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Construction Three Charts Based on Inter Quartile Range and Comparison of Efficiency with Three Charts Based on Range

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ABSTRACT

This study addresses an important application of statistics in the field of industry, which is known as statistical process control. Producing high quality products order to meet consumer fulfillment requirements had always been the main issue of the quality management. In this paper, Construction of three statistical quality control charts based on inter quartile range and compared with three quality control charts based on range to justify the efficiency and sensitively of the new charts for detecting are out of control cases.

Keywords:

Quality control charts;
Inter quartile range;
Range.

I. Introduction

The main objective of any productivity operation is to get high quality materials and conform to the specifications so as to meet consumer desires. The quality is a principle in which some may think it is new, but it is as old as human, because the man was still in a permanent search for a good thing, and paying attention to the quality. Quality has great care in the industrialized developed countries being of economies exporter seek to control the foreign markets. In the early twentieth century, quality control practices were limited to inspecting finished products and removing defective items. But this all

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changed as the result of the pioneering efforts of a young engineer named Walter A. Shewhart. In 1924 Shewhart prepared a memorandum that included a set of principles that are the basis for what is known today as the process control. And his memo also contained a diagram that would be recognized as a statistical control chart. Continuing his work in quality at Bell Telephone Laboratories in USA until his retirement in 1956, he brought together the disciplines of statistics, engineering, and economics and in doing so changed the course of industrial history. Shewhart is recognized as the father of statistical quality control.[4]

The recent development in the field of quality control charts is the composition of new quality control charts dependent in decision taken on more than one point to overcome some of the deficiencies found in the Shewhart's chart, many studies have been conducted for this purpose, prompting many researchers to continuously think to fulfill this goal.

In Iraq, the Iraqi researchers contributed in this area by publishing of many studies about quality control.

Quality Control Charts[4] [3]

A quality control chart (also called process chart) is a graph that shows average for the data (output) or the product fall within the common or normal range of variation if the process is under statistical control. Quality control charts were first invented by Walter A. Shewhart, and developed by him and his associates. He published a complete exposition of control charts in 1931. Which was used by Shewhart in the construction of his charts. He concluded that a distribution can be transformed into a normal shape by estimating its mean and standard deviation. Shewhart`s idea was whether the production process is going well and natural and the points plotted on the chart follow a normal distribution. For these reasons, Shewhart resorted to use the normal distribution in the construction of his charts.

Shewhart control charts consist of three parallel lines which are:

1. Center Line (or target line) of the control chart is the mean, or overall average, of the quality characteristic that is being measured, and symbolized as T.

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2. The upper control limit (UCL) is the maximum acceptable variation from the mean for a process that is in a state of control.

   Mathematically expressed as: $UCL = T + 3\sigma$

3. Lower control limit (LCL) is the minimum acceptable variation from the mean for a process that is in a state of control.

   Mathematically expressed as: $LCL = T - 3\sigma$

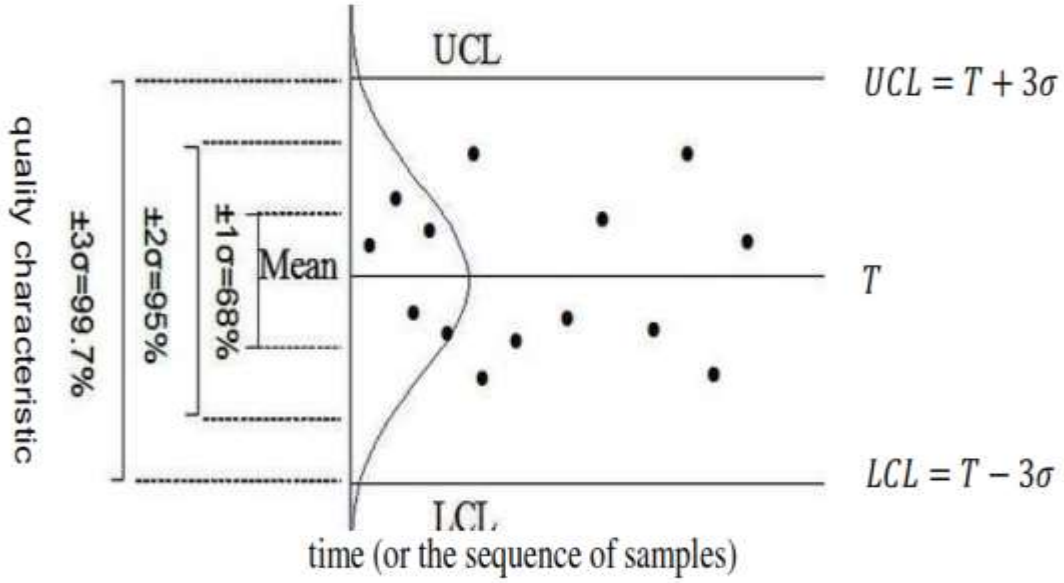

Figure 1: Normal distribution of continuous variables

Classification of control charts[3] [1] [5]

Control charts may be classified into two main types, which are:

1. Variable Control Charts

These charts are used in process control of products when the items produced are measurable (in one of the units of measurement).

The most important types of variable control charts can be divided into two types:

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1. Shewhart Variable Charts: the most familiar Shewhart charts are

a. Average – Chart (or $\bar{x}$- chart)
b. Standard Deviation- Chart (S-chart)
c. Range - Chart (R-chart)
d. Individual – Chart(X- chart).
e. Median chart (Me- chart).

2. **Non-Shewhart Variable Charts:** the most popular

A. Classic Variable Charts:[5] [7]

a. Cumulative sum control chart(CUSUM-chart)
b. Moving average chart (MA-chart)
c. Moving range chart (MR-chart)
d. Geometric Moving average chart (GMA-chart)

2. Attributes Control Charts

Attribute control charts are used when:
(a) Measurements are not possible (e.g., defect such as dented cans).
(b) Measurements are not practical (e.g., lengthy chemical analyses of raw products).
(c) Several characteristics are combined on one chart (e.g., counts of different kinds of defects). In this case, the various characteristics can be lumped together into a single chart, or at most two or three charts, each covering that group of characteristics which reflects their importance such as minor, major, and critical.[5] [1]

The attribute control charts can be classified into: [5] [6]

a. Defective or nonconforming chart. p-chart (fraction nonconforming)
b. np-chart (number nonconforming).
c. Defects or nonconformities charts. C-chart (number of nonconformities).

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d. U-chart (average number of nonconformities).

The following are charts used in this paper:

1- Inter quartile range chart:[2]

The inter quartile range (IQR) is a measure of variability, based on dividing a data set into quartiles. These quartiles divide a rank-ordered data set into four equal parts. The values that divide each part are called the first, second, and third quartiles; and they are denoted by Q1, Q2, and Q3, respectively.

- Q1 is the "middle" value in the first half of the rank-ordered data set.
- Q2 is the median value in the set.
- Q3 is the "middle" value in the second half of the rank-ordered data set.

The interquartile range is equal to Q3 minus Q1.

The center line of the IQR chart is the average interquartile range.

$$\overline{IQR} = \sum_{j=1}^{m} IQR_j / m$$

The lower and upper control limits are:

$$UCL = D_4 \overline{IQR}$$

$$LCL = D_3 \overline{IQR}$$

The points plotted are the values of quality characteristic (interquartile range of the i-th subgroups).

2- **Range chart:**[3] [1]

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This chart controls the process variability since the sample range is related to the process standard deviation. When the sample size is relatively small (less than 10), the center line of the R chart is the average range.

$$\bar{R} = \sum_{j=1}^{m} R_j / m$$

The lower and upper control limits are:

$$UCL = D_4 \bar{R}$$

$$LCL = D_3 \bar{R}$$

Where

D_4, D_3: Factors for Computing Central Lines and Control Limits based on sample size (n). [3] [1]

The points plotted are the values of quality characteristic (range of the i-th subgroups).

3- Xbar chart based on range

Use **x-bar** charts to monitor the changes in the mean of a process,

The center line of the xbar chart is calculated as follows:

$$\bar{\bar{x}} = \sum_{1}^{m} \bar{x}_j / m$$

The control limits of the mean chart based on range is calculated as follows:

$$UCL = \bar{\bar{x}} + A_2 \bar{R}$$

$$LCL = \bar{\bar{x}} - A_2 \bar{R}$$

A_2: Factors for Computing Central Lines and Control Limits based on sample size (n).[3] [1]

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The points plotted are the values of quality characteristic (xbar of the i-th subgroups).

4- **Xbar chart based on inter quartile range**.

Use **x-bar** charts to monitor the changes in the mean of a process

The control limits of the mean chart based on range is calculated as follows:

$$UCL = \bar{\bar{x}} + A_2 \overline{IQR}$$

$$LCL = \bar{\bar{x}} - A_2 \overline{IQR}$$

A_2 : Factors for Computing Central Lines and Control Limits based on sample size (n).[3] [1]

5-Median chart based on range

The center line is the median value of all subgroup medians, and the control limits are based on the median of all subgroup ranges[1]

$$T = \tilde{\bar{M}}e = Median(Me_1, Me_2, ..., Me_m)$$

The values plotted are the median of each subgroup.

$$UCL = \tilde{\bar{M}}e + A_5\ Me(R_1, R_2, ..., R_m)$$

6-Median chart based on inter quartile range

The center line is the median value of all subgroup medians, and the control limits are based on the median of all subgroup ranges

$$LCL = \tilde{\bar{M}}e - A_5\ Me(R_1, R_2, ..., R_m)$$

$$T = \tilde{\bar{M}}e = Median(Me_1, Me_2, ..., Me_m)$$

$$UCL = \tilde{\bar{M}}e + A_5\ Me(IQR_1, IQR_2, ..., IQR_m)$$

$$LCL = \tilde{\bar{M}}e - A_5 Me(IQR_1, IQR_2, ..., IQR_m)$$

The values plotted are the median of each subgroup.

A_5 : Factors for Computing Central Lines and Control Limits based on sample size (n)[7] [1]

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Number of Observations in Sample Sample size (*n*)	**Factor for X-bar Chart (A_2)**	**Factor for Lower control Limit in Range chart (D_3)**	**Factor for Upper control limit in Range chart (D_4)**	**Factor to estimate Standard deviation, (d_2)**	**Factor for Median Chart (A_5)**
2	1.88	0	3.27	1.128	2.224
3	1.02	0	2.57	1.693	1.265
4	0.73	0	2.28	2.059	0.829
5	0.58	0	2.11	2.326	0.712
6	0.48	0	2.00	2.534	0.562
7	0.42	0.08	1.92	2.704	0.520
8	0.37	0.14	1.86	2.847	0.441
9	0.34	0.18	1.82	2.970	0.419
10	0.31	0.22	1.78	3.078	0.369

Application

In this section, we apply both charts. The data collected on real-data of water quality (Chlorine) to the new suggested charts as well as to some existed charts. We used (Statgraphics 4.0 and Microsoft Excel) for computation purpose. The data consists of (100) observations.

Table1: The data of water quality (Chlorine)

sample.No	X_1	X_2	X_3	X_4	X_5	**Xbar**	**Median**	**Range**	**IQR**
1	21.3	21.3	21.3	24.85	17.75	**21.3**	**21.3**	**7.1**	**3.55**
2	21.3	24.85	21.3	21.3	21.3	**22.01**	**21.3**	**3.55**	**1.775**
3	24.85	21.3	17.75	21.3	17.75	**20.59**	**21.3**	**7.1**	**5.325**
4	17.75	17.75	14.2	17.75	17.75	**17.04**	**17.75**	**3.55**	**1.775**
5	21.3	21.3	14.2	10.65	24.85	**18.46**	**21.3**	**14.2**	**10.65**
6	21.3	24.85	21.3	24.85	28.4	**24.14**	**24.85**	**7.1**	**3.55**
7	17.75	21.3	21.3	21.3	24.85	**21.3**	**21.3**	**7.1**	**3.55**
8	24.85	21.3	17.75	14.2	21.3	**19.88**	**21.3**	**10.65**	**7.1**
9	14.2	17.75	21.3	21.3	17.75	**18.46**	**17.75**	**7.1**	**5.32**
10	21.3	17.75	17.75	17.75	21.3	**19.17**	**17.75**	**3.55**	**3.55**
11	21.3	17.75	21.3	21.3	17.75	**19.88**	**21.3**	**3.55**	**3.55**

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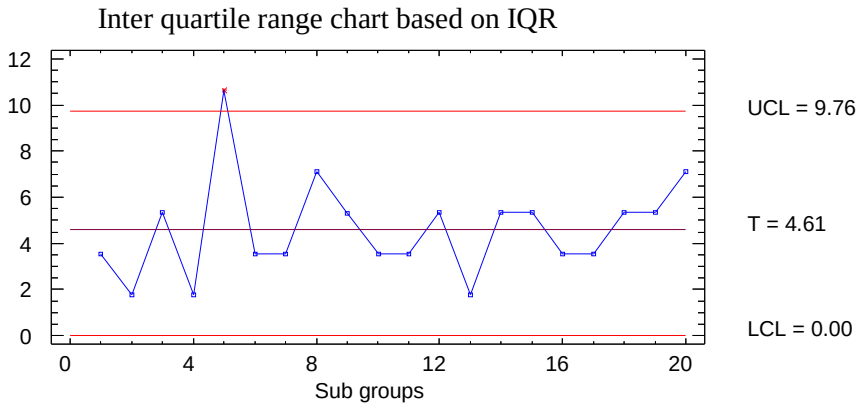
12	17.75	17.75	21.3	14.2	14.2	**17.04**	**17.75**	**7.1**	**5.325**
13	21.3	24.85	21.3	21.3	21.3	**22.01**	**21.3**	**3.55**	**1.775**
14	21.3	17.75	14.2	21.3	17.75	**18.46**	**17.75**	**7.1**	**5.325**
15	24.85	21.3	21.3	24.85	17.75	**22.01**	**21.3**	**7.1**	**5.325**
16	17.75	21.3	24.85	21.3	21.3	**21.3**	**21.3**	**7.1**	**3.55**
17	21.3	24.85	24.85	24.85	21.3	**23.43**	**24.85**	**3.55**	**3.55**
18	24.85	17.75	21.3	17.75	21.3	**20.59**	**21.3**	**7.1**	**5.325**
19	14.2	17.75	14.2	14.2	21.3	**16.33**	**14.2**	**7.1**	**5.325**
20	14.2	24.85	24.85	24.85	21.3	**22.01**	**24.85**	**10.65**	**7.1**

Construction Control Charts for data of water quality (Chlorine)

1. Inter quartile range chart



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2. Range chart

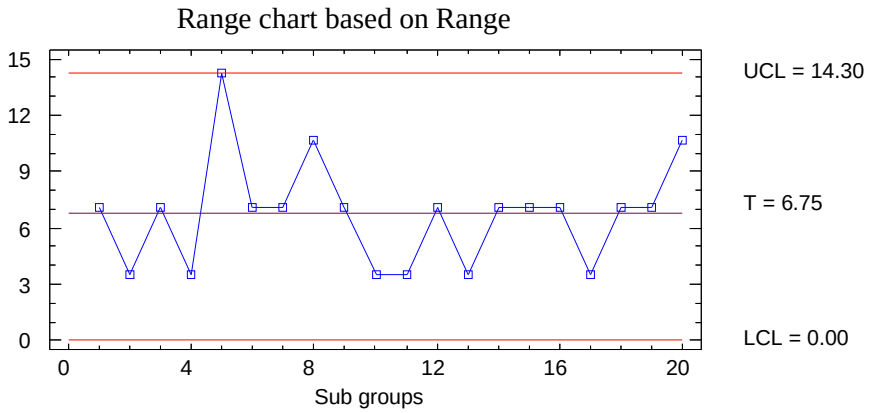
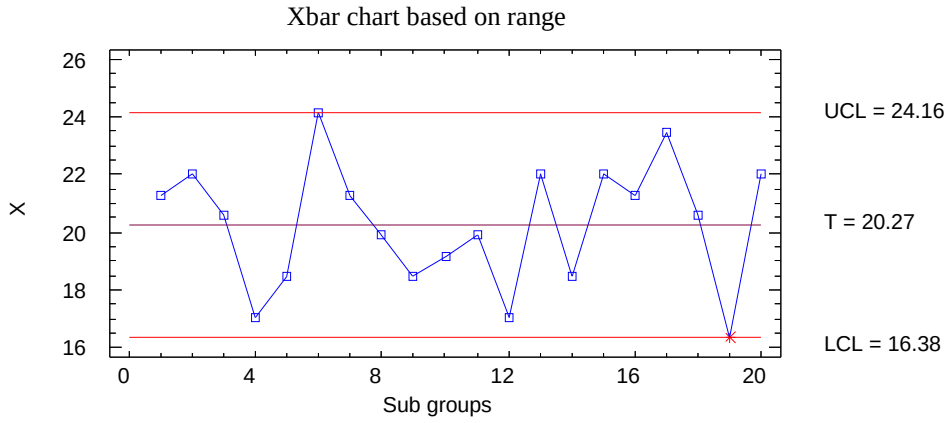


Table2. Comparison of Efficiency between (IQR chart& Range chart)

	Result	
	IQR chart	Range chart
UCL	9.76	14.30
CL	4.61	6.75
LCL	0	0
Out of control	1	0

3- Xbar chart based on range



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4- Xbar chart based on inter quartile range

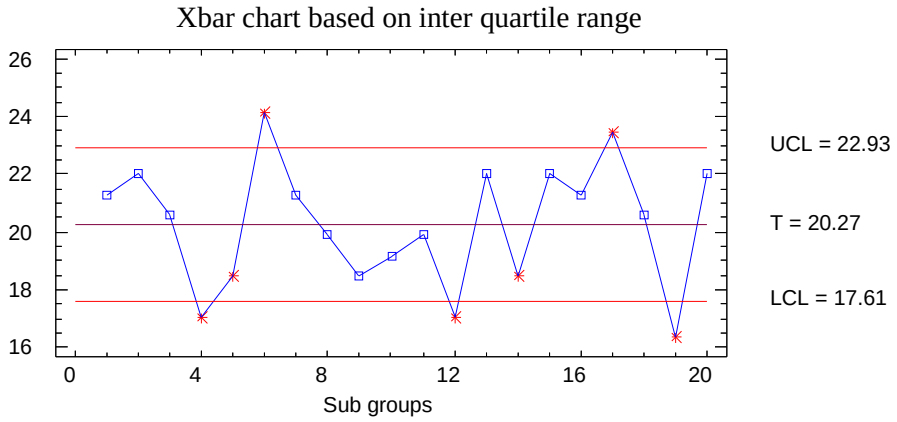
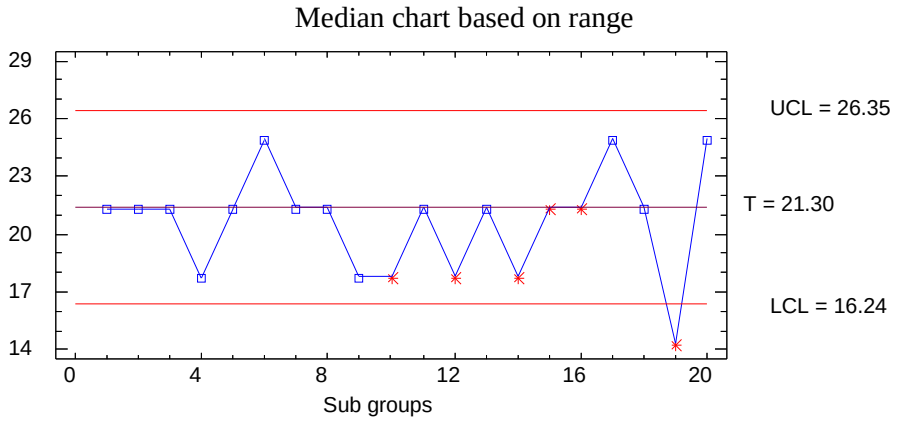


Table3. Comparison of Efficiency between (Xbar chart based on IQR & Xbar chart based Range)

	Result Xbar chart based on IQR	Xbar chart based on Range
UCL	22.93	24.16
CL	20.2705	20.2705
LCL	17.61	16.38
Out of control	5	1

5-Median chart based on range



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6-Median chart based on inter quartile range

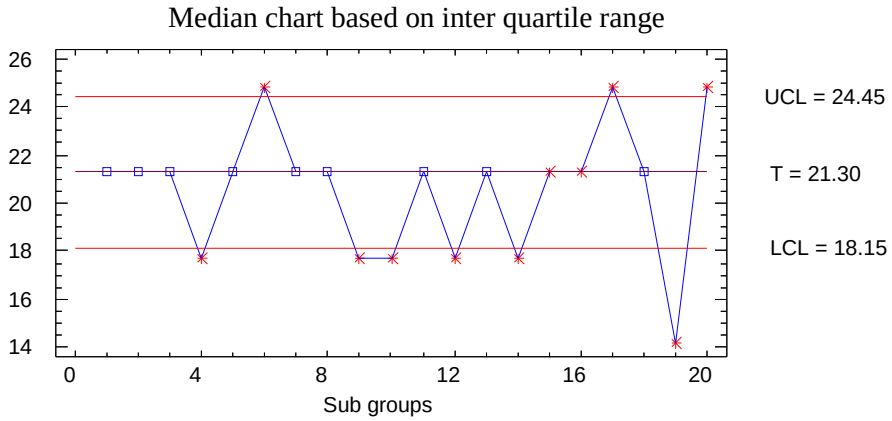

Table4. Comparison of Efficiency between (Median chart based on IQR & Median chart based Range)

	Result	
	Median chart based on IQR	Median chart based on Range
UCL	24.45	26.35
CL	21.3	21.3
LCL	18.15	16.24
Out of control	9	1

II. Conclusion

The outcome of data show three charts based on inter quartile range are better than three charts which are based on range because in the three charts which are based on inter quartile range points fall outside more than and the control limits interval charts based on inter quartile range are smaller than the control limits interval of the three charts based on range.

References

1. Besterfield, D. H. (2009) "Quality Control". 8th Edition. New York: Prentice-Hall Inc.

2. Besterfield, D. H. (2004) "Quality Control". 7thEdition, Prentice-Hall Inc. New York, U.S.A.

3. Grant, E. L. & Leavenworth, R. S. (1988) "Statistical Quality Control". 6th Edition, McGraw-Hill. Book Company. New York, U.S.A.

4. Montgomery, D. C. (2005): Introduction to Statistical Quality Control". 5thEdition, John Wiley & Sons Inc. New York, U.S.A.

5. Nandini, Das. (2008) "A Non-parametric Control Chart for Controlling Variability Based on Squared Rank Test", Journal of Industrial and Systems Engineering, Vol. 2, No. 2, pp 114-125.

6. Nanthakumar, C. & Vijayalakshmi,S. "Construction of Interquartile range (IQR) control chart using process capability for mean" International Journal of Modern Sciences and Engineering Technology(IJMSET) ,Volume 2, Issue 10, 2015, pp.52-59.

7. Salihi, Hazha, B. Q. (2015) "Constructing Bayesian and Maximum Likelihood Quality Control Charts using Logistic Distribution with Application" Unpublished MSc. of Science in Statistics. College of Administration and Economics at Salahaddin University –Erbil.