POLITEKNIK MALAYSIA
PORT DICKSON

QUALITY CONTROL
NOTE, QUESTION AND ANSWER

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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.

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.

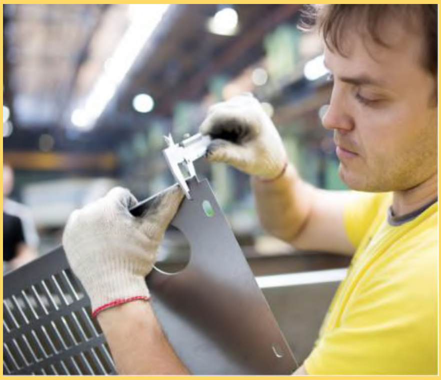
Finally, we would like to thank the staff of the Department of Mechanical Engineering for all the cooperation provided to make this book a success.

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

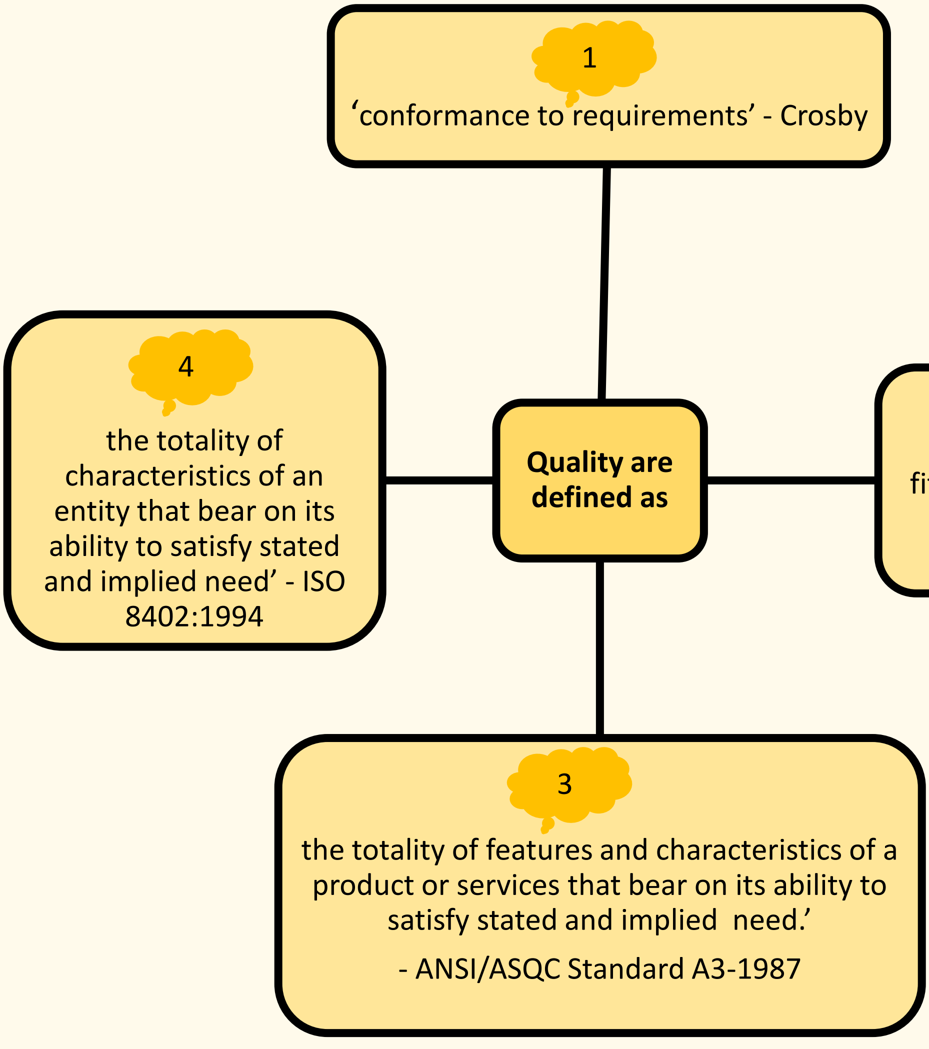
Topic 1

Basic Quality Concept

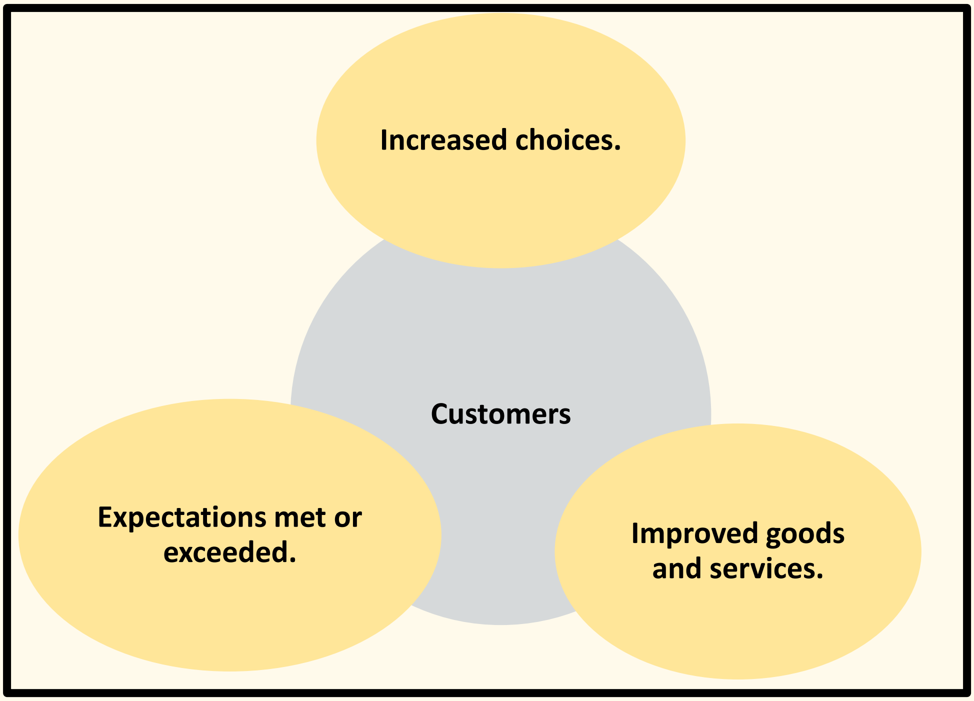
- 1.1 Quality Concept
- 1.2 Quality System Management
- 1.3 Basic Statistics In Quality Control
- Tutorial

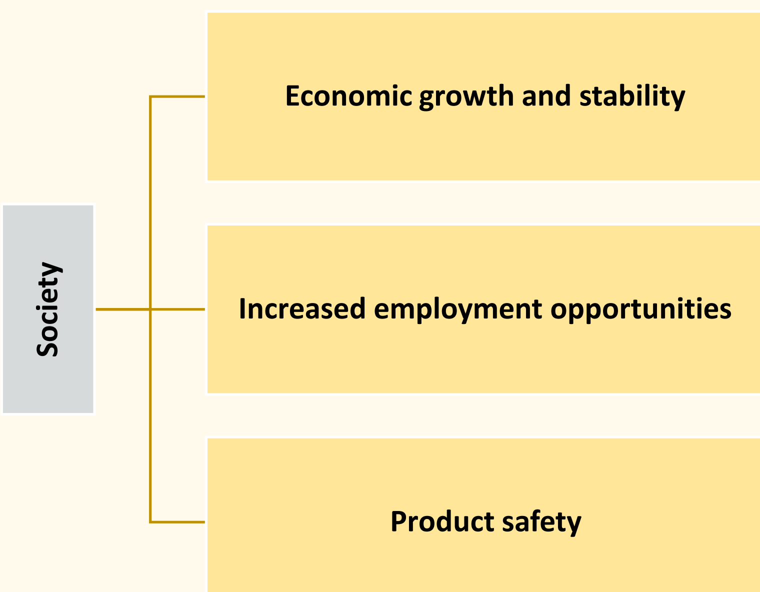
1.1 Quality Concept:

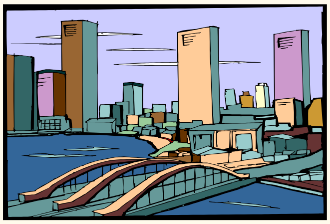
a) Definition

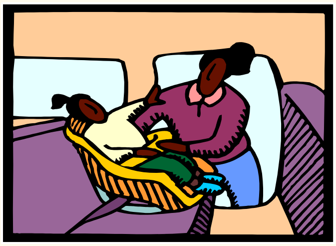


- A Quality Approach Will Benefits









c) Zero Defect

Zero Defects is to reduce and minimize the number of defects and errors in a process and to do things right the first time- Philips Crosby

d) The important of external and internal customers

i. External Customers

- One who receives a service or product from the organisation.
- They are the one who pay for a service or product and can make or break an organisation.
- If we lose them because of bad service, the business loses it's income.
- They have options and influence over the purchasing from the company.

ii. Internal Customers

- Can be within an organisation.
- Many departments deal with customers within it's organisation.
- High customer satisfaction is as important for internal customers as it is for external customers.
- The different is that internal customers do not have a choice.
- If the work of a particular department is not acceptable by another department, they cannot simply fire the department and look for another to finish the task.
- For a successful internal customer service, all departments must be able to work together productively and co- exist peacefully to meet common goals, which will lead to better quality products and service for external customers.

e) Quality associated terms and concepts:

1

Quality Control

- Definition: Quality control is the operational techniques and activities that are used to fulfill requirements for quality.
- The basic goal of quality control is to ensure that the products, services, or processes provided meet specific requirements and are dependable, satisfactory, and fiscally(money-wise) sound

2

Quality Assurance

- Definition: Quality assurance can be defined as "part of *quality management* focused on providing confidence that *quality requirements* will be fulfilled."
- All those planned and systematic activities implemented to provide adequate confidence that an entity will fulfill requirements for quality.

3

Total Quality Management

- TQM may be defined as managing the entire organization so that it excels on all dimensions of products and services that are important to the customer.
- TQM requires organizations to focus on continuous improvement, or kaizen. It focuses on process improvements over the long term, rather than simply emphasizing short-term financial gains.

4

Continuous Process Improvement

- Continuous improvement, sometimes called continual improvement, is the ongoing improvement of products, services or processes through incremental and breakthrough improvements.
- The basic goal of quality control is to ensure that the products, services, or processes provided meet specific requirements and are dependable, satisfactory, and fiscally(money-wise) sound

5

Six sigma

- Six Sigma is a data-driven methodology that provides tools and techniques to define and evaluate each step of a process.
- The increase in performance and decrease in process variation helps lead to defect reduction and improvement in profits, employee morale, and quality of products or services.

1.2 Quality System Management:

a) The needs of quality system

- Meeting the customer's requirements, which helps to instill confidence in the organisation, in turn leading to more customers, more sales, and more repeat business
- Meeting the organisation's requirements, which ensures compliance with regulations and provision of products and services in the most cost- and resource-efficient manner, creating room for expansion, growth, and profit

b) Quality Management Principles

Principle 1- **Customer- Focused Organisation:** " Organisation depend on their customers and therefore should understand current and future customer needs, meeting customer's requirements and strive to exceed customer expectations".

Principle 2- **Leadership:** " Leaders establish unity of purpose and direction of the organisation. They should create and maintain the internal environment in which people can become fully involved in achieving the organisation's objectives."

Principle 3- **Involvement of People:** " People at all levels are the essence of an organisation and their full involvement enables their abilities to be used for the organisation's benefit".

Principles 4- **Process Approach:** "A desired result is achieved more efficiently when related resources and activities are managed as a process.

Principles 5- **System Approach to Management:** " Identifying, understanding and managing a system of interrelated processes for a given objective improves the organization's effectiveness and efficiency"

Principles 6- **Continual Improvement:** "Continual Improvement: " Continual improvement should be a permanent objective of the organization"

Principle 7- **Factual Approach to Decision Making:** " Effective decisions are based on the analysis of data and information".

Principle 8- **Mutually Beneficial Supplier Relationships:** " An organisation and its suppliers are interdependent, and a mutually beneficial relationship enhances the ability of both to create value."

c. Basic concept and main terms in ISO 9000 series

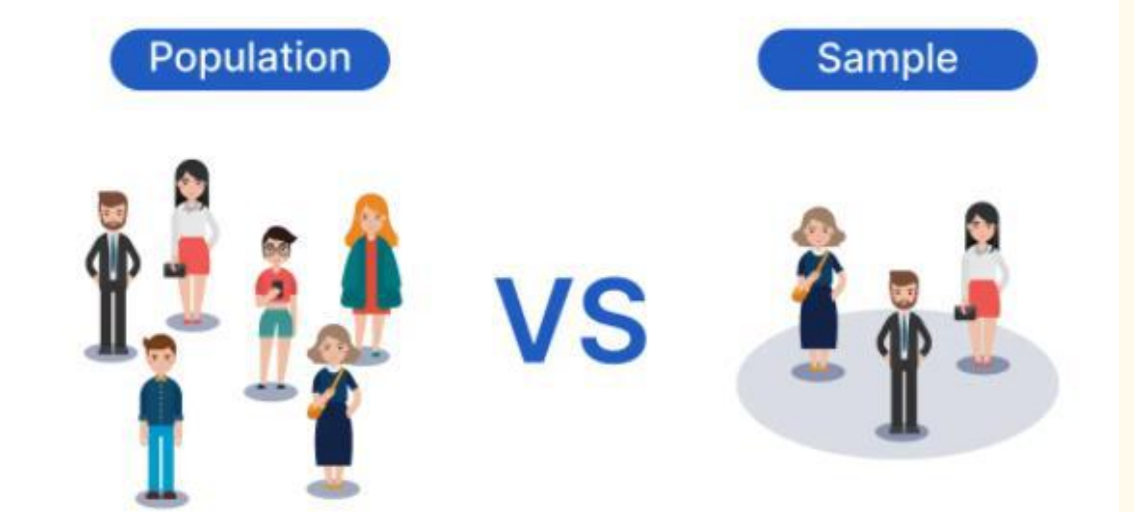
- **ISO 9000-** covers the basic concepts and language.
- **ISO 9001-** sets out the requirements of a quality management system.
- **ISO 9004-** focuses on how to make a quality management system more efficient and effective.

1.3 Basic Statistic In Quality Control

Statistics:

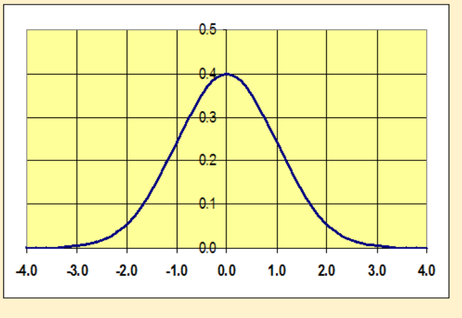
Is a standard method for collecting, organising, summarising, presenting, and analysing data and for drawing conclusions and making decisions based upon the analyses of these data.

- A **population** is a complete set of all of the possible instances of a particular object.
  - for example, the People in this room.
- A **sample** is a subset of the population
  - for example, any one of the Teams.
- We use samples to draw conclusions about the parent population.



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 a standard of performance management that adopts the attitude of defect prevention, to Do It Right The First Time.

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

Answer:

Six Sigma is a data-driven methodology that provides tools and techniques to define and evaluate each step of a process. It provides methods to improve efficiencies in a business structure, improve the quality of the process and increase the bottom-line profit.

- Define the project goals
- Measure critical components of the process and the product capabilities
- Analyze the data and develop various designs for the process, eventually picking the best one
- Design and test details of the process
- Verify the design by running simulations and a pilot program, and then handing over the process to the client

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 and quality assurance.

Answer

Quality Control (QC)	Quality Assurance (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. The basic goal of quality control is to ensure that the products, services, or processes provided meet specific requirements and are dependable, satisfactory, and fiscally(money-wise) sound.

ii. All those planned and systematic activities implemented to provide adequate confidence that an entity will fulfill requirements for quality.

iii. Continuous improvement, sometimes called continual improvement, is the ongoing improvement of products, services or processes through incremental and breakthrough improvements. These efforts can seek "incremental" improvement over time or "breakthrough" improvement all at once."

iv. TQM may be defined as managing the entire organisation so that it excels on all dimensions of products and services that are important to the customer.

v. 100 Percent Inspection means every part is inspected – in other words all parts of a particular batch are tested against predetermined tolerances of defined features.

6. There are THREE models of ISO 9000 series. List the THREE (3) models of ISO 9000 series and describe each model.

Answer :

- ISO 9000 describes fundamentals of quality management systems and specifies the terminology for quality management systems.ISO 9002 involves standards for both production and installation.
- ISO 9001 specifies requirements for a quality management system where an organization needs to demonstrate its ability to provide products that fulfil customer and applicable regulatory requirements and aims to enhance customer satisfaction.
- ISO 9004 provides guidelines that consider both the effectiveness and efficiency of the quality management system. The aim of this standard is improvement of the performance of the organization and satisfaction of customers and other interested parties.

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. An electrician testing the incoming line voltage for a residential house obtains five readings: 115, 113, 121, 115, 116. Calculate the average.

Answer:

Step 1

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

Step 2

$$x = \frac{115+113+121+115+116}{5}$$

$$= \frac{580}{5} = \underline{\underline{116}}$$

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;

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

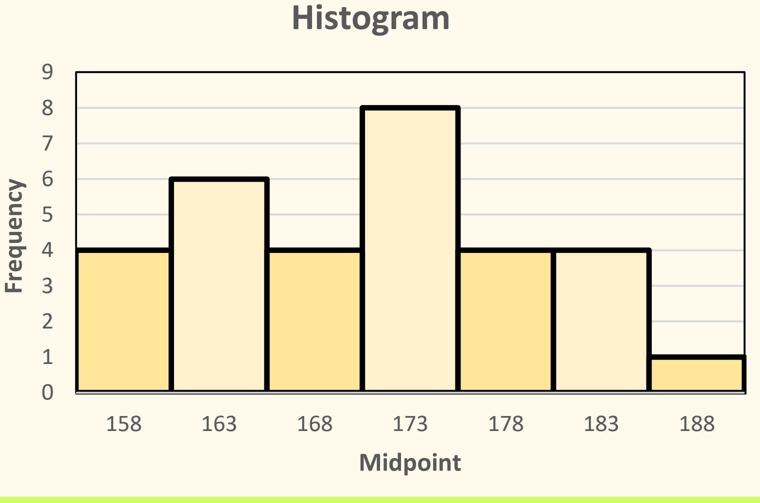
Step 4

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 weight of 65 castings in kilograms is distributed as follows:

Cell Midpoint	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

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

$= \sqrt{0.178}$

$= 0.42$

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

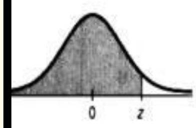
$$Z > \frac{X - \mu}{\sigma}$$

Step 3

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

Step 4

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



z	Second decimal place in 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	[illegible]	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	[illegible]	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	[illegible]	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	[illegible]	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	[illegible]	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	[illegible]	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	[illegible]	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	[illegible]	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	[illegible]	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	[illegible]	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	[illegible]	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	[illegible]	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	[illegible]	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	[illegible]	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	[illegible]	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	[illegible]	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	[illegible]	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	[illegible]	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	[illegible]	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	[illegible]	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	[illegible]	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	[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	[illegible]	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

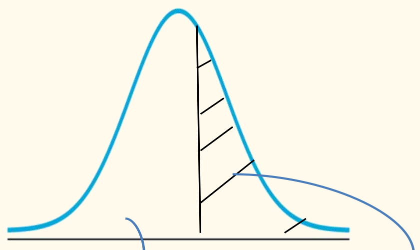
Step 5

= 1- 0.9901 = 0.00099 X100= 0.99%

12. Using Table Z (Areas under the normal curve), determine the probability (value of area) for Z value below,

Greater than Z = 1.0

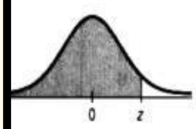
Answer:



0.8413

1- 0.8413 = 0.1587

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
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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
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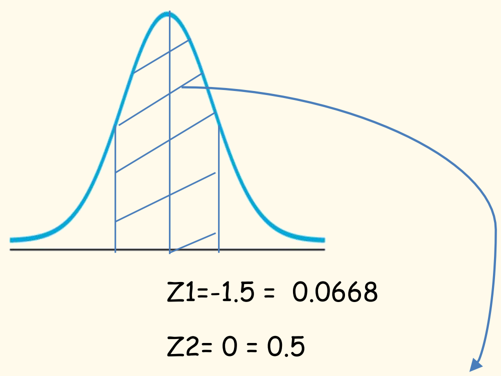
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
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 (Areas under the normal curve), determine the probability (value of area) for Z value below, between Z = -1.5 and Z = 0

Answer:



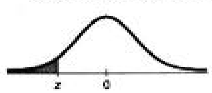
Z1=-1.5 = 0.0668

Z2= 0 = 0.5

Z3= 0.5 - 0.0668 = 0.4332

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[illegible]000†	−3.9
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0[illegible]001	−3.8
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0[illegible]001	−3.7
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0[illegible]002	−3.6
0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0[illegible]002	−3.5
0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0[illegible]003	−3.4
0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0[illegible]005	−3.3
0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0[illegible]007	−3.2
0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0[illegible]010	−3.1
0.0010	0.0010	0.0011	0.0011	0.0011	0.0012	0.0012	0.0013	0.0013	0[illegible]013	−3.0
0.0014	0.0014	0.0015	0.0015	0.0016	0.0016	0.0017	0.0018	0.0018	0[illegible]019	−2.9
0.0019	0.0020	0.0021	0.0021	0.0022	0.0023	0.0023	0.0024	0.0025	0[illegible]026	−2.8
0.0026	0.0027	0.0028	0.0029	0.0030	0.0031	0.0032	0.0033	0.0034	0[illegible]035	−2.7
0.0036	0.0037	0.0038	0.0039	0.0040	0.0041	0.0043	0.0044	0.0045	0[illegible]047	−2.6
0.0048	0.0049	0.0051	0.0052	0.0054	0.0055	0.0057	0.0059	0.0060	0[illegible]062	−2.5
0.0064	0.0066	0.0068	0.0069	0.0071	0.0073	0.0075	0.0078	0.0080	0[illegible]082	−2.4
0.0084	0.0087	0.0089	0.0091	0.0094	0.0096	0.0099	0.0102	0.0104	0[illegible]107	−2.3
0.0110	0.0113	0.0116	0.0119	0.0122	0.0125	0.0129	0.0132	0.0136	0[illegible]139	−2.2
0.0143	0.0146	0.0150	0.0154	0.0158	0.0162	0.0166	0.0170	0.0174	0[illegible]179	−2.1
0.0183	0.0188	0.0192	0.0197	0.0202	0.0207	0.0212	0.0217	0.0222	0[illegible]228	−2.0
0.0233	0.0239	0.0244	0.0250	0.0256	0.0262	0.0268	0.0274	0.0281	0[illegible]287	−1.9
0.0294	0.0301	0.0307	0.0314	0.0322	0.0329	0.0336	0.0344	0.0351	0[illegible]359	−1.8
0.0367	0.0375	0.0384	0.0392	0.0401	0.0409	0.0418	0.0427	0.0436	0[illegible]446	−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	0.0[illegible]	−1.5
0.0681	0.0694	0.0708	0.0721	0.0735	0.0749	0.0764	0.0778	0.0793	0[illegible]0808	−1.4
0.0823	0.0838	0.0853	0.0869	0.0885	0.0901	0.0918	0.0934	0.0951	0[illegible]0968	−1.3
0.0985	0.1003	0.1020	0.1038	0.1056	0.1075	0.1093	0.1112	0.1131	0[illegible]1151	−1.2
0.1170	0.1190	0.1210	0.1230	0.1251	0.1271	0.1292	0.1314	0.1335	0[illegible]1357	−1.1
0.1379	0.1401	0.1423	0.1446	0.1469	0.1492	0.1515	0.1539	0.1562	0[illegible]1587	−1.0
0.1611	0.1635	0.1660	0.1685	0.1711	0.1736	0.1762	0.1788	0.1814	0[illegible]1841	−0.9
0.1867	0.1894	0.1922	0.1949	0.1977	0.2005	0.2033	0.2061	0.2090	0[illegible]2119	−0.8
0.2148	0.2177	0.2206	0.2236	0.2266	0.2296	0.2327	0.2358	0.2389	0[illegible]2420	−0.7
0.2451	0.2483	0.2514	0.2546	0.2578	0.2611	0.2643	0.2676	0.2709	0[illegible]2743	−0.6
0.2776	0.2810	0.2843	0.2877	0.2912	0.2946	0.2981	0.3015	0.3050	0[illegible]3085	−0.5
0.3121	0.3156	0.3192	0.3228	0.3264	0.3300	0.3336	0.3372	0.3409	0[illegible]3446	−0.4
0.3483	0.3520	0.3557	0.3594	0.3632	0.3669	0.3707	0.3745	0.3783	0[illegible]3821	−0.3
0.3859	0.3897	0.3936	0.3974	0.4013	0.4052	0.4090	0.4129	0.4168	0[illegible]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	0.5[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**

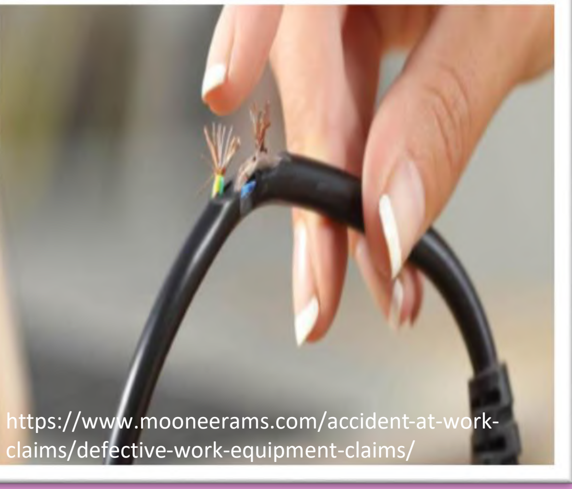
2.1 Source of Variation

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 is in state of 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 control inspector at Teguh Micro Chip Company has taken 5 samples with 10 observations for each volume of bags filled. The data are shown in the following table: A_2= 0.58, D_4=2.11, D_3= 0, (Round off all the value up to 2 decimal points)

   Based on Table 2.1,

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

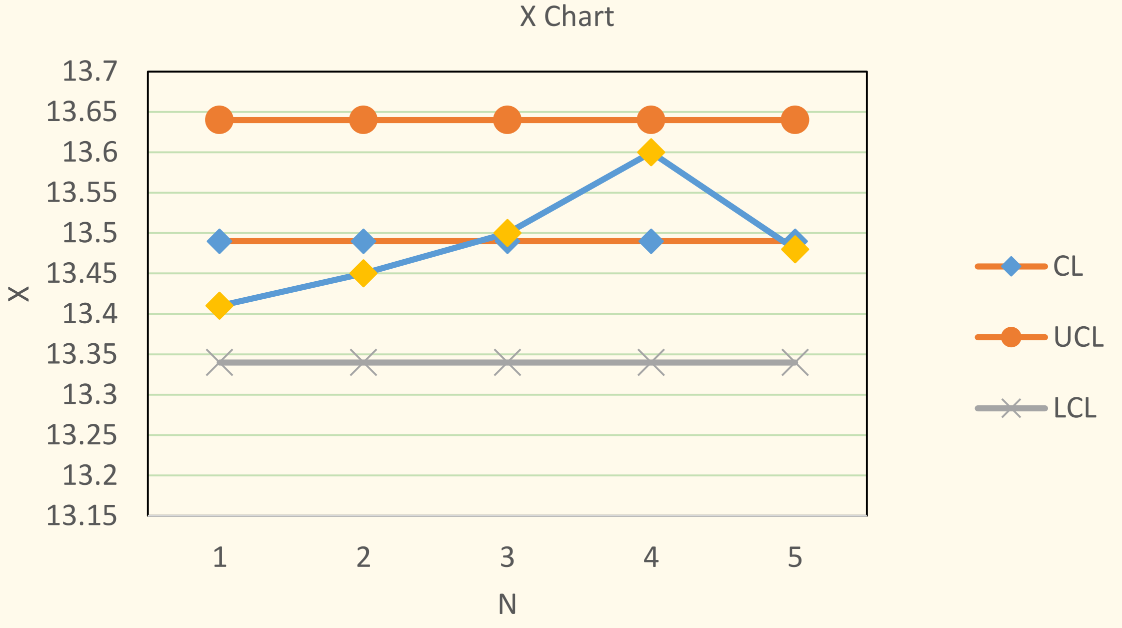
$D_4\bar{R}$

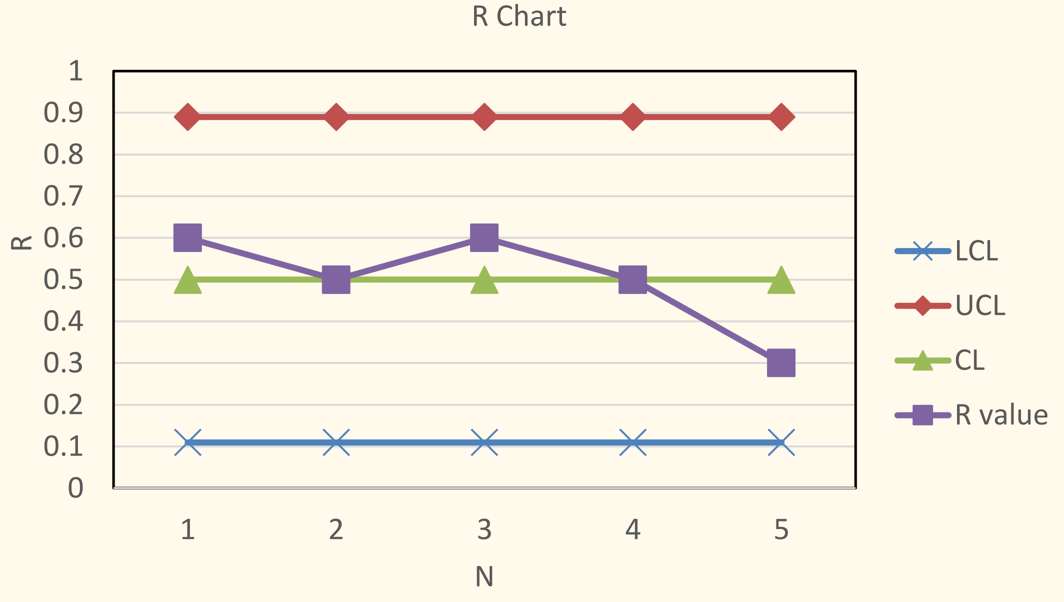
= 1.777(0.5) =0.89

$D_3\bar{R}$

=0.223 (0.5) = 0.11

Step 6: Plot graph





2. Table 2.2 is a typical and R chart form with information on acid content in milliliters. The average and range for each subgroup has been determined. Assuming the process is in a state of control, solve the followings.

Table 2.2

VARIABLES CONTROL CHART: DEP/ AREA: CHART ID:

Part ID:		Operation ID:					Characteristic: Acid 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 $\overline{X}$ and R charts central line and control limits (UCL and LCL) for the next production period 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 acid 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. Subgroup size is 6. Subgroup was 25, Σ X = 2046.5 and Σσ = 17.4. Determine control limits and center line.

Answer:

Step 1

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

= $\frac{2046.5}{25}$ = 81.86 ohms

Step 2

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

= $\frac{17.4}{25}$ = 0.696 ohms

Step 3

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

$= 81.86 + 1.287(0.696) =$ 82.76 ohms

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

$= 81.86 - 1.287(0.696) =$ 80.96 ohms

Step 4

$B_4\bar{s}$

= 1.970(0.696)= 1.37 ohms

$B_3\bar{s}$

=0.03(0.696) = 0.02 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

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

$\sum \boldsymbol{R} = 0.405$

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

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

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

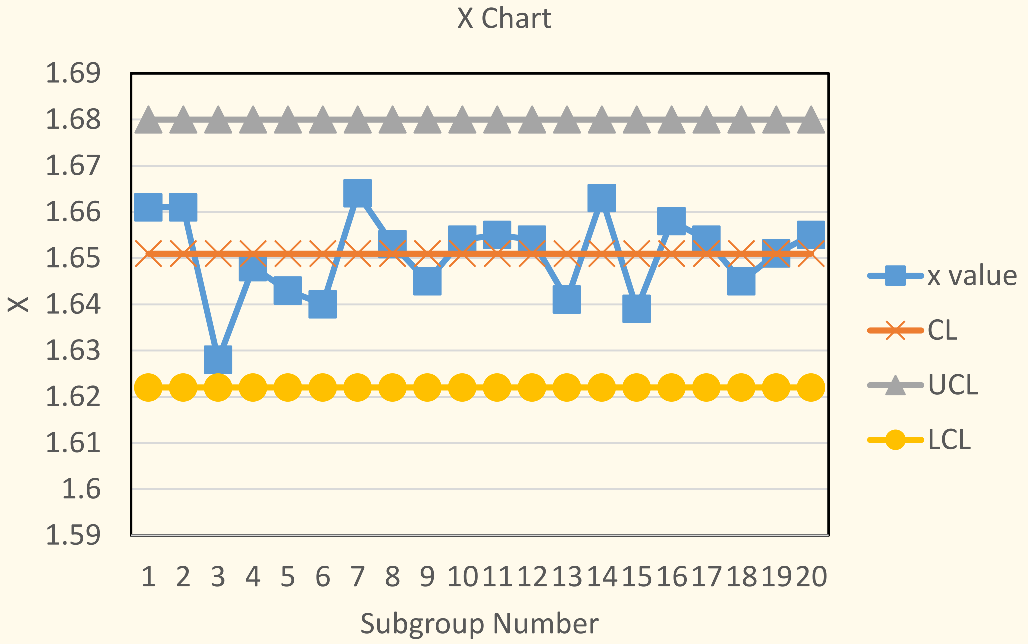
$B_4\bar{s}$

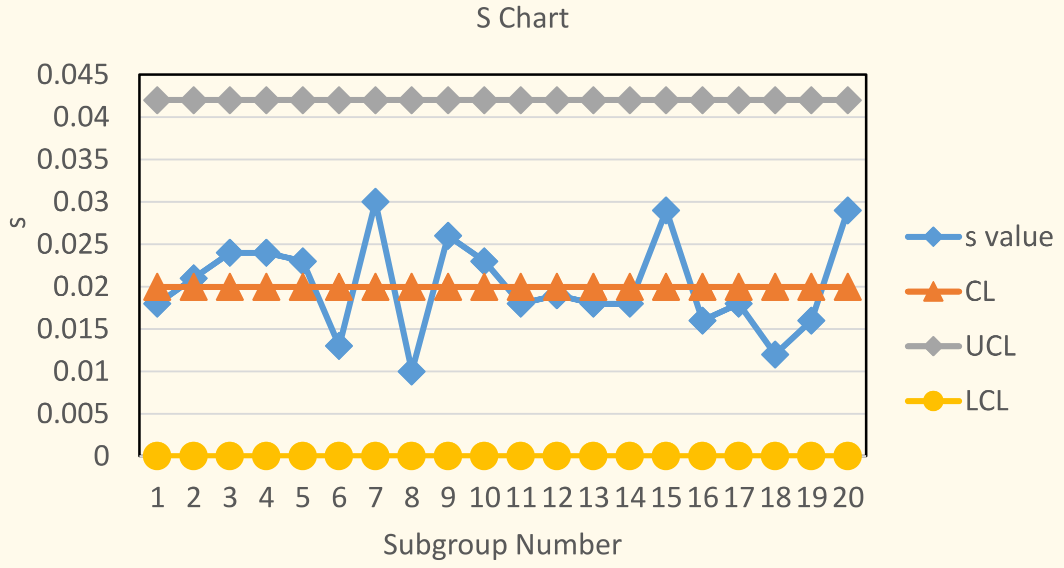
= 2.089(0.020)= 0.042

$B_3\bar{s}$

=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 subgroup size is 4. After 25 subgroup, Σ X = 13798 and Σ σ = 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

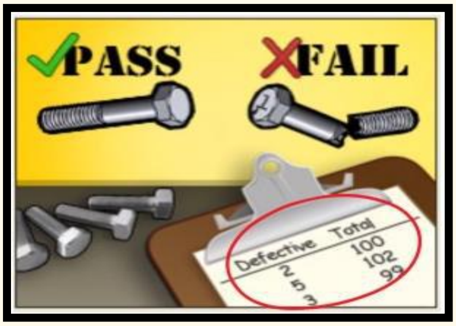
Topic 3

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	$\frac{np}{n}$	$\bar{p} = \frac{\sum np}{\sum n}$	$\bar{p} + 3\left(\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}\right)$	$\bar{p} - 3\left(\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}\right)$
	p_0	***CL***	***UCL***	***LCL***
np chart	$p_0 = \frac{\sum np}{\sum n}$	$\overline{np} = \frac{\sum np}{N}$	$\overline{np} + 3(\sqrt{\overline{np}\,(1-p_0})$	$\overline{np} - 3(\sqrt{\overline{np}\,(1-p_0})$
		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. Attribute Control Charts are used to determine whether the product is acceptable or not. 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. Calculate the center line and control limits for subgroup 30 Oct and 31 Oct. Show all related steps of calculation clearly.

ii. Construct the p chart for these data as in Table 3.1

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

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

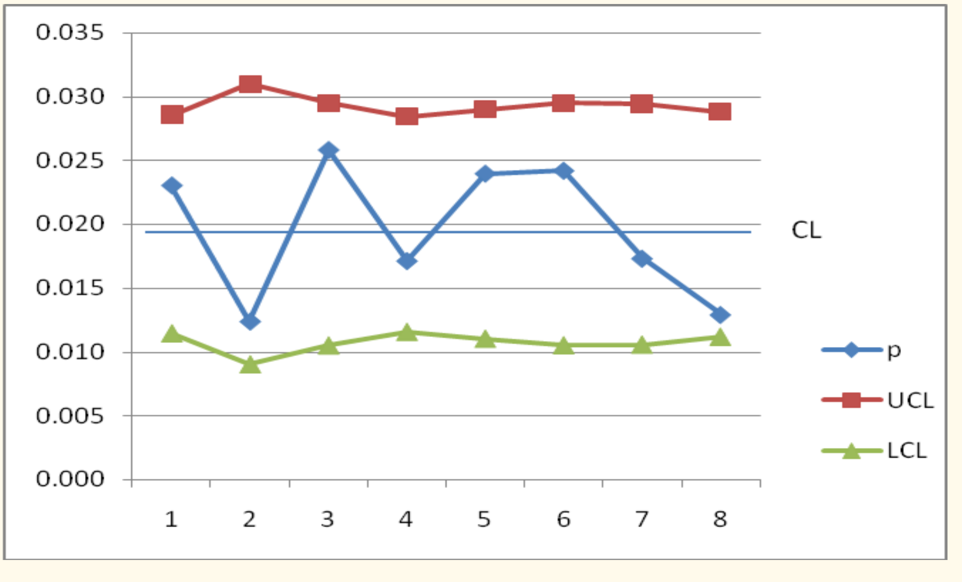
$$= 0.02 + 3\left(\sqrt{\frac{0.02(1-0.02)}{2385}}\right) = 0.029$$

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

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

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

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

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

$$p_o = 0.16$$

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

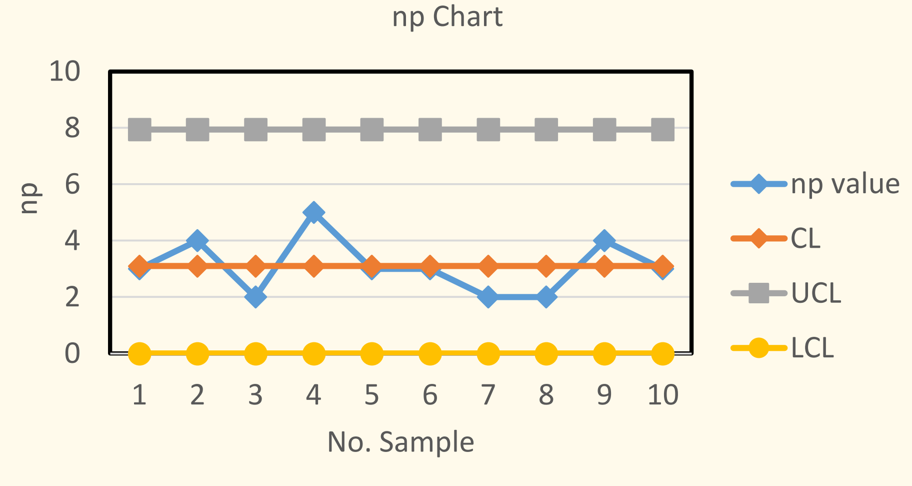
$$UCL = \overline{np} - 3\left(\sqrt{\overline{np}\,(1 - p_0}\right)$$

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

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

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

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

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

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

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

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

$$\bar{p} = 0.16$$

Step 2

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

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

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

$$= 0.41$$

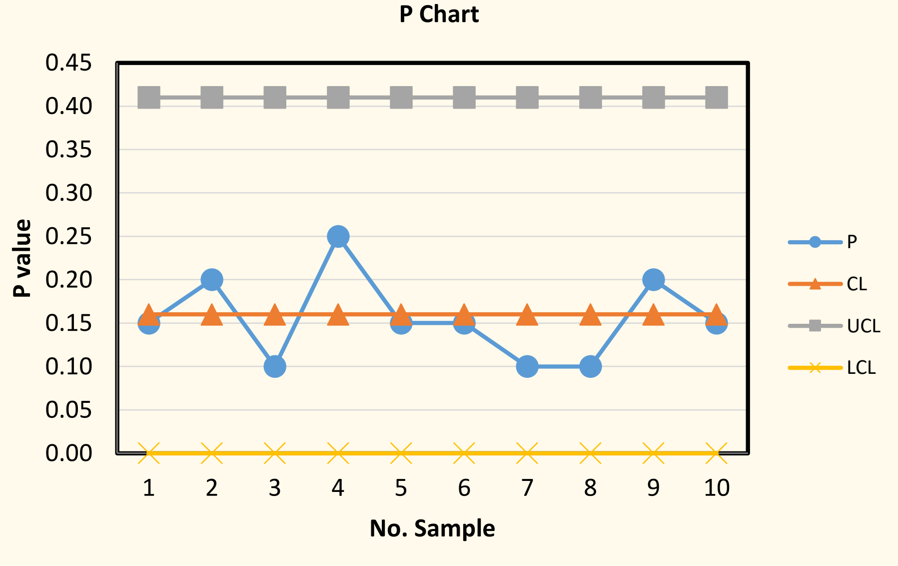
$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

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

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

$$= -0.09 \approx 0.00$$

Step 3



4. Determine:

   a) Trial central line and control limits

   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

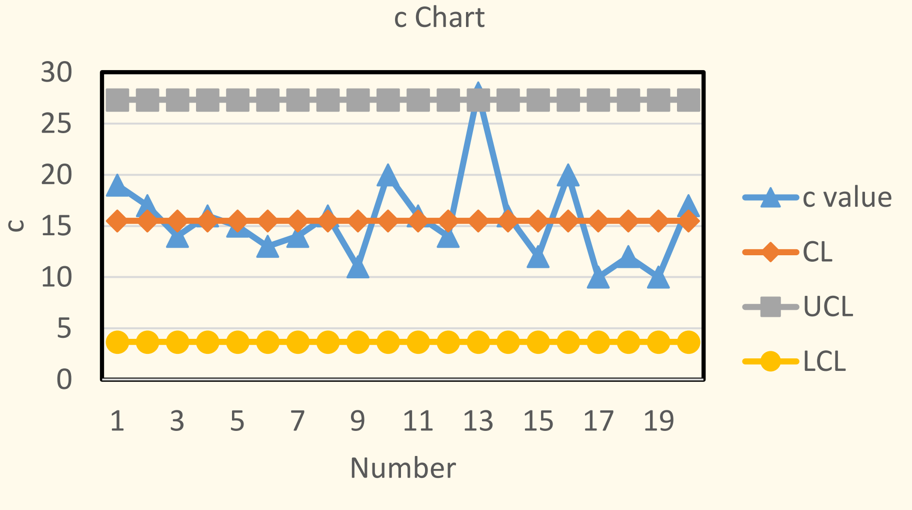
$$LCL = \overline{c} - 3\sqrt{\overline{c}}$$

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

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

$$LCL = 3.68$$

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

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

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

Step 3

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

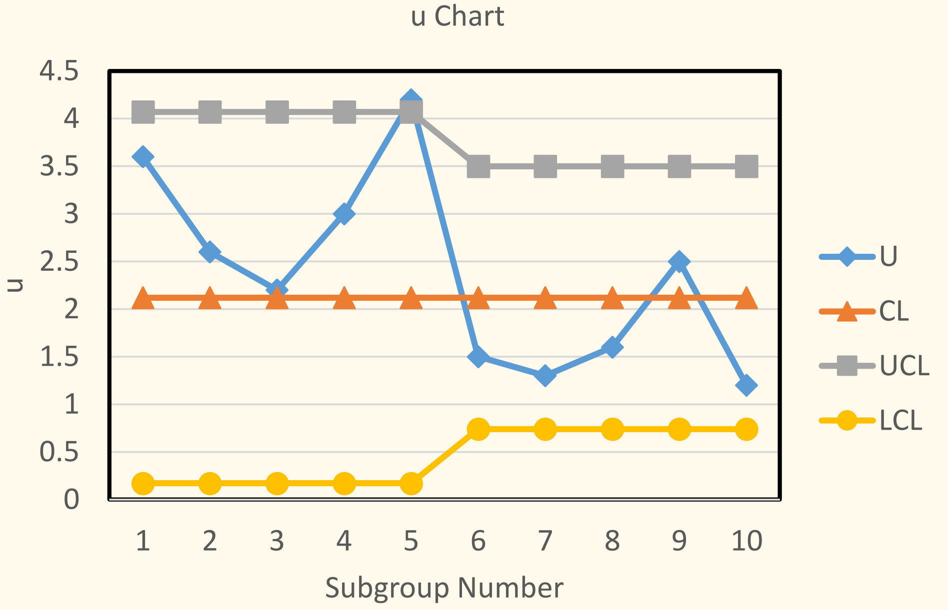
$$LCL_{1\text{-}5} = 2.12 - 3(\sqrt{\frac{2.12}{5}})=0.17$$

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 the test is destructive (such as a test on an electrical fuse or a tensile test) – all the product will be destroyed by testing.
- When the cost of 100% inspection is high in relation to the cost of passing a nonconforming unit.
- When there are many similar units to be inspected, sampling will produce as good.
- If vendor has excellent quality history

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	• Is more complicated than double or single sampling plan, but the technique is same like double sampling plan. More sampling than double sampling plan.

4.6 OC Curve

- the probability of accepting incoming lots.

Construct OC Curve

a) Assume **Po** value= 0.01, 0.02…

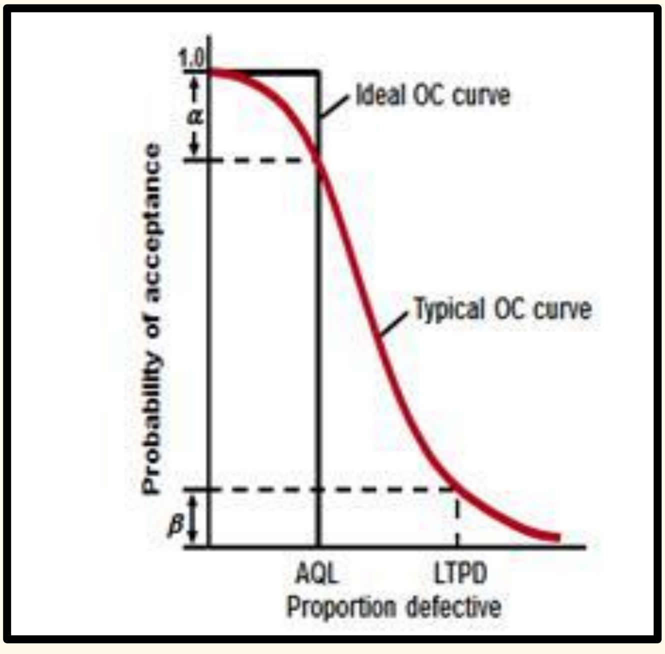
b) Calculate npo value

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*



4.7 Consumer- Producer Relationship

i. Producer's Risk

- When acceptance sampling is used, there is a conflicting interest between the consumer and the producer.
- The producer wants all acceptable lots accepted and the consumer wants all unacceptable lots rejected

Producer Risk

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

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

$\alpha = 0.05\ (0.001 - 0.10)$

α is not located on an OC curve

So:

$Pa = 1 - \alpha = 1 - 0.05 = 0.95$

Associated with the producer's risk is numerical definition of an acceptable lot, which is called Acceptable Quality Level (AQL).

ii. Consumer's Risk

Consumer Risk

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

LQL= in a lot or batch for which, for acceptance sampling purposes, the consumer wishes the probability of acceptance to be low.

Associated with the consumer's risk is a numerical definition of a nonconforming lot, called Limiting Quality Level (LQL).

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

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. "N= 9000, n_1= 60, c_1= 1, r_1= 5, n_2= 150, c_2= 6, and r_2= 7. An initial sample (n_1) of 60 is selected from the lot (N) of 9000 and inspected."

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 leading computer firm uses a sampling plan of n= 50 and c =0 regardless of lot sizes. Draw the OC curve using about 7 points. Use the OC curve to 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

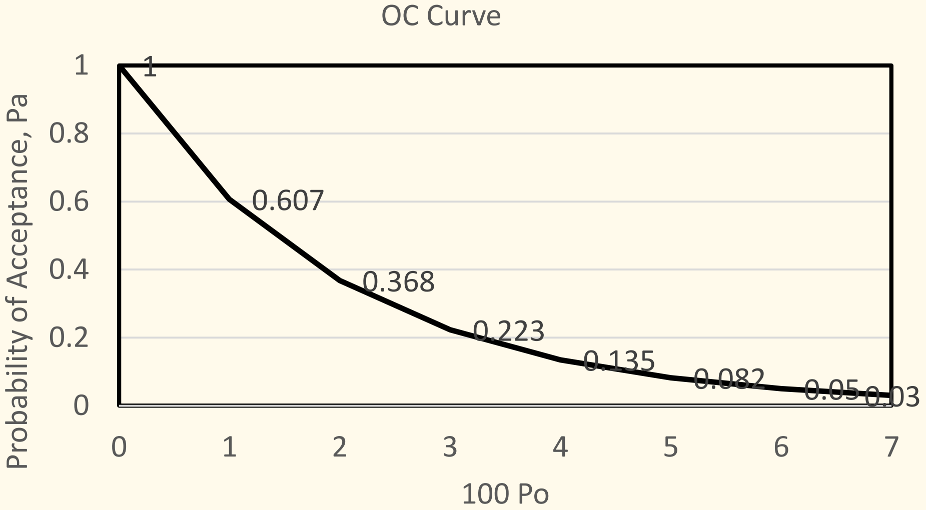
C. Cumulative Poission Distribution Table

	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

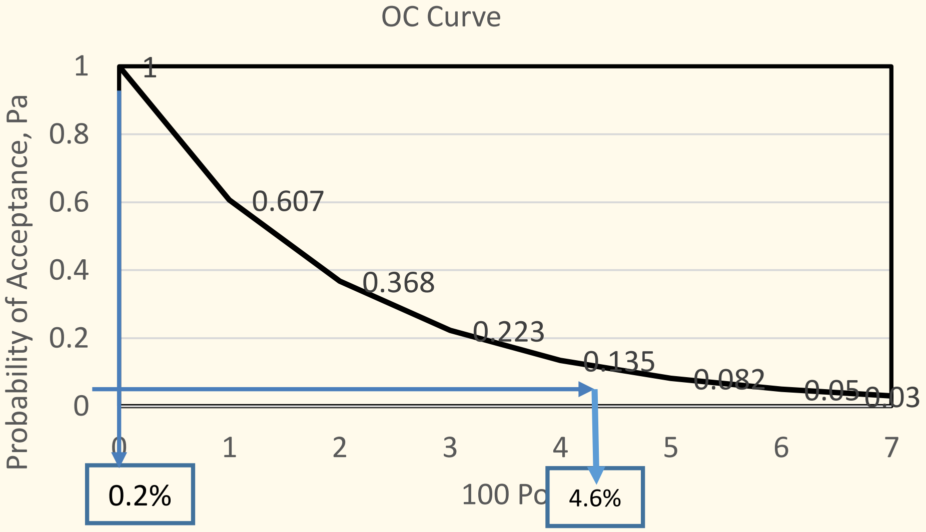
α = 0.05

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 Ac=3 Re=4	n= 200 Ac= 2 Re= 3	n= 80 Ac= 1 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 $\alpha = 0.05$ and the $\beta = 0.10$.

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

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

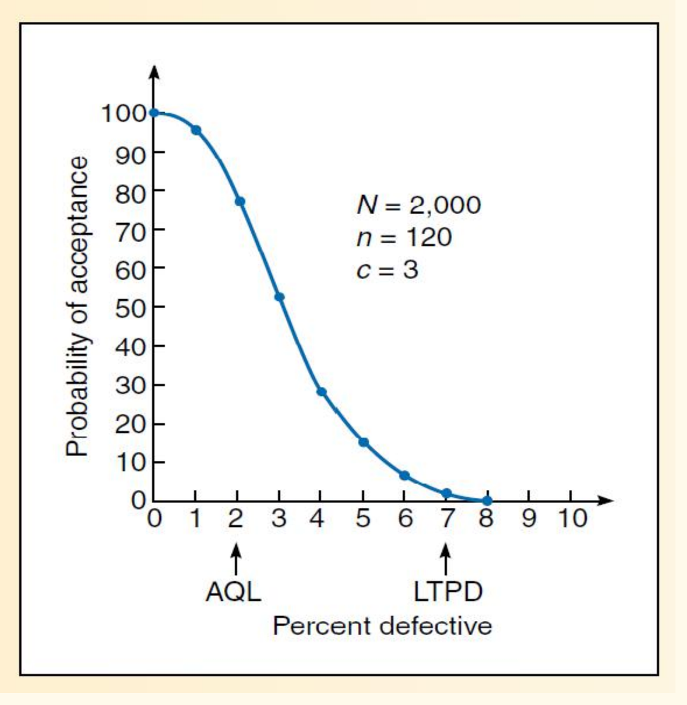
Answer:

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)

- A product that meets or exceeds its design specifications and is free of defects that degrade its performance is said to have **high quality of conformance**.
- Note that if an economy car is free of defects, it can have a quality of conformance that is just as high as defect-free luxury car.

- The purchasers of economy cars cannot expect their cars to be as opulently (wealthily) as luxury cars, but they can and do expect to be free of defects.
- **Quality Cost** or **Cost of Quality** means the costs to prevent, detect and dealing with defects cause.
- Instead the term quality cost refers to all of the costs that are incurred (earned) to prevent defects or that result from defects in products.
- The use of the term "quality cost" is confusing to some people. It does not refer to costs such as using a higher grade leather to make a wallet or using 14K gold instead of gold plating in jewelry.

5.2 Types of Quality Costs

- Prevention Costs
- Appraisal Costs
- Internal Failure Costs
- External Failure Costs

5.3 Prevention and Appraisal Costs: These are incurred (acquire) in an effort to keep defective products from falling into the hands of customers.

a) Prevention Costs

- to avoid having defects in the first place.
- It is much less costly to prevent a problem from ever happening than it is to find and correct the problem after it has occurred.
- **Prevention costs** support activities whose purpose is to reduce the number of defects.
- Companies employ many techniques to prevent defects for example statistical process control, quality engineering, training, and a variety of tools from total quality management (TQM).
- Examples: Systems development, Quality engineering, Quality training, Quality circles, statistical process control, Supervision of prevention activities, Quality data gathering, analysis, and reporting.

b) Appraisal Costs

- Sometimes called *inspection costs*, are incurred to identify defective products before the products are shipped to customers.
- Any defective parts and products should be caught as early as possible in the production process.
- Unfortunately performing appraisal activates does not keep defects from happening again and most managers realise now that maintaining an army of inspectors is a costly and ineffective approach to quality control.
- Examples: Test and inspection of incoming materials, Test and inspection of in-process goods, Final product testing and inspection, Supplies used in testing and inspection.

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 incurred when a product fails to conform to its design specifications.
- Failure costs can be either internal or external. **Internal failure costs** result from identification of defects before they are shipped to customers.
- The more effective a company's appraisal activities the greater the chance of catching defects internally and the greater the level of internal failure costs. This is the price that is paid to avoid incurring external failure costs, which can be upsetting.
- Examples: Net cost of scrap, Net cost of spoilage, Rework labor and overhead, Re-inspection of reworked products, Retesting of reworked products.

b) Appraisal Costs

- When a defective product is delivered to customer, external failure cost is the result.
- External failure costs usually give rise to another intangible cost. These intangible costs are hidden costs that involve the company's image. They can be three or four times greater than tangible costs. Missing a deadline or other quality problems can be intangible costs of quality.
- Examples: Cost of field servicing and handling complaints, Warranty repairs and replacements, Repairs and replacements beyond the warranty period, Product recalls, Liability arising from defective products, Returns and allowances arising from quality problems.

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 to avoid having defects in the first place.
  ii. Support activities whose purpose is to reduce the number of defects.
  iii. Include activities relating to quality control circles and statistical process control
- Appraisal cost
  i. Also called *inspection costs*,
  ii. Are incurred to identify defective products before the products are shipped to customers.
  iii. Any defective parts and products should be caught as early as possible in the production process.
- Internal failure costs,
  i. Internal failure costs result from identification of defects before they are shipped to customers.
  ii. These costs include scrap, rejected products, reworking of defective units, and downtime caused by quality problem.
- External Failure Costs
  i. Happened when a defective product is delivered to customer
  ii. Include warranty, repairs and replacements, product recalls, liability arising from legal actions against a company, and lost sales arising from a reputation for poor quality.

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

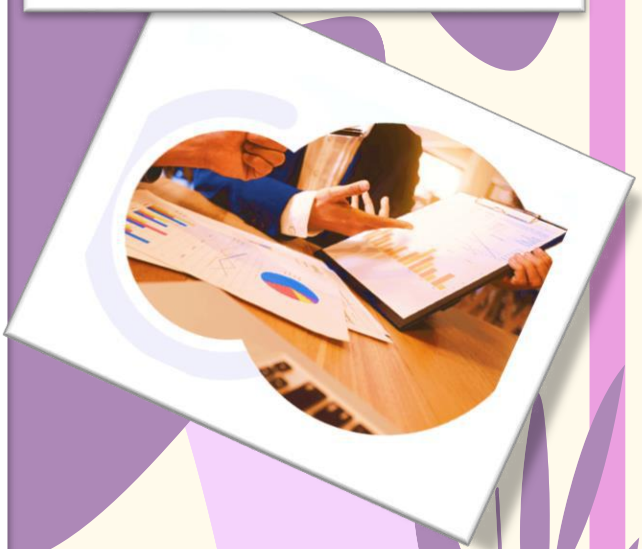
- External costs.
  - i. Cost of field servicing and handling complaints
  - ii. Warranty repairs and replacements
  - iii. Repairs and replacements beyond the warranty period.
  - iv. Product recalls
  - v. Liability arising from defective products
  - vi. Returns and allowances arising from quality 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 means of generating method.
- Brainstorming can be used to identify alternatives, obtain a complete list of items and to solve problems.

- There are a variety of brainstorming techniques.
- The common principle of brainstorming is to set aside the restrictive thinking processes so that many ideas can be generated.

6.2 Checksheet

- A basic tool for monitoring quality improvement processes
- Types of check Sheets

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

❑ **Cause Check Sheets**

Used to keep track of how often a problem happens or records the cause to a certain problem.

❑ **Classification Check Sheets**

Used to keep track of the frequency of major classifications involving the delivery of products or services


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

❑ **Distribution Check Sheets**

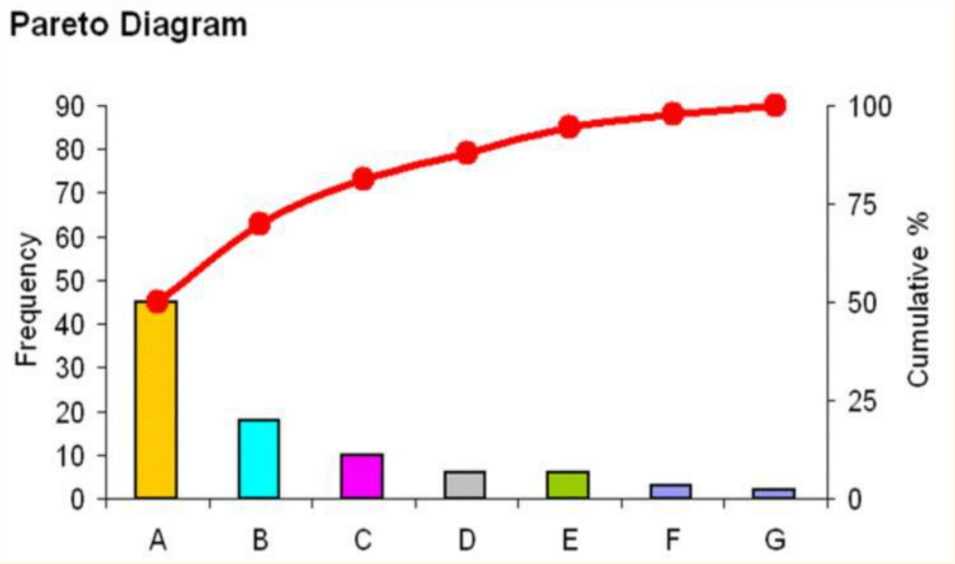
Used to collect data in order to determine how a variable is dispersed within an area of possible occurrences.

❑ **Location Check Sheets**

Highlights the physical location of a problem/defect in order to improve quality. They may also utilise visual(schematic) drawings of areas in order to record where problems are occurring.

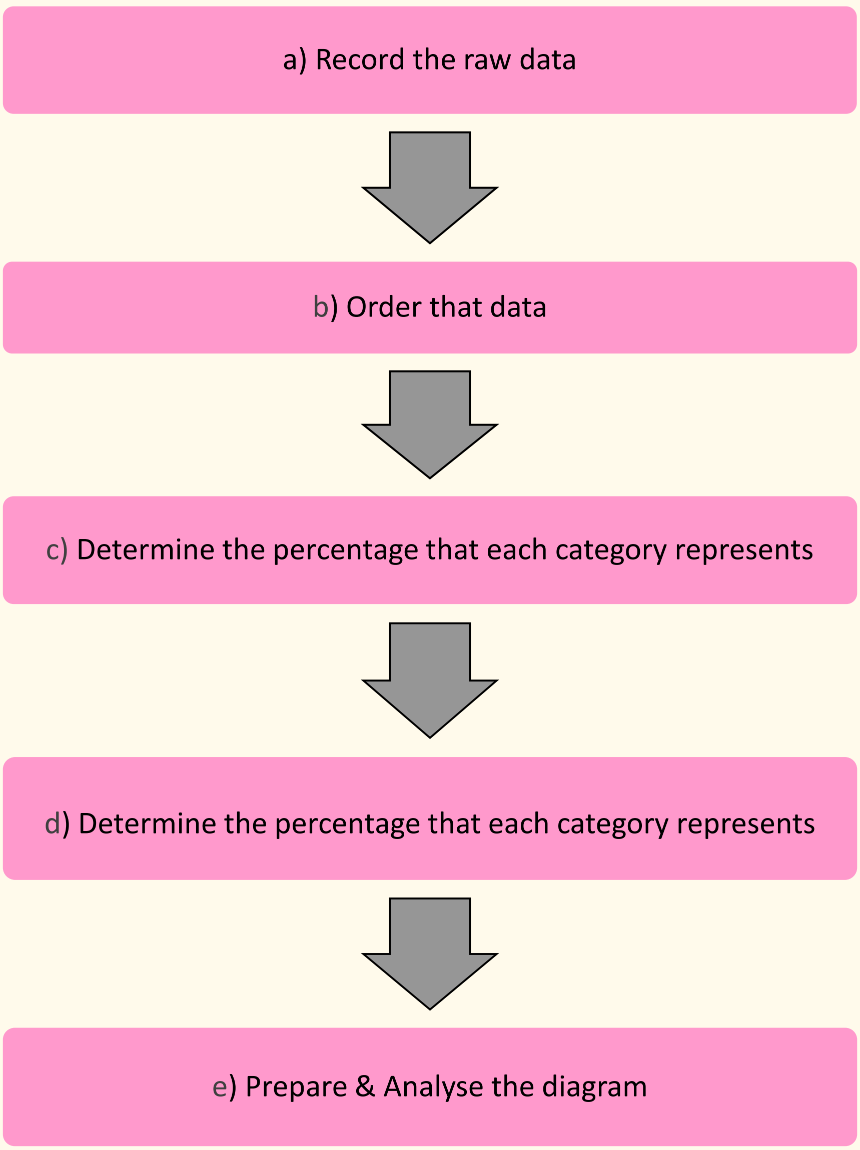
6.3 Pareto Diagram

- Pareto charts are used to identify and prioritize problems to be solved.
- They are actually histograms aided by the 80/20 rule adapted by Joseph Juran.
  - Remember the 80/20 rule states that approximately 80% of the problems are created by approximately 20% of the causes.



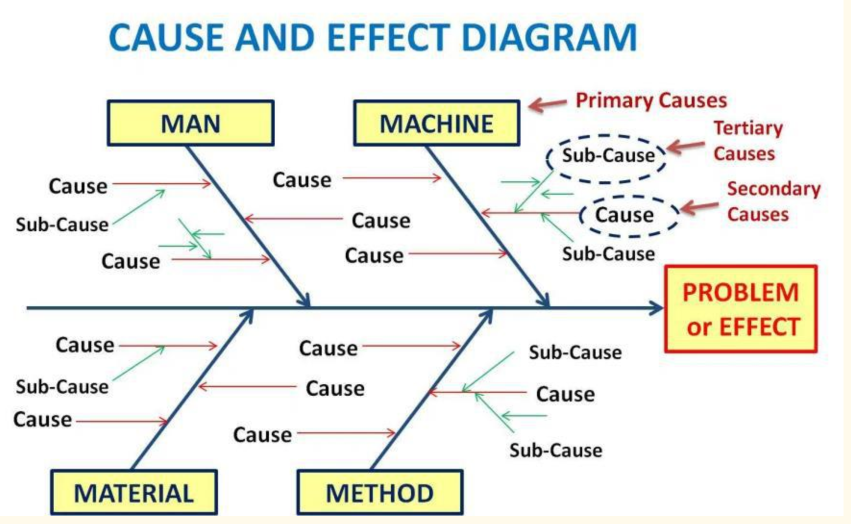
- Constructing a Pareto Chart
  - First, information must be selected based on types or classifications of defects that occur as a result of a process.
  - The data must be collected and classified into categories.
  - Then a histogram or frequency chart is constructed showing the number of occurrences.

6.3.1 Construction of Pareto Diagram



6.4 Cause and Effect Diagram

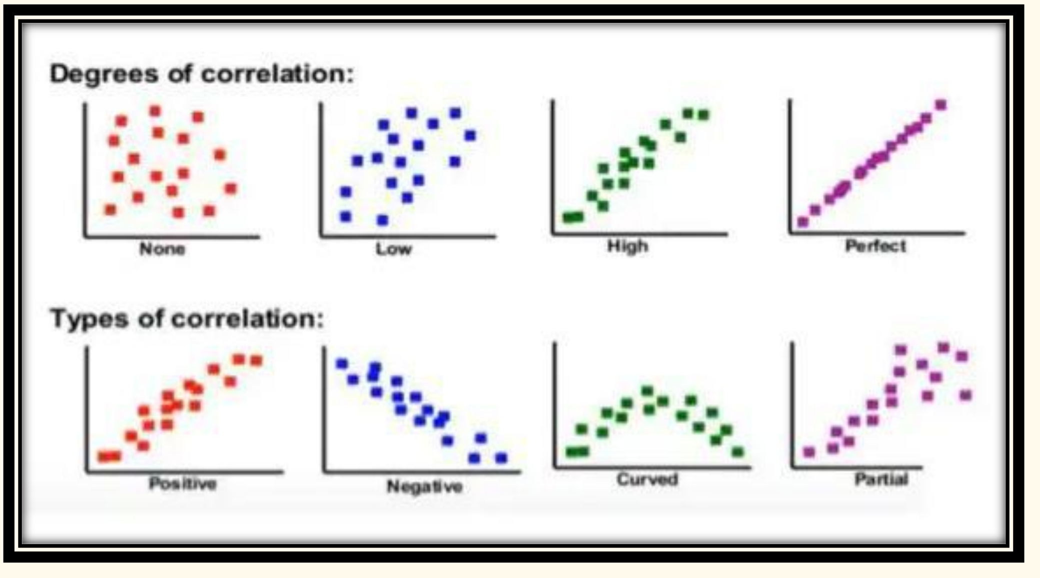
- The cause and effect diagram is also called the Ishikawa diagram or the fishbone diagram.
- It is a tool for discovering all the possible causes for a particular effect.
- The major purpose of this diagram is to act as a first step in problem solving by creating a list of possible causes.



- 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

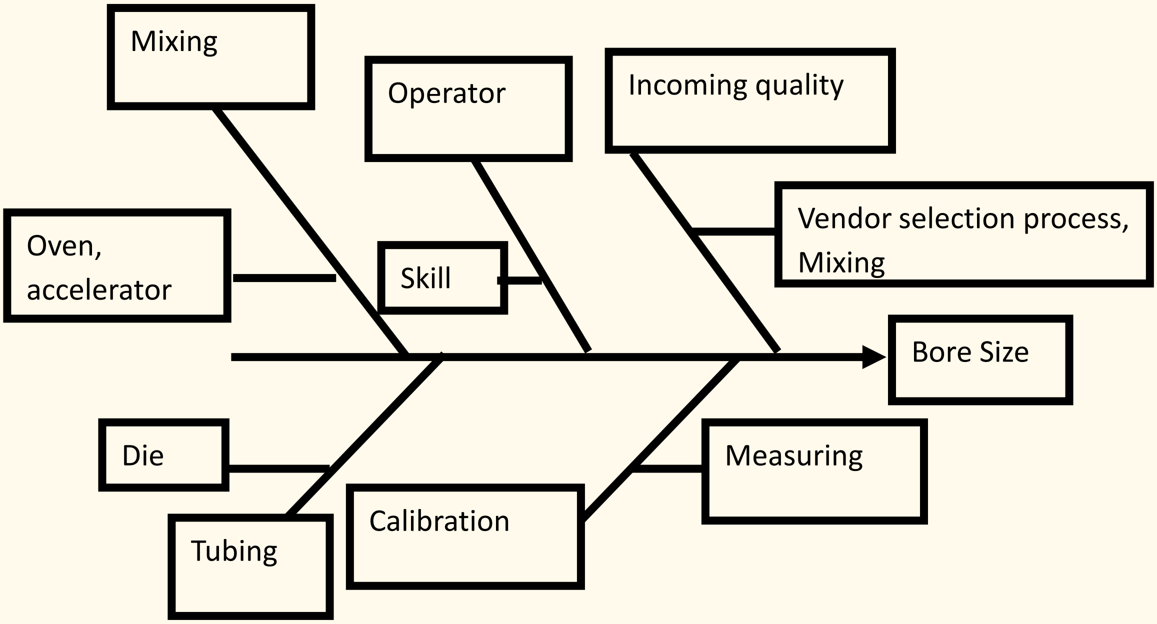
1. One the quality characteristic of interest in automobile tires is the bore size, which should be within certain specifications. In a cause and effect diagram, the final bore is the effect. Some of the main causes that influence the bore size are the incoming material, mixing process, tubing operation, 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**

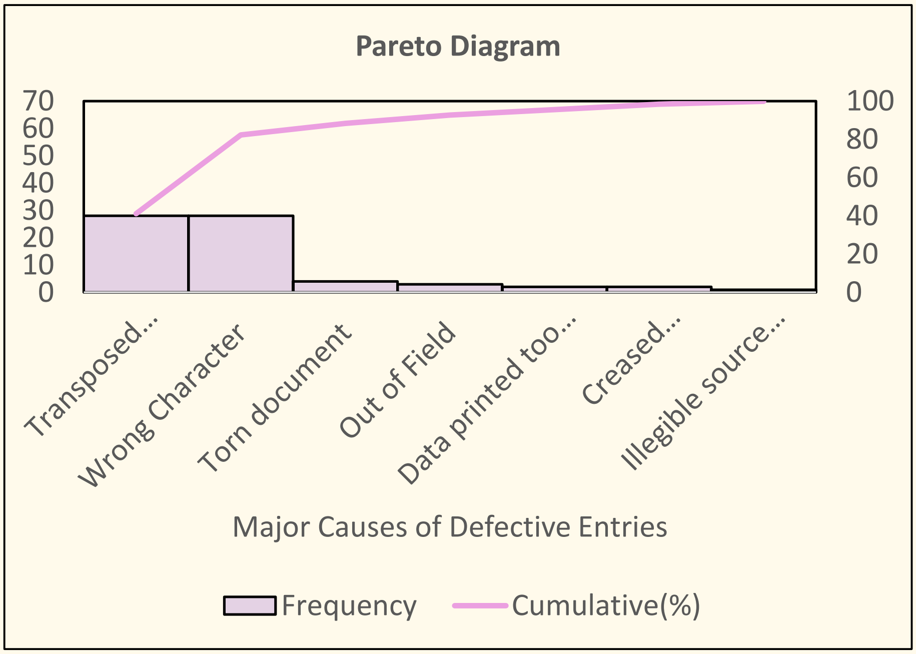
Step 2

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.

Sample data Table : Types of Errors Discovered During Surgical Setup

Error Type	Frequency
Wrong supplier	67
Excess count	24
Too few count	17
Wrong size	10
Wrong sterile instrument set	10
Missing item	8
Damage item	6
Other	2
TOTAL	**144**

Answer:

Step 1

Compute the percentage of annual usage for each item.

$$=\frac{67}{144}x100 = 46.5$$

Types of Errors Discovered During Surgical Setup		
Error Type	**Frequency**	**Percent**
Wrong supplier	67	46.5
Excess count	24	16.7
Too few count	17	11.8
Wrong size	10	6.9
Wrong sterile instrument set	10	6.9
Missing item	8	5.6
Damage item	6	4.2
Other	2	1.4
Total	144	100

Step 2

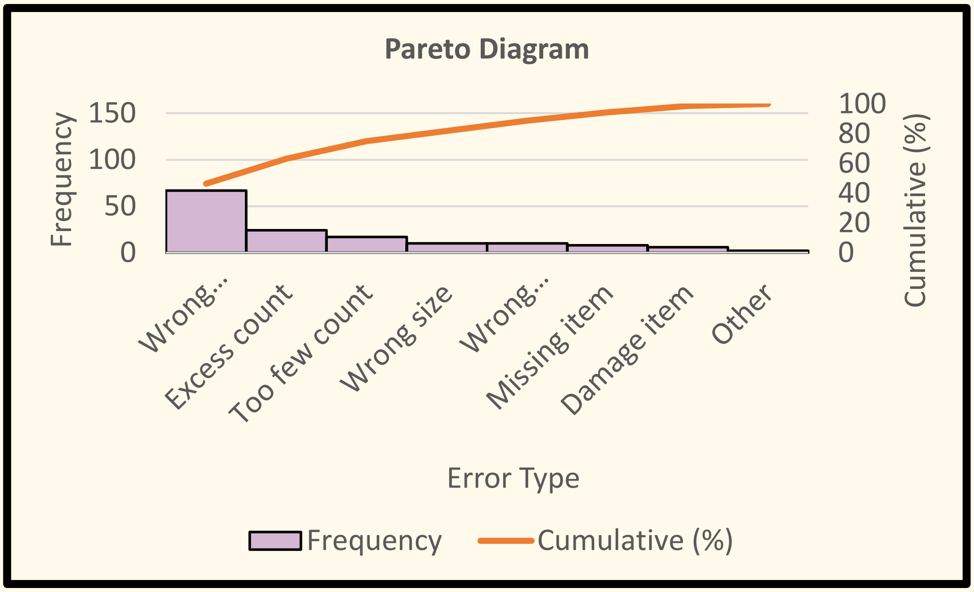
Calculate the cumulative consumption value (%).

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

Types of Errors Discovered During Surgical Setup			
Error Type	**Frequency**	**Percent**	**Cumulative %**
Wrong supplier	67	46.5	46.5
Excess count	24	16.7	63.2
Too few count	17	11.8	75
Wrong size	10	6.9	81.9
Wrong sterile instrument set	10	6.9	88.8
Missing item	8	5.6	94.4
Damage item	6	4.2	98.6
Other	2	1.4	100
TOTAL	144	100	

Step 3

Construct Pareto diagram.



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