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ABSTRACT

This module for a 1-semester Total Quality Management (TQM) course for high school or community college students gives a brief introduction to some statistical tools. It includes a section on process variation that is intended to familiarize students with the causes of variation such as common and special causes. Statistical definitions are given for common statistical terms such as "mean" and "standard deviation," with examples to aid students in understanding the meanings of the terms. Run charts and control charts are described. An eight-step process is defined for the use of control charts, and two examples are provided. An example of a run chart also is provided. A bibliography lists six references. Handouts and transparency masters are included. (KC)

TOTAL QUALITY MANAGEMENT (TQM):

TRAINING MODULE

ON

" STATISTICAL PROCESS CONTROL "

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June 1, 1993

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STATISTICAL PROCESS CONTROL

CONTENTS:

STATISTICAL PROCESS CONTROL

INTRODUCTION:

This Total Quality Management module on Statistical Process Control is intended to give a brief introduction to some statistical tools that can be easily used. This module includes a section on Process Variation where the student will learn about causes of variation such as common and special causes.

Statistical definitions will be given for common statistical terms such as "mean" and "standard deviation." Examples will be given to assist the student in better understanding the meaning of these words/terms. The student will become familiar with the concept of run charts and control charts. This will be the extent of the statistical process control described in this module.

An eight-step process is defined for the use of control charts. This section will allow the student to become familiar with control charts and how to use them through the step-by-step description. An example is provided that will allow the student to become familiar with the use of control charts.

There are three examples provided that will help the student become familiar with the control chart. The first example is an industrial example of using a control chart to measure the drilling of a hole in a metal plate. The second example is one of monitoring the temperature in a classroom. This will also allow the student to see how a control chart can be used in a practical application. The third example is one of a run chart instead of a control chart, but the characteristics are common with those of a control chart. The students should be able to understand the differences by studying this example.

STATISTICAL PROCESS CONTROL

NARRATIVE:

Since statistical process control typically relates to the control of a process, a brief introduction will be given to process variation. Process variation is defined along with the common causes and special causes of variation. An example of process variation is given which relates to the arrival time of students at school. This example is used to describe both a small and large variation, as well as common causes and special causes of variation.

An example of common causes, is explained in the delay in arrival at school, where the common cause of delay would be the traffic around the school. The times parents go to work and leave their children at school causes congestion when entering the school grounds. In one example provided, a couple of special causes of variation are; 1) the school bus broke down, and 2) a train wreck blocked the crossing to the school. In another example, a student measures the time it will take her, from the time the alarm goes off, until she leaves for school in the morning. These examples will give the person reviewing them an opportunity to better understand how to take measurements of the process and also some of the special causes and common causes of process variation.

Statistical process control can be a very intimidating subject. This module is intended to make the definition as basic as possible but yet give the student a good introduction to the subject matter. The statistical definitions provided describe distributions, averages and standard deviations of distributions. They also describe variances and the definition of run charts and control charts. The upper and lower control limits are described, related to control charts. Examples are given to help in the definitions.

A control chart process has been developed in order to help the novice understand how to make and use control charts. This eight-step process is presented in the section called Control Chart Process. These eight steps are:

- Step 1: Determine Process to Monitor
- Step 2: Determine Key Process Data to Collect
- Step 3: Collect Data
- Step 4: Develop Control Chart
- Step 5: Analyze Chart
- Step 6: Take Action as Required
- Step 7: Continue Collecting Data
- Step 8: Return to Step 4

These eight steps will allow the student to understand how to determine which process to monitor, what data to collect, as well as, give them some ideas on collecting data and then more detailed information on how to develop a control chart and analyze the chart. Steps

6 - 8 are very much like Problem Solving since action is required as a result of the use of the control chart. In fact, the use of the control chart along with good problem solving techniques is very important.

The use of statistical process controls such as control charts could be very helpful in the continuous improvement effort within Total Quality Management. It becomes evident that the disciplines of Total Quality Management such as continuous improvement, problem solving and statistical process control have a lot in common. Used in conjunction, these can be very powerful tools in making the improvements necessary to meet the customer's needs.

Three examples are given to assist the student in understanding the use of control charts. The first example describes a manufacturing process of drilling holes. This process uses all eight steps of the control chart process. The second example is an example from school. The temperature in the Biology Lab seems to vary greatly. The students and the teacher use the control chart process to determine if the temperature in the room is in control. They use the eight-step process whereby the student can better relate to a typical process they see every day. The third example uses a run chart which looks very much like a control chart.

The difference between the control chart and a run chart is that the run chart does not have upper and lower control limits, yet it uses the same axes and tracking is done in the same manner. The example given describes class attendance. Again, all eight steps of the control chart process can be followed, but treated slightly different. These three examples should provide the student with an opportunity to better understand statistical process control as well as the use of control charts.

This training module on statistical process control is not meant to make experts out of those using it, but rather to introduce them to the tools and provide them some resources they can use to gather more information. The examples are given to help the student become more familiar with the process and some of the tools.

" PROCESS VARIATION "

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PROCESS VARIATION

DEFINITIONS:

Variation

Variation is the inevitable difference among individual outputs of a process. The sources of variation can be grouped into two major classes: common causes and special causes.

Common Cause

Common cause is a source of variation that is always present; it is part of the random variation inherent in the process itself. Its original can usually be traced to an element of the system that only changing the process can correct.

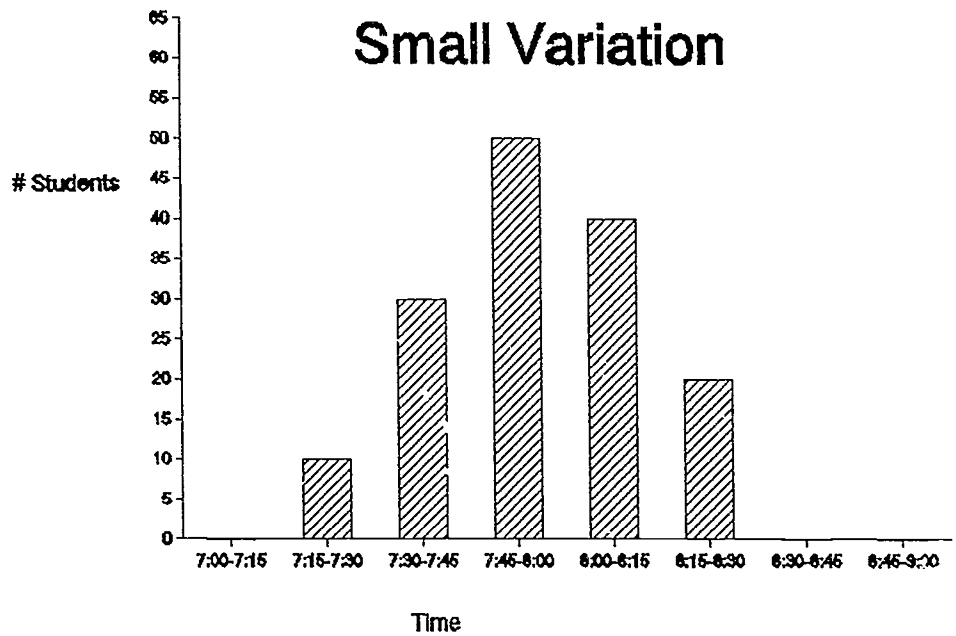
Special Cause

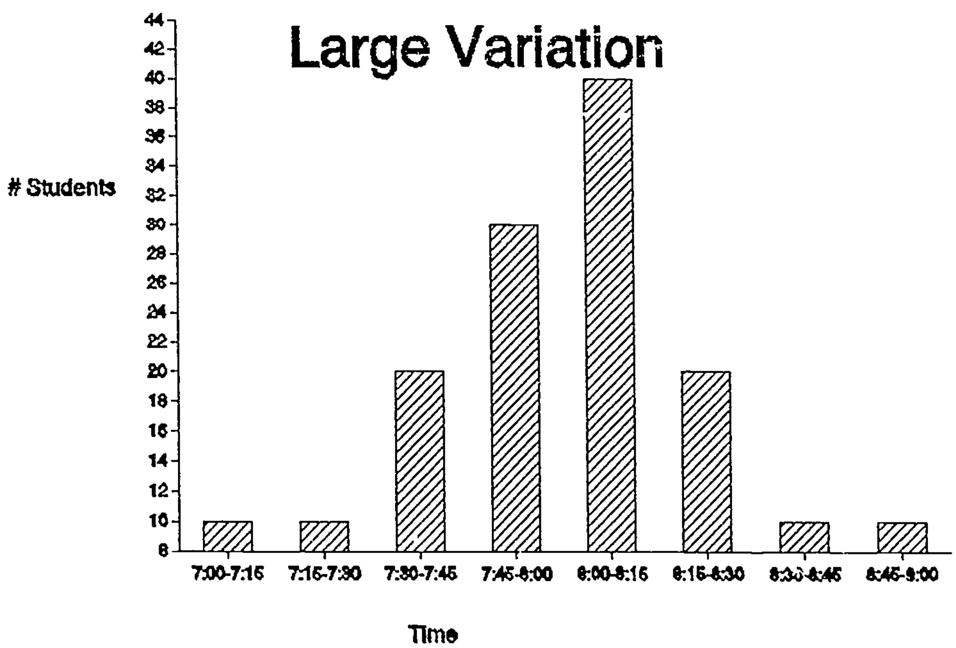
Special cause, also known as an assignable cause, is a source of variation that is intermittent, unpredictable, unstable. Special causes can be eliminated or reduced by the use of problem solving techniques.

PROCESS VARIATION

Graphical Representation:

Example: "Arrival Time at School"





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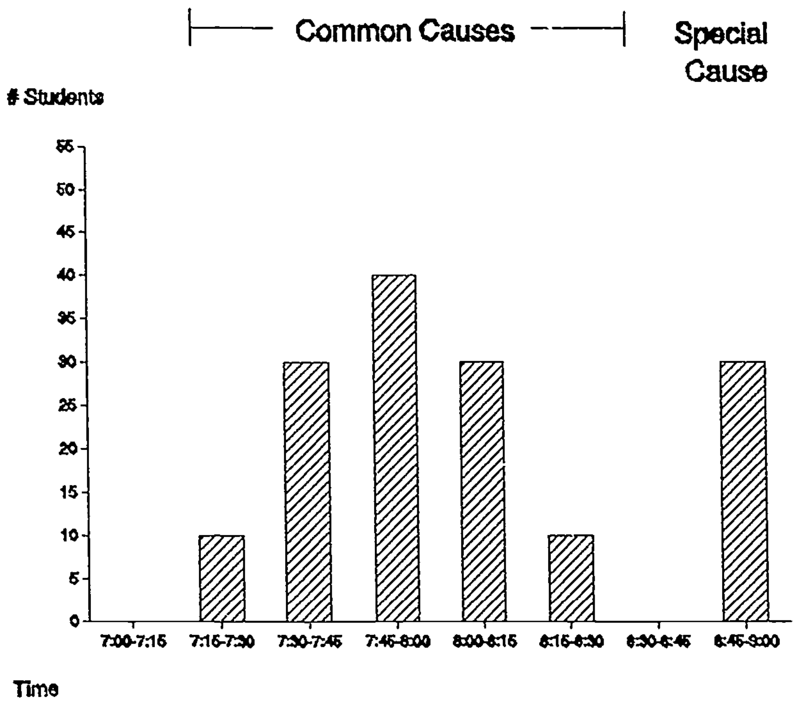
PROCESS VARIATION

Common and Special Causes:



Examples of Common Causes:

1. Traffic in town

2. Time parents go to work

3. Only one street into school causes congestion

Examples of Special Causes:

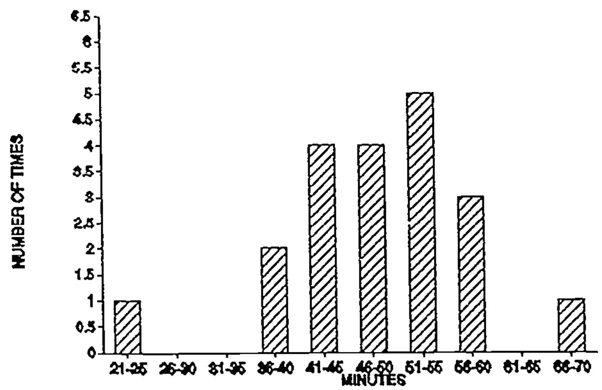
1. Bus broke down

2. Train wreck blocked crossing

PROCESS VARIATION

Example: "Getting Ready for School in the Morning"

A student decided to keep records of how long it was taking her to get ready to go to school. She wanted to sleep later, but was afraid she might be tardy. For one month (22 days), she measured the time from when the alarm went off until she left the house. She recorded her times in five minute increments.



After looking at the data, she determined that her common causes of variation caused her to take from 36-60 minutes. She attributed these common causes to:

1. Her hair style for a particular day.
2. How much time she spent selecting clothes to wear.
3. Whether or not she ate breakfast.
4. What she ate for breakfast.
5. How much time she spent talking with her parents.

She looked at the two days (21-25 minutes) and (66-70 minutes) and remembered the special causes for those days. They were:

1. She forgot to set her alarm, thus waking up late one morning and having to rush to get to school on time.

2. She left her hair dryer at a friends house one weekend and had to wait for her mother to finish before she could borrow her's.

She decided to eliminate the first special cause by putting a reminder next to her light switch. Her solution for her second special cause was that she would get dressed and eat first if she had to wait on the hair dryer again.

" STATISTICAL PROCESS CONTROL "

STATISTICAL DEFINITIONS

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STATISTICAL PROCESS CONTROL

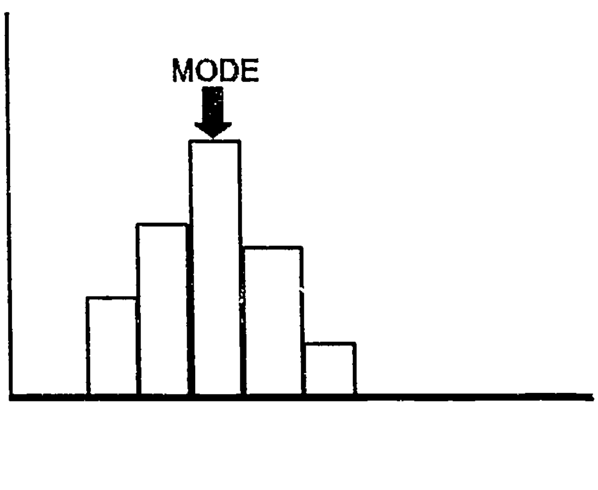
STATISTICAL DEFINITIONS:

- **Statistical Process Control (SPC)** sometimes called SQC for statistical quality control - SPC is the study of a process with aid of numbers (or data) in order to make it behave the way we want.

- **Mean** - The arithmetic means or "averages" is the mathematic average of all occurrences. If five peoples' ages are 12, 19, 23, 30, 34, the mean is
$$\frac{12 + 19 + 23 + 30 + 34}{5} = 23.6 \text{ years}$$

- **Median** - The median is the middlemost value. In the example above, the median age is 23. If there are an odd number of data points, the median will always be the middlemost point. If there are an even number, the median is calculated by averaging the two points in the middle. An example would be if only the first four ages were used in the above example (12, 19, 23, 30), the median is (19 + 23)/2 = 21.

- **Mode** - The mode represents the maximum point on the distribution curve. In a skewed distribution, the mean and the mode do not occur at the same point.



- **Variance** - The variance is the mean square deviation of values from their average.

- **Standard Deviation** - A standard deviation is the square root of the variance.

- **Range** - The range is the difference between the highest and lowest values in a set of observations.

Examples of Variance:

Let x = an individual value
AVG = the arithmetic mean of all values
n = number of values

$$\sigma = \frac{\text{Sum }[(X\text{-}AVG)^2]}{n}$$

Example: Given the numbers 8, 16, 4, 6, 11

Variance "σ^2" =

$$\sigma^2 = \frac{[(8-9)^2 + (16-9)^2 + (4-9)^2 + (6-9)^2 + (11-9)^2]}{5}$$

$$\sigma^2 = \frac{[(-1)^2 + (7)^2 + (-5)^2 + (-3)^2 + (2)^2]}{5} = \frac{1 + 49 + 25 + 9 + 4 = 17.6}{5}$$

σ^2 = 17.6 (Variance)

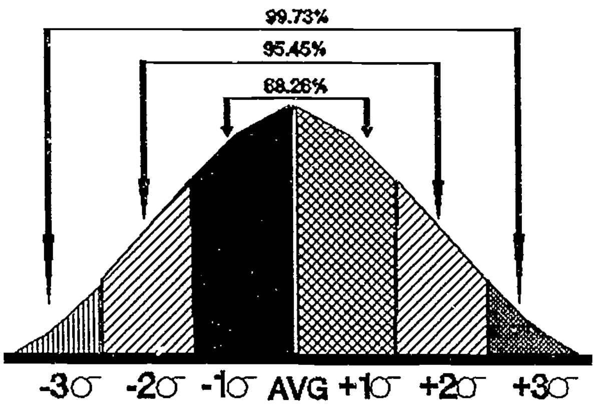
Standard deviation "σ" =

$\sigma=\sqrt{17.6}=4.2$ (Standard deviation)

Range "R" =

R = highest value - lowest value = 16 - 4 = 12 (Range)

- **Normal Distribution** - The normal distribution is one which is symmetrical in shape with its mode, median, and mean being the same. This is sometimes called the "bell" curve. Although it is not the most common distribution, it is often used to approximate distributions.

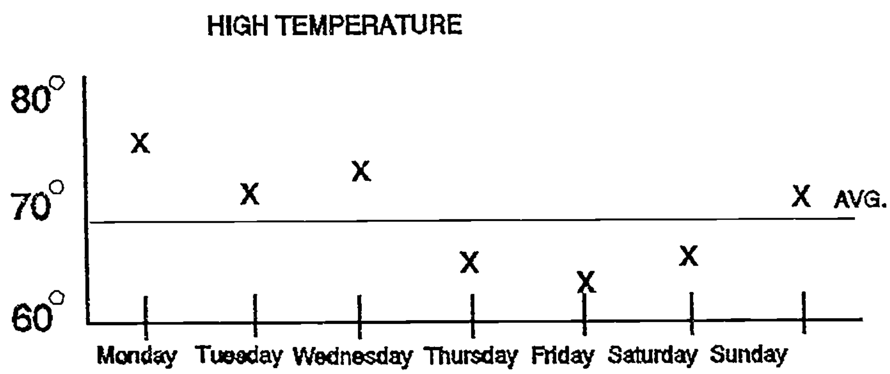


About 68.26% of the total area is included in an area + or - 1σ from the mean.
About 95.45% of the total area is included in an area + or - 2σ from the mean.
About 99.73% of the total area is included in an area + or - 3σ from the mean.

- **Skewed Distribution** - Distributions are said to have a positive or negative skewness depending on the direction of the longer tail. A distribution is skewed positively if the long tail is on the maximum side and negatively if the long tail is on the minimum side.

Positive Skew Negative Skew

- **Run Chart** - Run charts are plots of data in time sequence. Analysis of run charts is performed to determine if the patterns can be attributed to common or special causes of variation.



Example: The high temperatures for each day of the week are:

Monday	75
Tuesday	70
Wednesday	73
Thursday	65
Friday	62
Saturday	65
Sunday	70

The average high temperature is 68.6

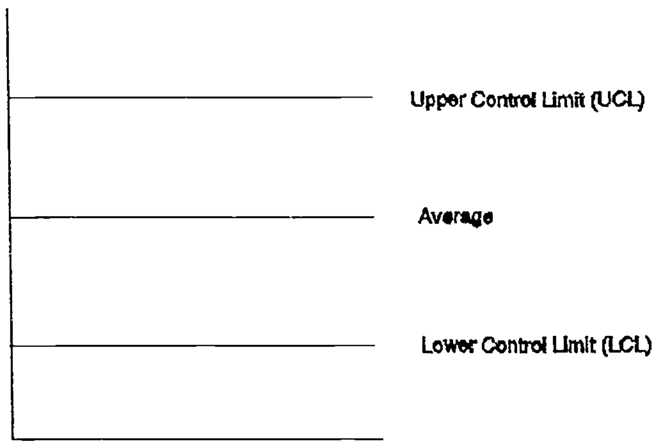
The special cause of the lower temperatures on Thursday, Friday and Saturday was a cold front.

- **Control Chart** - A control chart is similar to a run chart except that there are calculated upper control limits (UCL) and lower control limits (LCL). Each data point on the control chart usually represents an average of multiple data points.

  There are several different types of control charts. They all use the same concepts. Their names come from the nature of the data they contain.

  "$\bar{x}$" - "x bar" chart uses the average of the subgroups
  "R" chart uses the ranges of the subgroup
  "p" chart uses the proportion of defects
  "np" chart uses the number of defects

  In order to simplify this discussion on control charts, the generic term "control chart" will be used. For the student desiring a more detailed understanding of control charts and their application, the bibliography provides three references.



Control Chart

Use of the control chart does not signify that the process is achieving desired results, only that the results are predictable and repeatable.

Normally, control limits that are very close to the average are desirable (small amount of variation).

- **Upper Control Limit (UCL) and Lower Control Limit (LCL)** - these are calculated limits that are determined by the observed data that has been collected in the process. The method of calculation varies depending on the type of control chart used. For the purposes of this module the following method will be used to calculate the UCL and LCL:

$$\text{UCL (UPPER CONTROL LIMIT)} = \text{AVG} + 3\sigma$$

$$\text{LCL (LOWER CONTROL LIMIT)} = \text{AVG} - 3\sigma$$

For the student interested in a more detailed understanding, there are several good references in the bibliography.

" STATISTICAL PROCESS CONTROL "

CONTROL CHART PROCESS

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CONTROL CHART PROCESS

Control charts offer useful tools for monitoring processes. The following eight step process for the use of control charts is provided.

Step 1:	Determine Process to Monitor
Step 2:	Determine Key Process Data to Collect
Step 3:	Collect Data
Step 4:	Develop Control Chart
Step 5:	Analyze Chart
Step 6:	Take Action as Required
Step 7:	Continue Collecting Data
Step 8:	Return to Step 4

The control chart and the control chart process is most useful when a certain process has specified outcomes. The control chart has many industrial applications.

An example would be drilling holes that are 1/2" in diameter. the specification allows the hole to vary .05" larger or smaller than the nominal specification (.5"). The use of the control chart would be very useful in this example in order to insure that the process for drilling holes is "in control" and to monitor the process for "out of control" situations. this example will be shown in the section on Control Chart Examples as Example #1.

Most educational applications do not have defined specifications and acceptable levels of variance. Two examples would be the classroom temperature within a certain temperate range and the gas milage of school buses within a set range. The example for classroom temperature will be shown in the section on Control Chart Examples as Example #2.

Again, the purpose of the control chart is to monitor a process to insure that it is in control. A process that is "in control" may not be delivering acceptable results. The temperature in a classroom may be 60° and never vary more than 1°F from 60°. This process is "in control" but the temperature is not at an acceptable level.

A run chart or control chart can be used to gather data to insure that a process does not deviate out of an acceptable level. An example of this could be student attendance. The goal would be to have student attendance at least 90%. The mean, UDL, and LCL would not apply in this case, but the control chart process could still be used. This example will be shown as Example #3 in the section on Control Chart Examples.

In summary, the control chart process should be used carefully. The problem solving process or the continuous improvement processes may be more appropriate for addressing process problems.

STEP 1: DETERMINE PROCESS TO MONITOR

- Select a process that has identifiable ranges of acceptable performance.
- Select a process that appears to be "out of control" (have a large variation in results), or
- Select a key process where the results are very important to the success of the organization.

STEP 2: DETERMINE KEY PROCESS DATA TO COLLECT

- Select the most important process measurement.
- Make sure that data can be easily obtained.

STEP 3: COLLECT DATA

- Collect the data at the same time and place to avoid variation.
- Use a prepared form for convenience.
- Collect data for a long enough time to insure that the data is representative of the process capability.

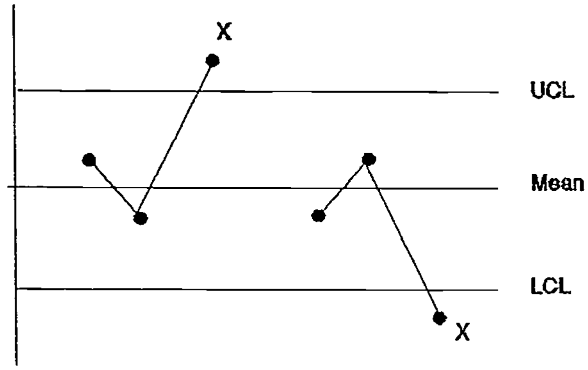
STEP 4: DEVELOP CONTROL CHART

- Use the data to calculate the mean, UCL (UPPER CONTROL LIMIT) and LCL (LOWER CONTROL LIMIT).
- Draw the lines on the chart that represent the mean, UCL, LCL, and label these lines.
- Properly identify and label the x and y axes of the chart.
- Plot each data point.

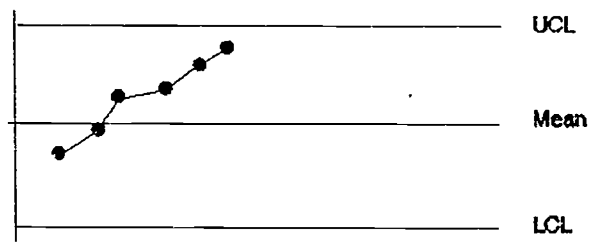
STEP 5: ANALYZE CHART

- Look for the following three conditions:

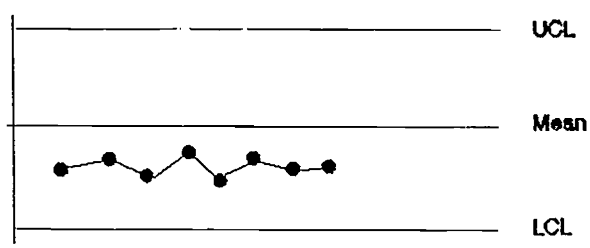
A. One data point above the UCL or below the LCL.



- B. Six data points in a row steadily decreasing or increasing.



- C. Nine successive data points are on the same side of the mean.



- All these conditions are normally special causes and preventative action should be considered.

- Are both the UCL and LCL within the required limits of the process (within specification). If the control limits are not within the specification limits, the process is not capable of meeting the specifications. This condition is known as "the process is not capable" of meeting requirement. This will require modifications to the process.

STEP 6: TAKE ACTION AS REQUIRED

- If one of the three conditions in Step 5 occurs, understand the cause.

- If condition A in Step 5 occurs, preventative actions should be put in place to avoid reoccurrence.

- If either conditions B or C occurs, process adjustments might be necessary. These are usually caused by something in the process changing.

STEP 7: CONTINUE COLLECTING DATA

- If adjustments were made to the process, additional data is needed to verify that the changes achieved the desired results.

- Even if the process is "in control" regular monitoring of the data is necessary to insure that the process stays "in control".

- The frequency of data collection can be lengthened if the process has a history of being "in control."

STEP 8: RETURN TO STEP 4

- This step is especially important if process modifications have been made.

- This step will help insure continuous improvement.

- The control chart process is designed to be a continuous process, therefore periodic analysis and action, if required, are necessary.

" STATISTICAL PROCESS CONTROL "

CONTROL CHART EXAMPLES

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CONTROL CHART EXAMPLES

EXAMPLE #1:

A critical step in a manufacturing process is the drilling of holes. These holes are designed to be .5" in diameter with a tolerance of +/- .05". This means that the holes meet the specification (they're good) if their diameter is between .45" and .55."

The control chart process will be demonstrated using this example:

STEP 1: DETERMINE PROCESS TO MONITOR

- The drilling of the .5" hole is the process that will be monitored.

STEP 2: DETERMINE KEY PROCESS DATA TO COLLECT

- The hole diameter will be measure five times per day for ten days using a "plug gauge."

STEP 3: COLLECT DATA

- The data will be collected by measuring the most recently produced part at 8AM, 10AM, NOON, 2PM and 4PM. These measurements will be recorded in a specially prepared table.

  The data collected is shown below:

	DAY									
TIME	1	2	3	4	5	6	7	8	9	10
8AM	.53	.51	.46	.49	.48	.47	.49	.45	.46	.47
10AM	.49	.47	.48	.48	.47	.48	.47	.46	.45	.45
NOON	.52	.48	.49	.48	.47	.45	.46	.47	.45	.46
2PM	.46	.49	.50	.49	.46	.46	.48	.46	.47	.45
4PM	.50	.50	.47	.50	.48	.47	.46	.47	.46	.46
AVG.	.50	.49	.48	.488	.472	.466	.472	.462	.458	.458

STEP 4: DEVELOP CONTROL CHART

$$Mean = \frac{.50+.49+.48+.488+.472+.466+.472+.462+.458+.458}{10}$$

$$Mean = \frac{4.746}{10} = .475''$$

$$\sigma = \sqrt{\left(\frac{\sum[(x-AVG)^2]}{n}\right)}$$

$$\sigma = \sqrt{\left(\frac{(.50-.475)^2+(.49-.475)^2+(.48-.475)^2+(.488-.475)^2+(.472-.475)^2+(.466-.475)^2+(.472-.475)^2+(.462-.475)^2+(.458-.475)^2+(.458-.475)^2}{10}\right)}$$

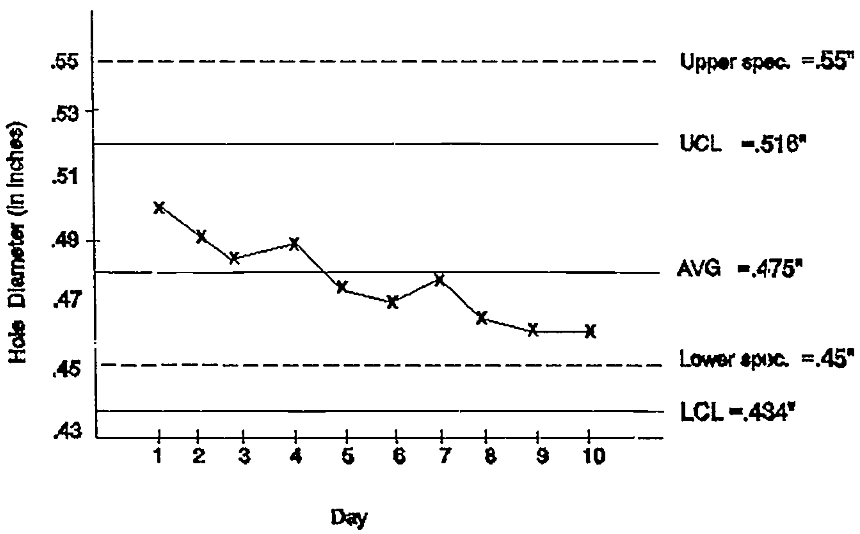
$$\sigma = \sqrt{\left(\frac{(.025)^2+(.015)^2+(.005)^2+(.013)^2+(-.003)^2+(-.009)^2+(-.003)^2+(-.013)^2+(-.017)^2+(-.017)^2}{10}\right)}$$

$$\sigma = \sqrt{\left(\frac{(.000625)+(.000225)+(.000025)+(.000169)+(.000009)+(.000081)+(.000009)+(.000169)+(.000289)+(.000289)}{10}\right)}$$

$$\sigma = \sqrt{\left(\frac{.00189}{10}\right)} = \sqrt{.000189} = .01375$$

UCL = AVG + 3σ
UCL = .475" + 3(.01375")
UCL = .475" + .04125"
UCL = .516"

LCL = AVG - 3σ
LCL = .475" - 3(.01375")
LCL = .475" - .04125"
LCL = .434"



STEP 5: ANALYZE CHART

Upon analyzing the chart, none of the three conditions for action are found. In fact all data points are clearly within the specification limits of .45" - .55".

Further analysis of the data points out two items of interest:

1. The lower control limit of the process is below the lower specification limit (LCL =.434" and lower specification limit = .45")

   This clearly indicates that while the process is "in control", it can produce parts that do not meet the specification. Although this has not occurred, it is time to take action.

2. Although six consecutive data points don't show a downward trend, the overall trend is clearly downward. Judgement should be used in cases like this to justify action. Again, this trend shows that further investigation is required.

STEP 6: TAKE ACTION AS REQUIRED

- Through the use of problem solving techniques, it was determined that the drill "bit" had become worn. A new "bit" was installed.

STEP 7: CONTINUE COLLECTING DATA

- Another ten days of data were collected after the new drill "bit" was installed. This data is shown below:

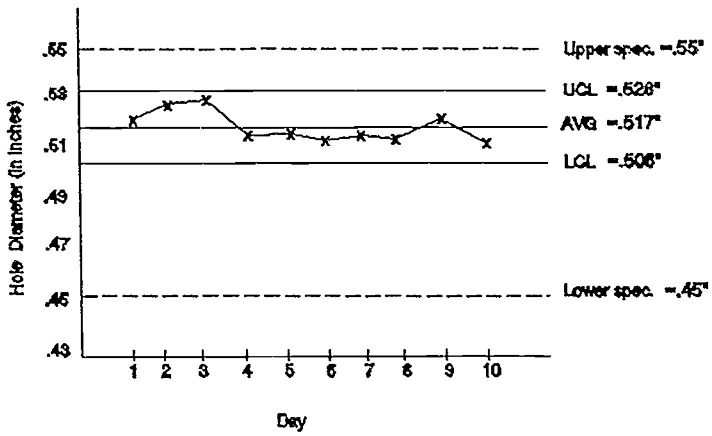
TIME	DAY									
	1	2	3	4	5	6	7	8	9	10
8AM	.53	.50	.51	.52	.51	.52	.53	.49	.52	.51
10AM	.52	.54	.52	.51	.53	.52	.51	.53	.52	.50
NOON	.51	.52	.53	.52	.51	.51	.50	.52	.51	.51
2PM	.52	.53	.52	.50	.52	.52	.52	.52	.53	.53
4PM	.51	.52	.54	.53	.51	.50	.52	.51	.51	.51
AVG.	.518	.522	.524	.516	.516	.514	.516	.514	.518	.512

STEP 8: RETURN TO STEP 4

Mean = .517"

σ = .0035"

UCL = Mean + 3σ = .517" + 3(.0035") = .5275" or .528"
LCL = Mean - 3σ = .517" - 3(.0035") = .5065" or .506"



Analysis of the chart shows that the process is "in control" with a very tight UCL and LCL. Notice that a new control chart, mean, UCL, and LCL were used. It is appropriate to recalculate the mean, UCL, and LCL when modifications are made in the process.

Note that the UCL and LCL are well within the tolerances (specification limits) for the hole. Although the hole diameter is on the high side of the specification limit, the gradual wear on the drill "bit" will cause the readings to "drift" toward the lower limits.

It is important to continue to monitor this process to insure that it remains "in control." It would be appropriate to take fewer readings each day until some problem is experienced.

CONTROL CHART EXAMPLES

EXAMPLE 2:

The temperature in the biology lab seemed to vary greatly. The students and teacher often complained of it being too hot or too cold. The teacher decided to use the control chart process to teach her students the use of the control chart and to also see if there was a problem with the climate control in the lab.

STEP 1: DETERMINE PROCESS TO MONITOR

The temperature control in the biology lab is the process that will be monitored.

STEP 2: DETERMINE KEY PROCESS DATA TO COLLECT

The room temperature is the data that will be collected. The control device is designed to keep the temperature within 2°F of the setting. The setting is on 72°F, therefore the temperature range should be between 70°F & 74°F.

STEP 3: COLLECT DATA

This temperature will be measured twice a day (10AM and 2PM) for a week. A lab thermometer will be placed beside the control device and used to take the readings.

The data collected is shown below:

	DAY				
TIME	Mon	Tue	Wed	Thu	Fri
10AM	68°F	67°F	68°F	74°F	68°F
2PM	72°F	75°F	69°F	71°F	70°F
AVG	70°F	71°F	68.5°F	72.5°F	69°F

STEP 4: DEVELOP CONTROL CHART

$$Mean = \frac{70+71+68.5+72.5+69}{5} = \frac{351}{5} = 70.2°F$$

$$\sigma = \sqrt{\left(\frac{\sum[(X-AVG)^2]}{n}\right)}$$

$$\sigma = \sqrt{\left(\frac{(70-70.2)^2+(71-70.2)^2+(68.5-70.2)^2+(72.5-70.2)^2+(69-70.2)^2}{5}\right)}$$

$$\sigma = \sqrt{\left(\frac{(.2)^2+(.8)^2+(1.7)^2+(2.3)^2+(1.2)^2}{5}\right)}$$

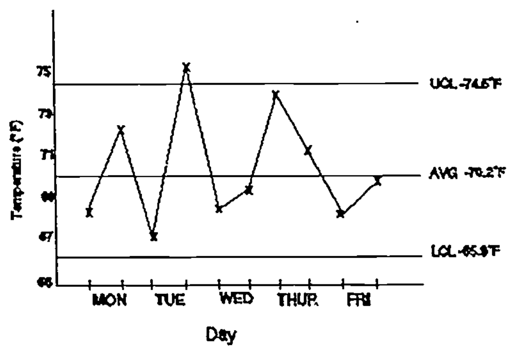
$$\sigma = \sqrt{\left(\frac{.04+.64+2.89+5.29+1.44}{5}\right)} = \sqrt{\left(\frac{10.3}{5}\right)}$$

$$\sigma = \sqrt{2}.06 = 1.435$$

$$\sigma = 1.44°F$$

$$UCL = mean + 3\sigma = 70.2°F + 3(1.44°F)$$
$$UCL = 74.5°F$$

$$LCL = mean - 3\sigma = 70.2°F - 3(1.44°F)$$
$$LCL = 65.9°F$$



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STEP 5: ANALYZE CHART

Analysis shows that two conditions are present:

1. The data point for Tuesday at 2 PM was 75°F. This was above the UCL and therefore the process is "out of control".

2. Both the UCL and LCL exceed the specified range for temperature control. The UCL is 74.5°F while the maximum specification is 74°F. the LCL is 69.5°F while the minimum specification is 70°F. this clearly shows that the process is not capable of meeting requirements.

Both conditions indicate that action is required.

STEP 6: TAKE ACTION AS REQUIRED

Two actions were taken. The first action was to replace the thermocouple (temperature sensing unit) in the control device. The data collected after action did not show any significant change.

The second action was to replace the circuit board in the control device.

STEP 7: CONTINUE COLLECTING DATA

Another week's data was collected after the circuit board was replaced. This data is shown below:

	DAY				
TIME	Mon	Tue	Wed	Thu	Fri
10AM	71°F	71°F	72°F	71°F	72°F
2PM	72°F	73°F	73°F	72°F	72°F
AVG	71.5°	72°F	72.5°F	71.5°F	72°F

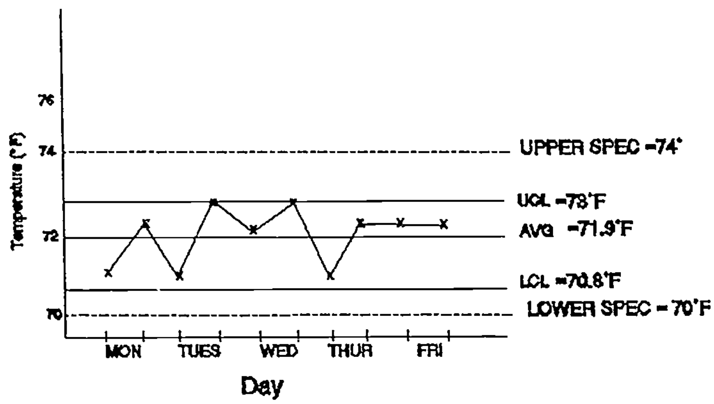
STEP 8: **RETURN TO STEP 4**

Mean = 71.9°F

σ = .378°F

UCL = Mean + 3σ = 71.9°F + 3(.378°F) = 73°F

LCL = Mean - 3σ = 71.9°F - 3(.378°F) = 70.8°F



Analysis of the new control chart shows that the process is "in control". The range of the UCL and LCL is 2.2°F where it had been 8.6°F before the new circuit board was installed in the control device.

It is appropriate to recalculate the mean, UCL, and LCL when modifications are made in the process.

Note that the UCL and LCL are well within the tolerances (specification limits) for the control device. The UCL and LCL are 73°F and 70.8°F and the specification range is 74°F to 70°F with a setting of 72°F.

This process would probably not be monitored again unless there were additional complaints of discomfort in the lab.

CONTROL CHART EXAMPLES

EXAMPLE 3:

The high school principal decided to monitor the average daily attendance to see if there were any opportunities to improve on the 90% attendance of the last six weeks. He decided to use the control chart process.

STEP 1: DETERMINE PROCESS TO MONITOR

The attendance of the high school students is the process that will be monitored.

STEP 2: DETERMINE KEY PROCESS DATA TO COLLECT

The average daily attendance is the data that will be gathered.

STEP 3: COLLECT DATA

The average daily attendance was collected for a three week period of time. This data is shown below:

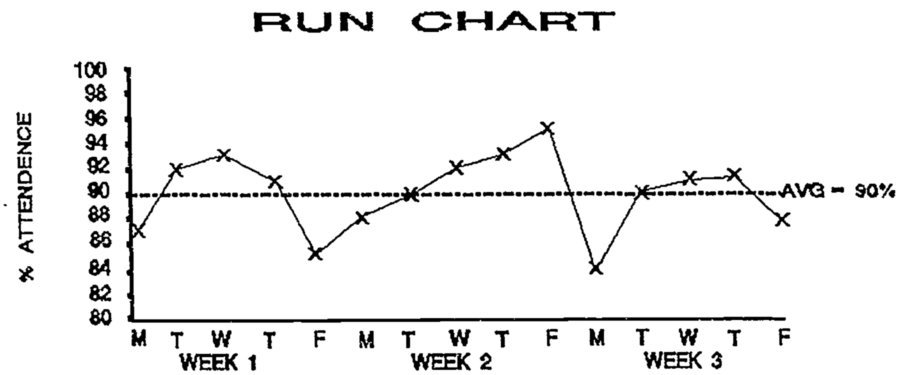
DAY	% ATTENDANCE
Mon	87%
Tues	92%
Wed	93%
Thu	91%
Fri	85%
Mon	88%
Tue	90%
Wed	92%
Thu	93%
Fri	95%
Mon	84%
Tue	90%
Wed	91%
Thu	91%
Fri	88%

STEP 4: **DEVELOP CONTROL CHART**

In this case a run chart will be used.

Mean = 90% attendance

No control limits will be calculated.



STEP 5: **ANALYZE CHART**

The data showed that the average attendance had not changed since the last six week period.

Further analysis showed that Monday and Friday were the low attendance days with the exception of the second Friday which had the highest attendance of any day (95%).

This second Friday was a special activity day where the students did not attend regular classes, but rather participated in the activities of their choice.

STEP 6: **TAKE ACTION AS REQUIRED**

The principal decided to organize a group of students into a problem solving team. This team used problem solving techniques to define several solutions to improve the overall attendance with special emphasis on Monday and Friday.

They decided to give "school dollars" to people with high attendance. Absences on Monday or Friday counted as "double" the regular absences. This made it difficult for students missing school on Monday or Friday to earn "school dollars."

The "school dollars" could be redeemed for discounts of free items at area merchants. Records were kept for those students earning the "student dollars" and a special recognition luncheon was given for them at the end of the semester.

STEP 7: CONTINUE COLLECTING DATA

The students on the problem solving team assisted the principal in continuing to collect data.

STEP 8: RETURN TO STEP 4

The problem solving team continued to monitor the attendance by using the run chart. They were able to see improvements as a result of their actions.

They have begun to post the run chart in the school "commons" area where it has generated an interest in a larger number of students.

STATISTICAL PROCESS CONTROL

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