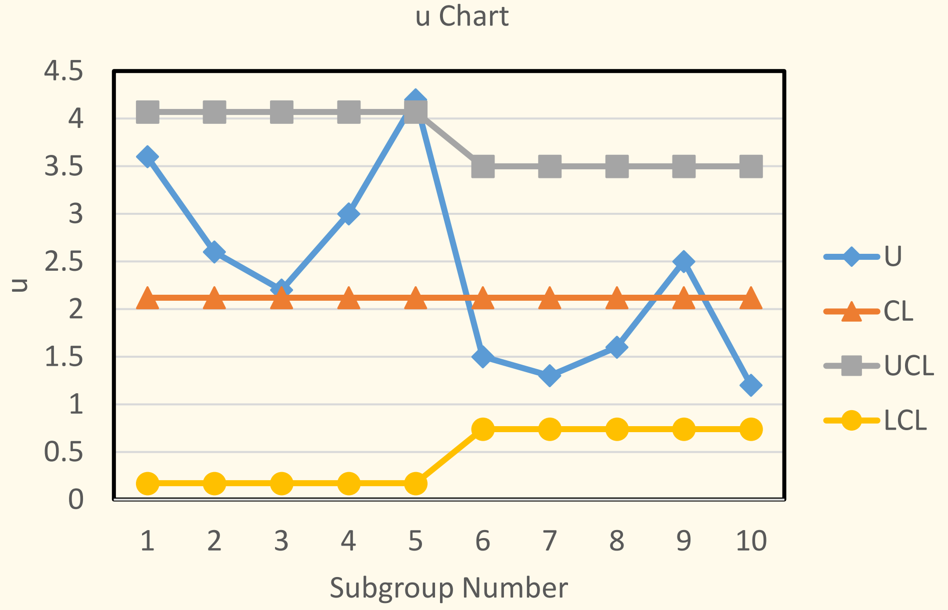
$$LCL_{1\text{-}5} = 2.12 - 3(\sqrt{\frac{2.12}{5}})=0.17$$

Step 4

$$UCL_{6\text{-}10} = 2.12 + 3\ (\sqrt{\frac{2.12}{10}})=3.50$$

$$LCL_{6\text{-}10} = 2.12 - 3(\sqrt{\frac{2.12}{10}})=0.74$$

Step 5



Topic 4

Acceptance Sampling

- **4.1 Definition of Sampling Plan**
- **4.2 Usage of Sampling Plan**
- **4.3 Advantages of using Sampling Plan**
- **4.4 Disadvantages of using Sampling Plan**
- **4.5 Types of Sampling Plan**
- **4.6 OC Curve**
- **4.7 Consumer Producer Relationship**
- **4.8 Use MIL-STD 105D sampling inspection table to determine Single Sampling for Normal, Tightened and Reduce Inspection.**
- **Tutorial**

4.1 Definition of Sampling Plan

- Acceptance Sampling uses statistical sampling to determine whether to accept or reject production lot of material.
- Acceptance sampling solves these problems by testing a representative sample of the product for defects.

4.2 Usage of Acceptance Sampling

- When inspection involves destructive testing. Therefore, sampling is required to avoid the entire product being destroyed during the testing process.
- The cost for 100% inspection is high.
- Where there are many similar units to be inspected.
- When information on producer risks such as control charts is not available.

4.3 Advantages of Acceptance Sampling

- Less expensive
- Reduced damage
- Reduces the amount of inspection error

4.4 Disadvantages of Acceptance Sampling

- Risk of accepting “bad” lots, rejecting “good” lots
- Less information generated
- Requires planning and documentation

4.5 Types of Sampling Plan

Single Sampling Plan	Double Sampling Plan	Multiple Sampling Plan
• The acceptance or rejection of the lot is based on the results from a single sample - thus a single-sampling plan.	• More complicate • a) To accept the lot • To reject the lot • To take another sample	• More than two times taking samples. The methods is the same as double sampling plan.

4.6 OC Curve

- the probability of accepting incoming lots.

Construct OC Curve

a) Assume **Po** value= 0.01, 0.02…

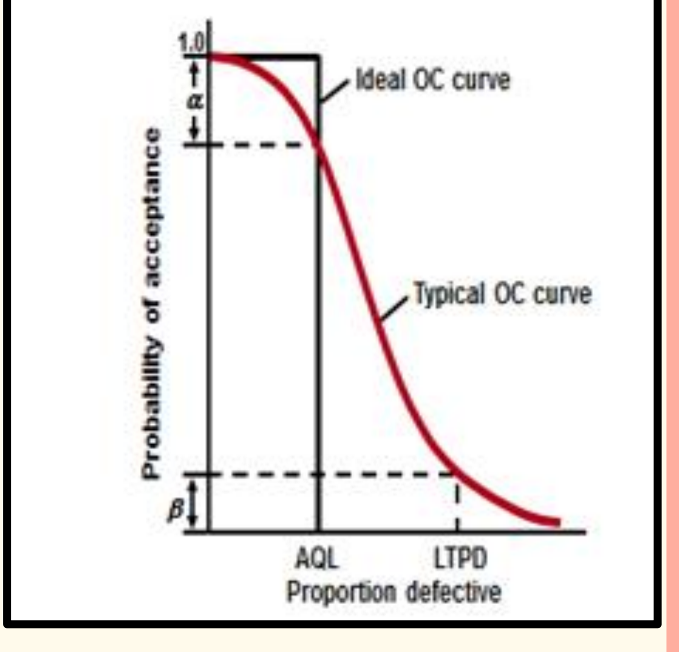
b) Calculate npo value

c) From a Poisson table, find **Pa** using the applicable c and npo value

d) Plot point (100po, Pa)

e) Repeat 1,2,3,4 until a smooth curve is obtained

po	$100P_o$	n	npo	Pa
0.01	1.0	89	0.9	0.938
0.02	2.0	89	1.8	0.731
0.03	3.0	89	2.7	0.494
0.04	4.0	89	3.6	0.302
0.05	5.0	89	4.5	0.174
0.06	6.0	89	5.3	0.106*
0.07	7.0	89	6.2	0.055*



when sampling is used, there is a conflict between consumers a

4.7 Consumer- Producer Relationship

i. Producer's Risk

- When acceptance sampling is used, there is a conflict between consumers and producers.
- The producer requests all good lots will be accepted and the user wishes all bad lots rejected

Producer Risk

The producer's risk, α is the <u>rejection probability</u> of a conforming lot.

AQL= is the maximum percent nonconforming that can be considered satisfactory for the purposes of acceptable sampling.

α = 0.05 (0.001- 0.10)
α is not located on an OC curve
So:
Pa = 1 – α = 1- 0.05 = 0.95

Acceptable Quality Level (AQL is the numerical definition of an acceptable lot.

ii. Consumer's Risk

Consumer Risk

The consumer's risk , β= is the probability of acceptance of a nonconforming lot.
β = 0.10.

LQL is in a batch or lot size for acceptance sampling purposes and the consumer wishes the probability of acceptance to be low.

Limiting Quality Level (LQL) is a numerical definition of a nonconforming lot associated with the consumer's risk

4.8 Use MIL-STD 105D sampling inspection table to determine Single Sampling Plan for the Inspection of Normal, Tightened and Reduce.

a) Determine the lot size

↓

b) Determine the inspection level

↓

c) Enter table and find sample- size code letter

↓

d) Determine the AQL

↓

e) Determine the type of sampling plan to use (single, double, multiple)

↓

f) Enter the appropriate table to find the sampling plan

↓

g) Determine the corresponding normal and reduced inspection plans to be used when required.

TUTORIAL

1. A lot with size (N) of 9000 is chosen to be inspected and the first sample, n_1= 60 is selected. The r_1 *value is* = 5 with the n_2= 150, c_2= 6, and r_2= 7. Analyse the double sampling plan above.

Answer:

a) If there are 1 or fewer nonconforming units (c_1) = lot accepted

b) If there are 5 or more nonconforming units (r_1) = lot rejected

c) If there are 2,3,4 nonconforming units= no decision is made and second sample is taken

A second sample of 150 (n_2) from the lot (N) is inspected, and one of the following judgments is made:

a) If there are 6 or fewer nonconforming units (c_2) in both samples = lot accepted

b) If there are 7 or more nonconforming units (r_2) in both samples = lots rejected

2. A famous workstation company uses a sampling plan of n = 50 and c = 0. Regardless the lot sizes, draw an OC curve using about 7 points. By using the curve, determine the AQL value and LQL value.

Answer:

Step 1

Calculate 100Po

= 100 x 0.01 = 1

Step 2

Calculate npo

= 50 x 0.01 = 0.5

Step 3

Construct the table

Po	100Po	n	nPo	Pa
0.01	1	50	0.5	
0.02	2	50	1.0	
0.03	3	50	1.5	
0.04	4	50	2.0	
0.05	5	50	2.5	
0.06	6	50	3.0	
0.07	7	50	3.5	

Step 4

Find Pa from Cumulative Poisson Distribution Table

nPo= 0.5 c=0

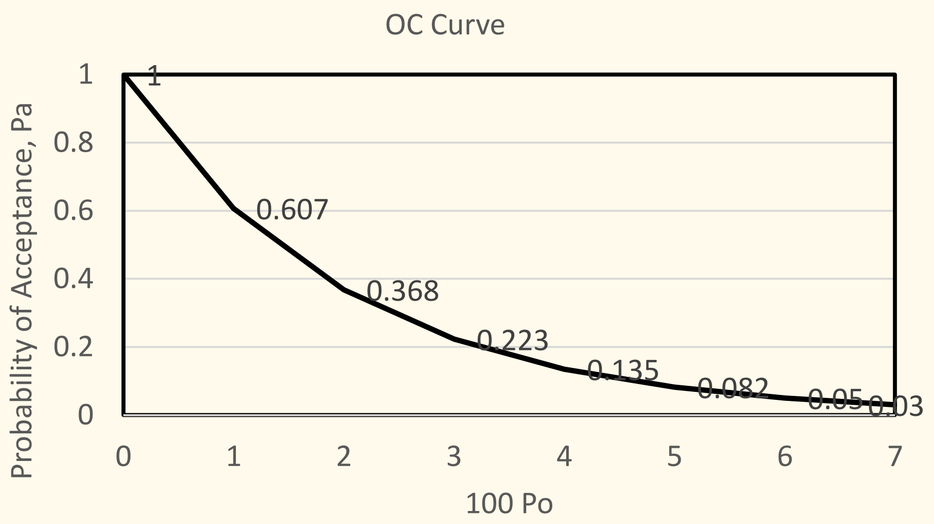
C. Cumulative Poission Distribution Table

	np_0										
c	0.01	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	0.990	0.951	0.905	0.819	0.741	0.670	0.607	0.549	0.497	0.449	0.407
1	1.000	0.999	0.995	0.982	0.963	0.938	0.910	0.878	0.844	0.809	0.772
2		1.000	1.000	0.999	0.996	0.992	0.986	0.977	0.966	0.953	0.937
3				1.000	1.000	0.999	0.998	0.997	0.994	0.991	0.987
4						1.000	1.000	1.000	0.999	0.999	0.998
5									1.000	1.000	1.000

Po	100Po	n	nPo	Pa
0.01	1	50	0.5	0.607
0.02	2	50	1.0	0.368
0.03	3	50	1.5	0.223
0.04	4	50	2.0	0.135
0.05	5	50	2.5	0.082
0.06	6	50	3.0	0.050
0.07	7	50	3.5	0.030

Step 5

Construct OC Curve



Find AQL and LQL

Step 6

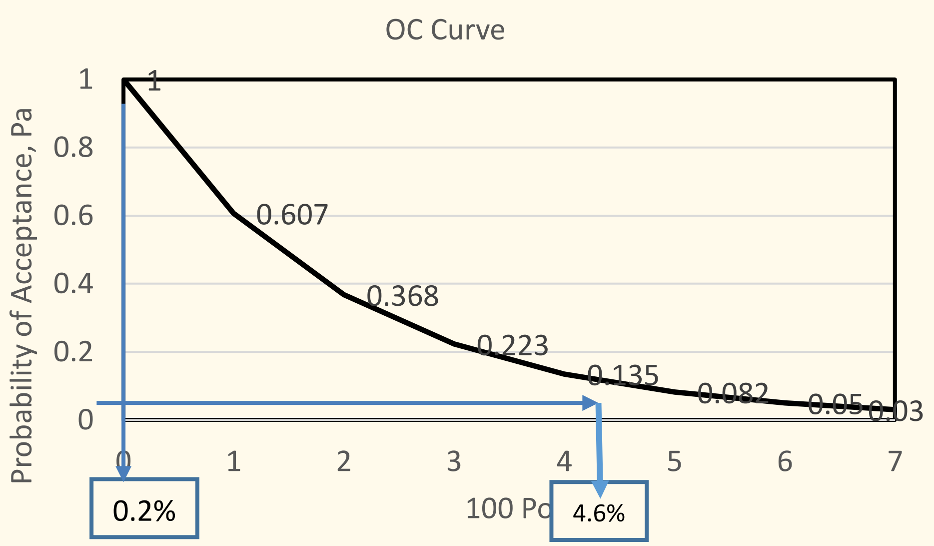
α = 0.05

Pa= 1- 0.05

= 0.95

(α, AQL) = 0.05, 0.2%

(β, LQL) =0.10, 4.6%



3. Inspection results for the last 4 lots are as below :

Lot	
I	1 nonconforming units
II	4 nonconforming units
III	3 nonconforming units
IV	5 nonconforming units

Refer to MIL-STD-105D/Z1.4 table for the single sampling plan of Code Letter L and AQL = 0.65%, interpret (**ACCEPT or REJECT**) your decision if:

1) Normal inspection is used for lot I
2) Tightened inspection is used for lot II
3) Normal inspection is used for lot III
4) Reduced inspection is used for lot IV

Answer:

Step 1

Refer Table MIL-STD-105D/Z1.4 to determine n, Ac and Re for Normal, Tightened and Reduced Inspection.

Normal	**Tightened**	**Reduced**
n=200	n= 200	n= 80
Ac=3	Ac= 2	Ac= 1
Re=4	Re= 3	Re= 4

Step 2

Interpret (ACCEPT or REJECT) decision for each lots

a) Normal inspection is used for lot I

Answer:

= 1 nonconforming unit < Ac (refer Normal table above

= Accept lot I

b) Tightened inspection is used for lot II

Answer:

= 4 nonconforming units > Ac (refer Tightened table above

= Reject lot II

c) Normal inspection is used for lot III

Answer:

= 3 nonconforming units < Ac (refer Normal table above)

= Accept lot III

d) Reduced inspection is used for lot IV

Answer:

= 5 nonconforming units > Ac (refer Reduced table above)

= Reject lot IV

4. A shipment of 2,000 portable battery units for microcomputers is about to be inspected by a Malaysian importer. The Korean manufacturer and the importer have set up a sampling plan in which the risk is limited to α= 0.05 and the β = 0.10.

   i. Construct the OC curve for the plan of *n* = 120 sample size and an acceptance level of *c* ≤ 3 defectives.

   ii. Identify the value of LQL (LTPD) and AQL for this sampling plan by using the drawn OC Curve.

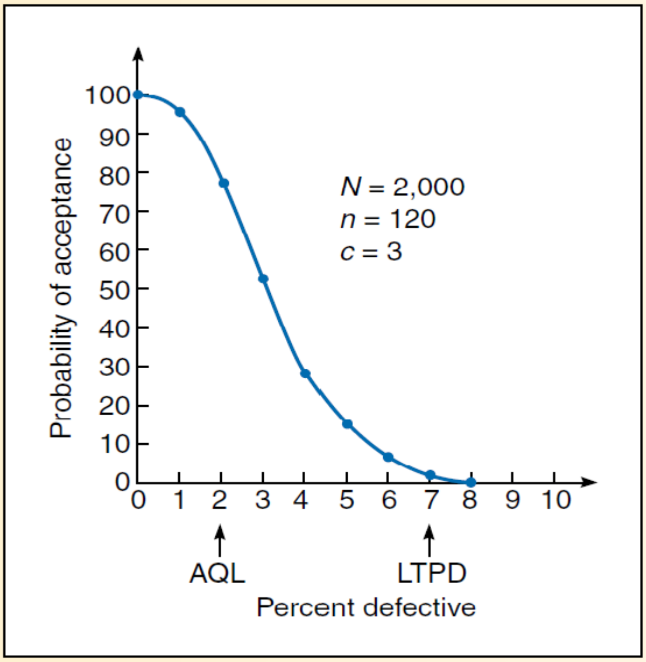
Answer:

Step 1

Assume process quality		Sample Saiz,n	nP_o	Pa
P_o	$100P_o$			
0.01	1.0	120	1.2	0.966
0.02	2.0	120	2.4	0.779
0.03	3.0	120	3.6	0.515
0.04	4.0	120	4.8	0.294
0.05	5.0	120	6.0	0.151
0.06	6.0	120	7.2	0.072
0.07	7.0	120	8.4	0.032

Step 2

OC Curve



Step 3

Refer to plotted graph above Pa= 0.95

AQL = 2% (100Po = range 1.8% to 2.5%)

Refer to plotted graph above Pa= 0.10

LQL = 7% (100Po = range 6.8% to 7.5%)

Topic 5

Quality Cost

- 5.1 Quality Cost
- 5.2 Types of Quality Cost
- 5.3 Prevention and Appraisal Cost
- 5.4 Internal and External Failure Cost
- Tutorial

5.1 Quality Cost (general relation)

- Products that meet or exceed its design specifications and are free from defects are considered to be of high quality.
- For example on a budget handphone that has no defects, it has a same quality conformance as great as a non-defect expensive handphone.

- The buyers of the expensive handphone can expect their phone to be multitasking and free of defects.
- **Quality Cost** means the costs to prevent, detect and dealing with defects cause.
- It refers to the total costs that are acquired to prevent defects happen in product.

5.2 Quality Cost Categories

- Prevention (Avoidance) Cost
- Appraisal (Evaluation) Cost
- Failure Cost (Internal)
- Failure Cost (External)

5.3 Prevention and Appraisal Costs: These cost are acquired to prevent defective products from falling to the customers.

a) Prevention (Avoidance) Cost

- Prevention costs is a cost to prevent defects occur at the early process.
- The cost become less to prevent a problem from happen at the early process compare to correct it after the defect has happened.
- These costs support most actions to reduce the number of defects.
- Businesses hire many methods to avoid defects from happen such as Quality Engineering, Training, Statistical Process Control and Total Quality Management (TQM) tools.
- Examples:, Quality circles, Data gathering, Statistical process control

b) Appraisal (Evaluation) Cost

- Known as Inspection Cost.
- Used for testing and inspection to assess whether the product meets the prescribed quality standards before the products sent to the customer.
- Includes the inspection cost of raw materials, work in progress and semi - finished product.
- Examples: Incoming materials (test and inspection), in process product (test and inspection), final product (test and inspection), maintenance of inspection equipment.

5.4 Internal and External Failure Costs: are incurred because defects are produced despite efforts to prevent them therefore these costs are also known as *costs of poor quality.*

c) Internal Failure Costs

- Failure costs are acquired when factory quality problems occur.
- Internal failure costs refers to production losses and repair costs of semi -finished and finished products before they are shipped to customers.
- Examples: Costs of rework, costs of retesting good, costs of rework labor, product in re-inspection or reworked

d) External Failure Costs

- Refers to losses due to product quality that does not meet the needs caused after delivery.
- Including the cost of the guarantee. Loss of return, loss of discount, cost of liability, product recalls and legal action fees.
- Examples: Replacement or repairs product, warranty.

TUTORIAL

1. Explain **FOUR (4)** types of quality cost by giving **TWO (2)** point facts each.

Answer:

a) FOUR (4) types of Quality costs; (Any TWO fact)

- Prevention cost
  i. Is the cost incurred to avoid product failure.
  ii. Includes development of dispensing procedure, training of staff, testing of products, maintenance of precautions on machines used to manufacture products and assessment of supplier eligibility
- Appraisal cost
  i. Is the inspection cost necessary to reduce the risk of shipping a defective product to the customer.
  ii. These costs include supplier component testing, quality control product testing, process analysis and any testing equipment costs
- Internal failure costs,
  i. These are the costs associated with defective products found prior to delivery to the customer.
  ii. These costs include rework of defective products, additional testing of rework products, scrap, purchase of spare parts and lost profits on products.
- External Failure Costs
  i. These are costs associated with defective products found after delivery to customers.
  ii. These costs include lost revenue from customers who will no longer buy from the company, processing returned goods, warranty claims management, field services fees, liability lawsuits and possibly even a complete product recall.

b) TWO (2) examples for each type of Quality costs;

Answer:

- Prevention costs
    i. Systems development
    ii. Quality engineering
    iii. Quality training
    iv. Quality circles
    v. statistical process control
    vi. Supervision of prevention activities

- Appraisal costs
    i. Systems development
    ii. Test and inspection of incoming materials
    iii. Test and inspection of in-process goods
    iv. Final product testing and inspection
    v. Supplies used in testing and inspection
    vi. Supervision of testing and inspection activities.
    vii. Maintenance of test equipment

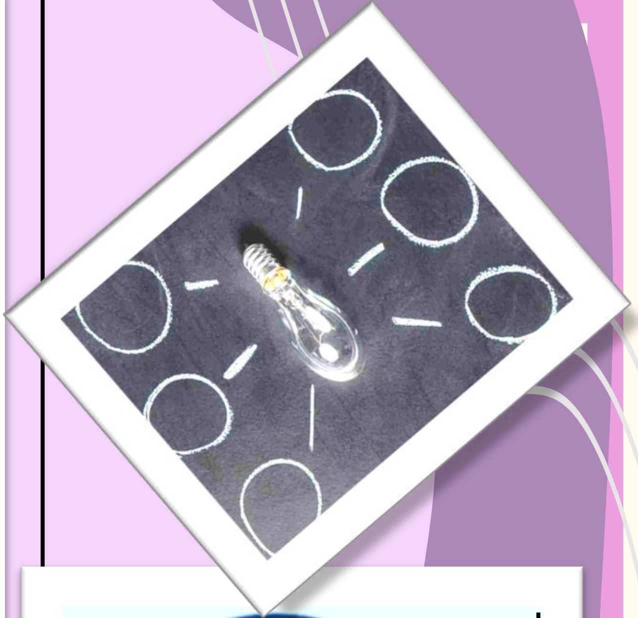
- External costs.
    i. Cost of field servicing and handling complaints
    ii. Warranty repairs and replacements
    iii. Repairs and replacements beyond the warranty period.
    iv. Product recalls
    v. Liability arising from defective products
    vi. Returns and allowances arising from quality problems

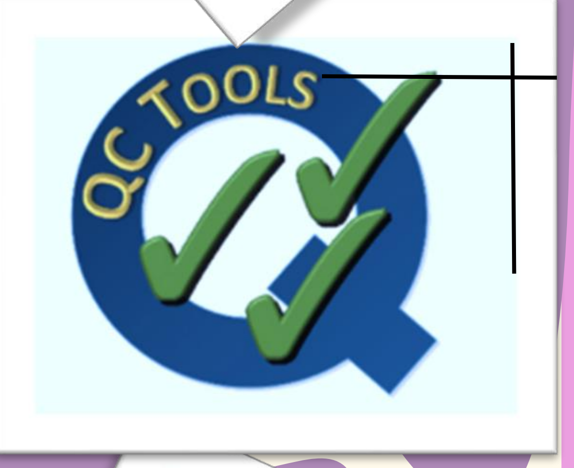
- Internal costs.
    i. Net cost of scrap
    ii. Re-inspection of reworked products

Topic 6

Tools and Technique for Quality Improvement

- 6.1 Brainstorming
- 6.2 Check Sheet
- 6.3 Pareto Diagram
- 6.4 Cause and Effect Diagram
- 6.5 Scatter Diagram
- 6.6 Quality Control Circle
- Tutorial





6.1 Brainstorming

- Brainstorming is a method for finding alternative solutions to solve problems.
- It is also known as mind development where everyone in the group can contribute their thoughts and opinions on a topic being discussed.

- During the discussion session, good and bad ideas were strongly encourage with the aim of stimulating other experts to generate more ideas.

6.2 Checksheet

- Is a method of recording data to identify the frequency of things, events or problems.

https://profiletree.com/what-is-quality-control

- Types of check Sheets
  - **Tabular Check Sheets**

    Used to collect data on quality problems and determine the frequency of occurrence- for example, the reason for an accident during a laboratory experiment.
  - **Graphical Check Sheets**

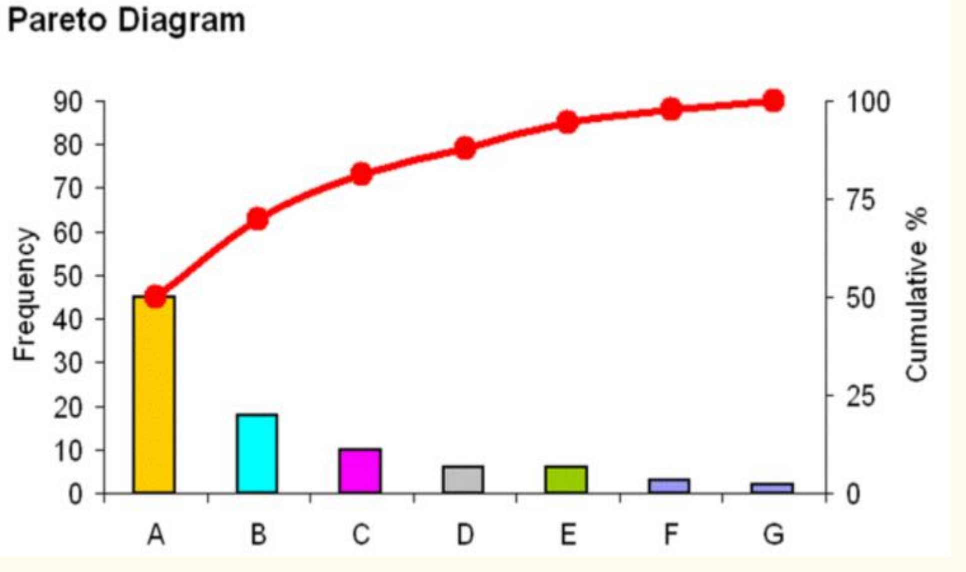
    It uses a form of graphical representation so that observers can collect data and visualize the circulation of data.
  - **Location Check Sheets**

    This usually uses a representation of the problem based on an image. For example, one can indicate the damage and dents to the body of a train by marking the appropriate location in the drawing.


https://timstruckcapital.com/blog/a-six-point-truck-inspection-checklist

6.3 Pareto Diagram

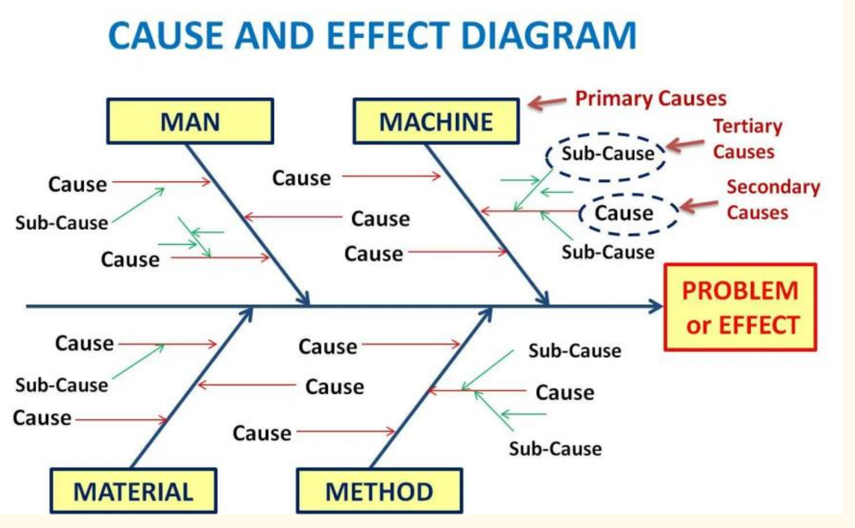
- Pareto charts is a combination of bar graph and line graph where can identify the main problem.
- For example, this diagram can be used to illustrate the causes of problem. The highest value indicates the main cause and it is followed by other causes.



- Constructing a Pareto Chart
  - Collect data for each problem and measure it with the appropriate unit.
  - Construct a graph where X axis explains the cause of the problem while Y axis explains the frequency of the problem.
  - Identify the main causes of the problem.
  - The straight positions are arranged from left to right.
  - The highest value shows the main cause and is followed by other causes.
  - Line graphs are built on the basis of their accumulated frequency and their hundredths.

6.4 Cause and Effect Diagram

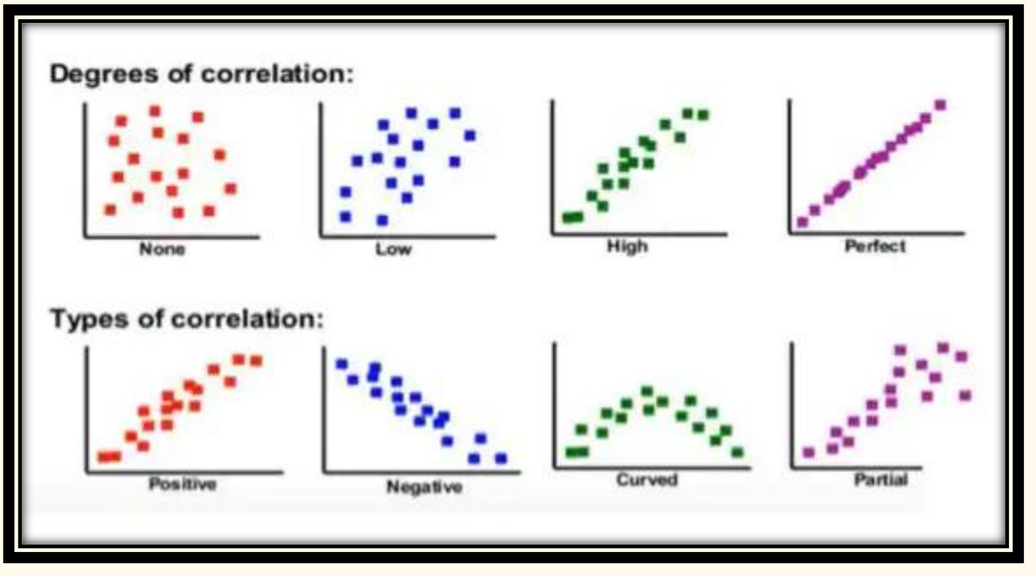
- The cause and effect diagram is also known as the Ishikawa diagram or the fishbone diagram.
- It is a tool to find out all the possible causes for a certain result.
- The main objective of this diagram is to act as a first step in problem solving by generating a list of possible causes.



- Constructing a Cause and Effect Diagram
  - First, clearly identify and define the problem or effect for which the causes must be identified. Place the problem or effect at the right or the head of the diagram.
  - Identify all the broad areas of the problem.
  - Write in all the detailed possible causes in each of the broad areas.
  - Each cause identified should be looked upon for further more specific causes.
  - View the diagram and evaluate the main causes.
  - Set goals and take action on the main causes.

6.5 Scatter Diagram

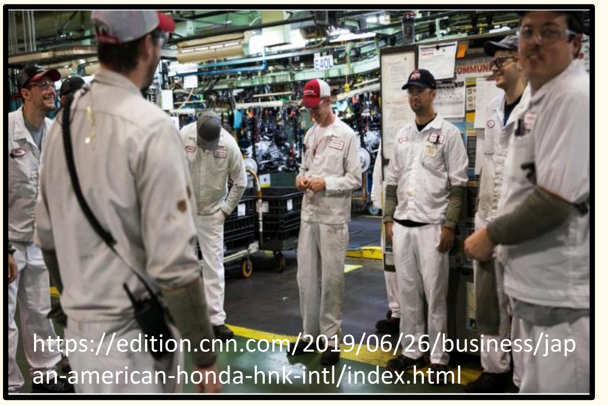
- Scatter Diagrams are used to study and identify the possible relationship between the changes observed in two different sets of variables.
- The scatter diagram graphs pairs of numerical data, with one variable on each axis, to look for a relationship between them. If the variables are correlated, the points will fall along a line or curve. The better the correlation, the tighter the points will hug the line. This cause analysis tool is considered one of the seven basic quality tools.



- Constructing a Scatter Diagram
  - First, collect two pieces of data and create a summary table of the data.
  - Draw a diagram labeling the horizontal and vertical axes.
    - It is common that the “cause” variable be labeled on the X axis and the “effect” variable be labeled on the Y axis.
  - Plot the data pairs on the diagram.
  - Interpret the scatter diagram for direction and strength.

6.6 Quality Control Circle (QCC)

- A small group of workers doing similar or related work meeting and continuously
  - Identifying
  - Selecting
  - Analysing and
  - Solving
- work-related problems



- **Structure QCC**

a) **QCC Manager-** Manager is the committee that formulates policies for the implementation of QCC.

b) **Facilitators-** are chosen from among Heads of Divisions or workers selected by the Management.

c) **Quality Circle Leaders-**may come from among Unit Heads or selected workers and have the following roles.

d) **Quality Circle Members-** operator

- **Benefit of QCC**

a) Closer relationship between the workers and Management;

b) Cultivation of cooperation among workers;

c) Job satisfaction;

d) Increased motivation to work;

e) Building of self-confidence;

f) Development of leadership among workers

TUTORIAL

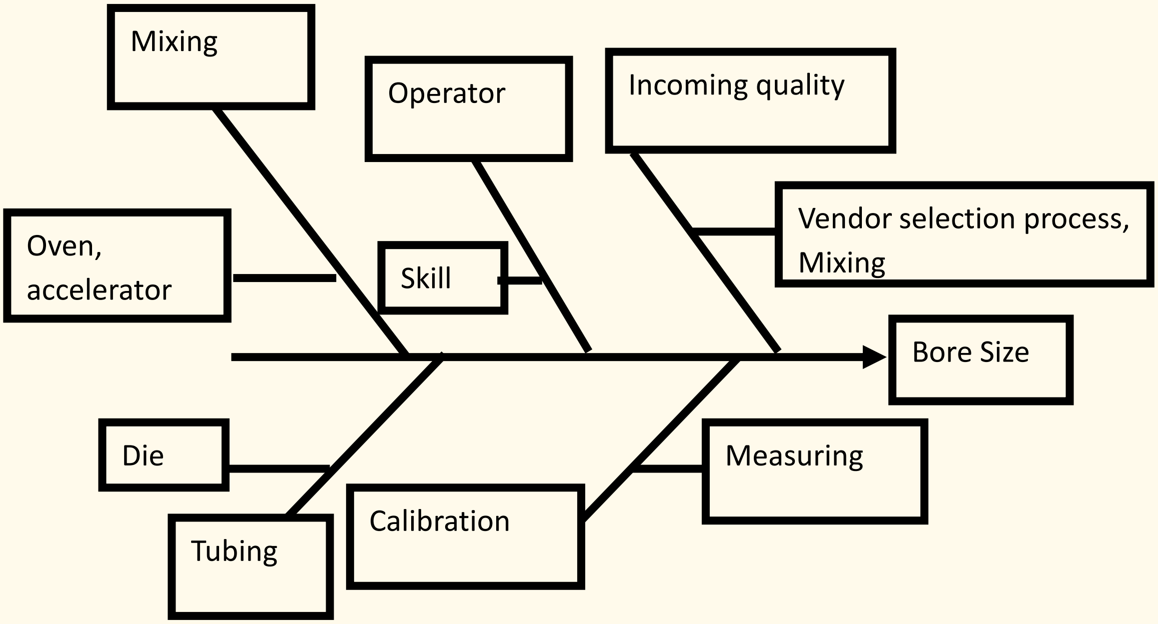
1. One the quality characteristic of interest in automobile tires is the bore size, which should be within certain specifications. In a cause and effect diagram, the final bore is the effect. Some of the main causes that influence the bore size are the incoming material, mixing process, tubing operation, press operation, operator and measurement equipment. For each main cause, sub causes are identified and listed in Table 6.1

Table 6.1

Main cause	Sub causes
Incoming quality	Vendor selection process
Mixing	Oven, accelerator
Tubing	Die
Press	Filter
Operator	Skill
Measuring	Calibration

Construct a cause and effect diagram by using the problem above.

Answer:



2. The defects information on Data Entry Operator is shown in a check sheet in Table 6.2 below to determine the sources of Operator 004's defective entries.

Table 6.2

Record of Defects for Data Entry Operator: Checksheet to determine the Source of Operator 004's Defective Entries (1/94 - 4/94)					
Major Causes of Defectives Entries	**Month**				
	1/94	**2/94**	**3/94**	**4/94**	**Total**
Transposed numbers	7	10	6	5	28
Out of field	1		2		3
Wrong character	6	8	5	9	28
Data printed too lightly		1	1		2
Torn document	1	1		2	4
Creased document			1	1	2
Iliegible source document			1		1
Total	15	20	16	17	68

i. Construct a frequency table of Defects for Data Entry Operator

ii. Construct a Pareto Chart to determine major causes of Defective Entries for Operator 004.

Answer:

Step 1

Arrange all of the items in the descending order of their annual consumption value

Major Causes of Defective Entries	Frequency
Transposed numbers	28
Wrong Character	28
Torn document	4
Out of Field	3
Data printed too lightly	2
Creased document	2
Illegible source document	1
Total	**68**

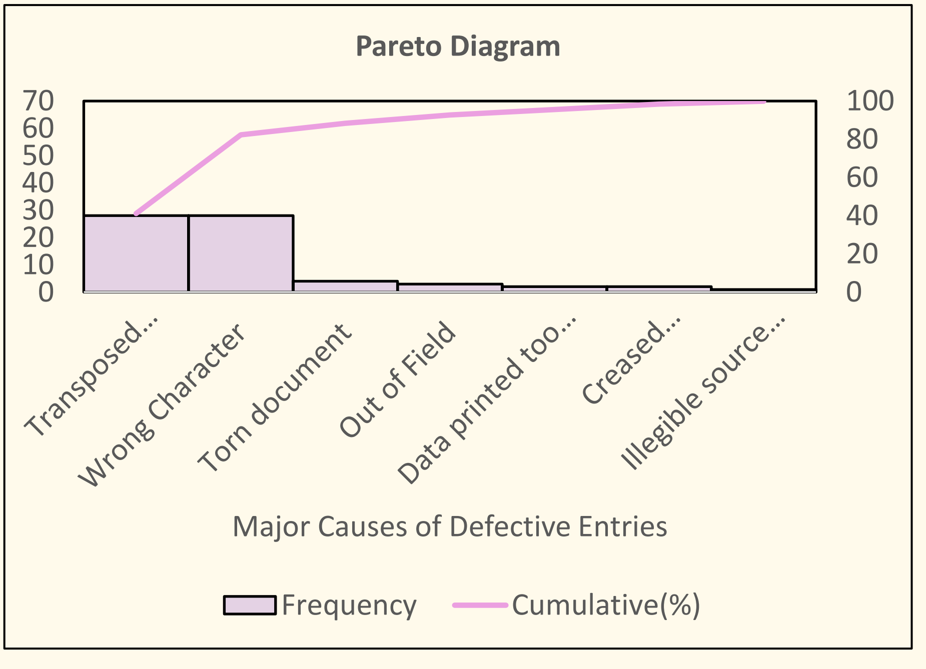
Step 2

Write the cumulative consumption value and find the percentage of this cumulated consumption value to total inventory value

Major Causes of Defective Entries	Frequency	Cumulative Frequency	Percent	Cumulative (%)
Transposed numbers	28	28	41.2	41.2
Wrong Character	28	56	41.2	82.4
Torn document	4	60	5.9	88.3
Out of Field	3	63	4.4	92.7
Data printed too lightly	2	65	2.9	95.6
Creased document	2	67	2.9	98.5
Illegible source document	1	68	1.5	100

Step 3

Construct Pareto diagram.



4. Based on the sample data below, construct a Pareto diagram.

Types of defect	
Defect	**Frequency**
Stretches	68
Scratches	34
Crack	16
Stain	12
Broken	11
Other	2
TOTAL	**143**

Answer:

Step 1

Compute the percentage of annual usage for each item.

$$=\frac{68}{143}\text{x}100 = 47.6$$

Types of Defect		
Defect	**Frequency**	**Percent**
Stretches	68	47.6
Scratches	34	23.8
Crack	16	11.2
Stain	12	8.39
Broken	11	7.69
Other	2	1.4
		100

Step 2

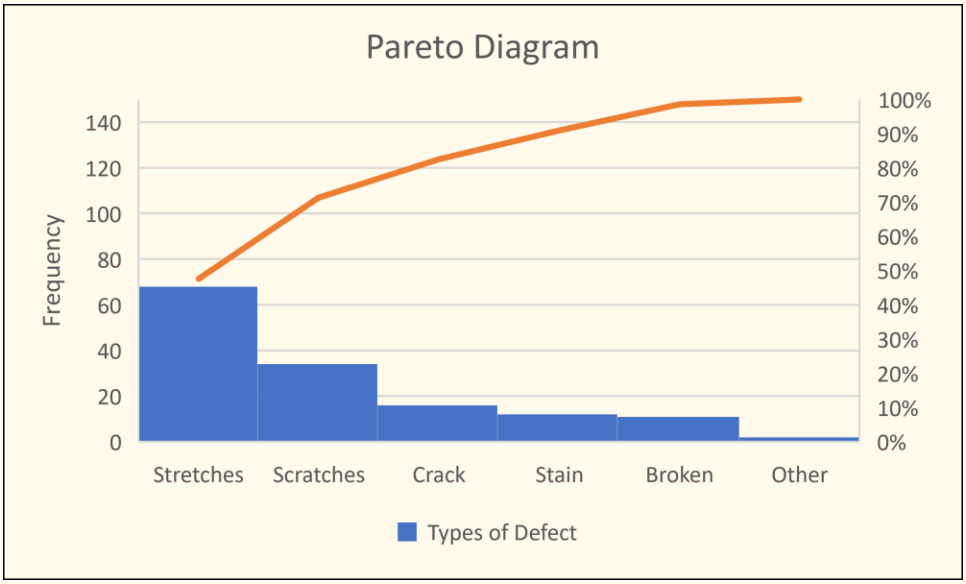
Calculate the cumulative consumption value (%).

Cumulative= $\frac{Frequency}{Total} * 100$

Types of Defect			
Defect	**Frequency**	**Percent**	**Cumulative %**
Stretches	68	47.6	47.6
Scratches	34	23.8	71.4
Crack	16	11.2	82.6
Stain	12	8.39	90.99
Broken	11	7.69	98.68
Other	2	1.4	100

Step 3

Construct Pareto diagram.



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