

QUALITY CONTROL TOOLS (The Seven Basic Tools)

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The Seven Basic Tools

- The seven basic tools are:
 - Check sheet
 - Flow chart
 - Run chart
 - Histogram
 - Pareto chart
 - Control charts
 - Scatter diagram
- All, except the scatter diagram, are covered in these slides.

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CHECK SHEET

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What are check sheets?

Check sheets are special types of forms for data collection. They make it easier to collect data, they tend to make the data collection effort more accurate, and they automatically produce some sort of data summarization which is often very effective for a quick analysis. The form of the check sheet is individualized for each situation.

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Illustration (Painting defects)

Type	Tally	Total
Blister	 	21
Light spray		38
Drips		22
Overspray		11
Splatter		8
Runs		47
Others		12

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Another illustration

Monday	
Billing Errors	
Wrong Account	
Wrong Amount	
A/R Errors	
Wrong Account	
Wrong Amount	

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Cross Tabulation check sheets

Cross tabulation check sheets show two categorical variables. The cross tabulation also shows the interrelationships between the two variables.

An illustration follows ----->

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Painting Defects				
Type of defect	Shift			Total
	Day	Evening	Night	
Pinholes				12
Scratches				9
Overspray				8
	4	15	10	29 ₈

FLOW CHART

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Why use a flowchart?

To allow a team to identify the actual flow or sequence of events in a process that any product or service flows.

Flowcharts can be applied to anything from the travels of an invoice or the flow of materials, to the steps in making a sale or servicing a product.

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One set of flowchart symbols



An oval is used to show the materials, information or action (inputs) to start the process or to show the results at the end (outputs) of the process.



A box or rectangle is used to show a task or activity performed in the process.



A diamond shows those points in the process where a yes/no question is being asked or a decision is required.



A circle with either a letter or number identifies a break in the flowchart and is continued elsewhere on the same page or another page.



An arrow shows the direction or flow of the process.

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Another set of Flow Charting Symbols



Inspection or check



Decision



Transportation



Operation



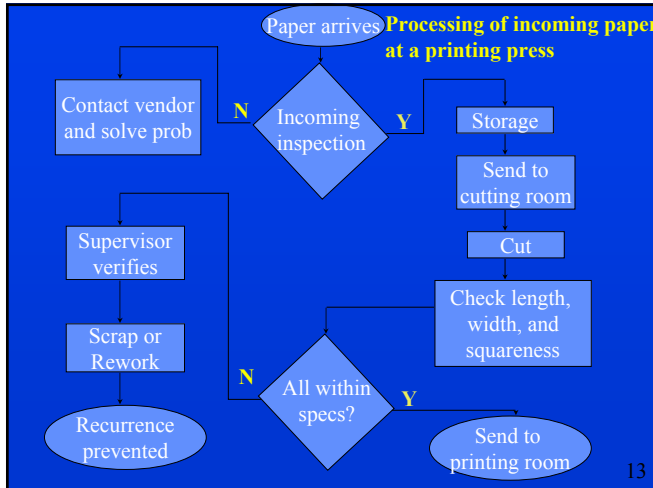
Delay



Storage

These are the ASME standard symbols.

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Some tips for flowcharting

- Keep the flowchart simple.
- As the situation requires, add or invent other symbols.
- Be consistent in the level of detail shown.
- Label each process step using words that are understandable to everyone.
- Identify your work. Include the title of your process, the date the chart was made, and the names of the team members.

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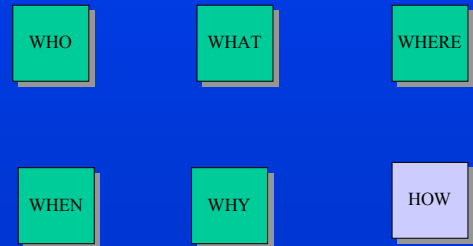
During and after flowcharting
always keep in mind the
following factors and questions



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FIVE W's and ONE H

→ Using the five W's and One H encourages employees to look at a process and ask questions.



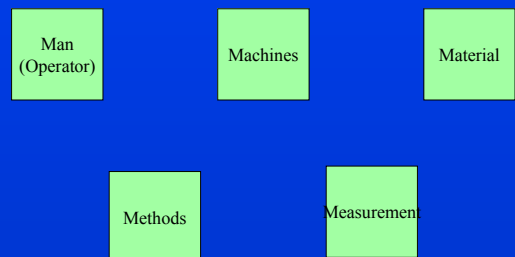
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FIVE W's and ONE H contd..

- **Who** --- Who is doing it? Who should be doing it?
- **What** --- What is being done? What should be done?
- **Where** --- Where is it being done? Where should it be done?
- **When** --- When is it being done? When should it be done?
- **Why** --- Why is it being done? Why do it that way?
- **How** --- How is it being done? How should it be done?

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Five - M Checklist



The Five-M Checklist is an approach that focuses attention on the five key factors which are present in any process.

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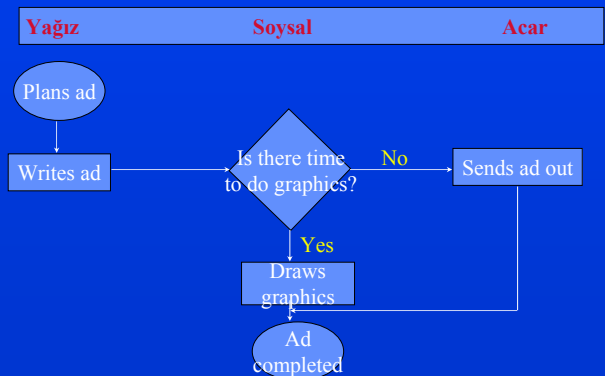
Other questions that should be asked for each activity or step of the flowchart

- ELIMINATE
- COMBINE
- SIMPLIFY
- CHANGE SEQUENCE

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Deployment Flowchart

Shows people or departments responsible and the flow of the process steps or tasks they are assigned.



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RUN CHART

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What is a Run Chart?

Run charts are used to analyze processes according to time or order. Run charts are useful in discovering patterns that occur over time.

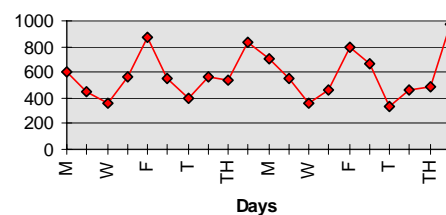
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Illustration of run chart

No of cars arriving at Akay intersection between 5 and 6 pm				
Day	Week 1	Week 2	Week 3	Week 4
M	600	550	700	665
T	452	400	550	334
W	356	567	365	467
TH	570	540	457	489
F	869	831	799	975

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Number of vehicles arriving at Akay intersection between 5 and 6 pm



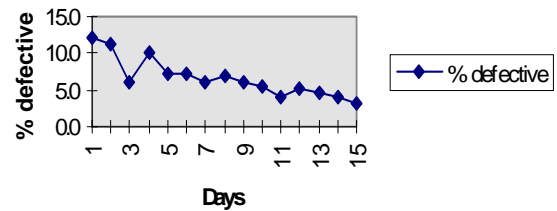
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Another illustration from Process Control

Day	# of defectives	% defective
1	130	18.1
2	123	17.1
3	67	9.3
4	109	15.2
..
10	60	8.3
11	45	6.3
12	56	7.8
13	50	7.0
14	45	6.3
15	34	4.7
TOTAL	719	

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Percentage Defective Run Chart



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HISTOGRAM

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What is a histogram?

A histogram is a device for graphically portraying a frequency distribution. It enables the user to obtain useful information about the shape and dispersion (spread) of a set of data. Most importantly, the histogram allows for a very concise portrayal of information in a bar chart format.

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What does the histogram do?

- Displays large amounts of data that are difficult to interpret in tabular form
- Shows the relative frequency of occurrence of the various data values
- Reveals the centering, variation, and shape of the data
- Illustrates quickly the underlying distribution of the data
- Provides useful information for predicting future performance of the process

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What does the histogram do? contd...

- Helps to indicate if there has been a change in the process
- Helps answer the question "Is the process capable of meeting requirements?"

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Constructing a Frequency Distribution

Suppose the following exam grades were obtained in a course of 50 students:

78 87 65 64 93 56 67 76 75 88 96 45 33 76
75 78 82 90 78 76 73 70 67 69 65 89 70 76
73 45 31 75 56 50 77 79 84 83 86 71 73 75
77 69 59 64 63 78 75 95

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1. Decide on how many classes to use and the range each class should cover (class width or interval). Usually as a rule we use somewhere between 6 and 15 classes. For our example let us decide to use 6 classes.

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2. Next we determine the width of the class interval by using the following equation:

$$W = \frac{\text{next value after largest value in data} - \text{smallest value in data}}{\text{total number of classes}}$$

Highest value = 96 Lowest value = 31

$$W = (96 - 31) / 6 \\ = 11$$

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3. Sort the data points into classes and count the number of points in each class: Hence our frequency distribution will look like this:

Class	Frequency
31 - 41	2
42 - 52	3
53 - 63	4
64 - 74	14
75 - 85	19
86 - 96	8
Total	50

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Here is how the Excel output will look like..

Bin	Frequency
31-41	2
42-52	3
53-63	4
64-74	14
75-85	19
86-96	8

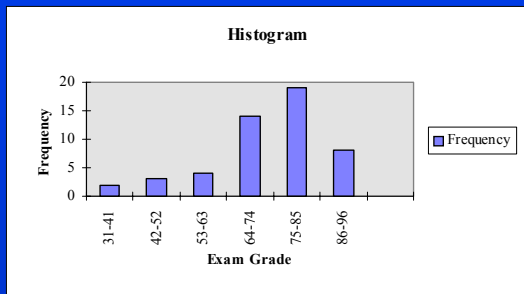
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4. Illustrate the data as a histogram either manually or by using an application program such as Excel, Lotus, etc.

Here is how it will look using Excel ----->

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Histogram obtained by Excel



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Interpretation of the histogram

When combined with the concept of the normal curve and the knowledge of a particular process, the histogram becomes an effective, practical working tool in the early stages of data analysis. A histogram may be interpreted by asking three questions:

1. Is the process performing within specification limits?
2. Does the process seem to exhibit wide variation?
3. If action needs to be taken on the process, what action is appropriate?

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The answer to these three questions lies in analyzing three characteristics of the histogram.

1. How well is the histogram centered?
The centering of the data provides information on the process aim about some mean or nominal value.
2. How wide is the histogram? Looking at histogram width defines the variability of the process about the aim.
3. What is the shape of the histogram?

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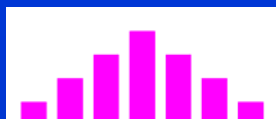
Interpretation of the histogram, contd...

Remember that the data is expected to form a normal or bell-shaped curve. Any significant change or anomaly usually indicates that there is something going on in the process which is causing the quality problem.

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Normal shape

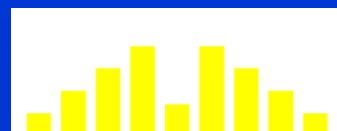
- Depicted by a bell-shaped curve
 - most frequent measurement appears as center of distribution
 - less frequent measurements taper gradually at both ends of distribution
- Indicates that a process is running normally (only common causes are present).



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Bi-modal shape

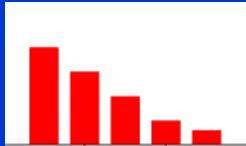
- Distribution appears to have two peaks
- May indicate that data from more than process are mixed together
 - materials may come from two separate vendors
 - samples may have come from two separate populations (machines, processes, etc)



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Cliff-like shape

- Appears to end sharply or abruptly at one end
- Indicates possible sorting or inspection of non-conforming parts.

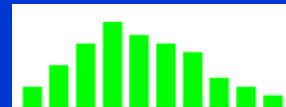


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Skewed shape

Appears as an uneven curve; values seem to taper to one side. Right or left skewed.

Some processes may be naturally skewed; therefore do not expect every distribution to follow the normal (bell-shaped) curve.



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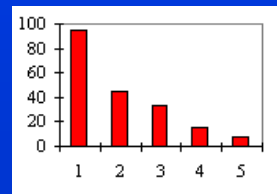
Saw-toothed shape

- Also commonly referred to as a comb distribution, appears as an alternating jagged pattern
- Often indicates a measuring problem
 - improper gage readings
 - gage not sensitive enough for readings.
- Data may have come from two or more different sources (i.e. populations). These could be shifts, machines, people, suppliers, etc.



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PARETO CHART



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History and Background

The Pareto Analysis is based on the principle which states that most of the effects are the result of a few causes. This concept was first noted by Vilfredo Pareto, a nineteenth century Italian economist. He observed that a large percent of the national wealth was held by a small number of people (does this sound familiar?). Pareto found this ratio to be about 80:20.

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History and Background, contd...

This idea was later referred to as "the vital few and the trivial many" by one of the founding fathers of quality improvement, Joseph Juran. Today this idea is commonly referred to as the 80:20 Rule or the Pareto Principle.

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Purpose of Pareto Analysis

The purpose of Pareto Analysis is to "separate the vital few from the trivial many". It has been said that 80% of the defects come from 20% of the causes. This data analysis method helps to direct your work where the most improvement can be made. Thus Pareto analysis helps you focus your efforts on the problems that offer the greatest potential for improvement.

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What does it do?

- Helps a team to focus on those causes that will have the greatest impact if solved.
- It is based on the proven "Pareto principle": 20 % of the sources cause 80% of any problem or 80% of the defects come from 20% of the causes.
- Displays the relative importance of problems in a simple, quickly interpreted, visual format.

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What does it do? contd...

- Helps prevent "shifting the problem" where the "solution" removes some causes but worsens others.
- Progress is measured in a highly visible format that provides incentive to push on for more improvement.
- Pareto analysis can be used in manufacturing or non-manufacturing applications of quality improvement.

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How do I construct a Pareto chart?

1. Decide which problem you want to know more about.

As an example let us take the case of Pizza Cut which has enjoyed moderate success, but the management has been receiving some complaints about the quality of pizza from their customers. After a brainstorming session they have decided to conduct a customer survey concerning the quality of their pizza.

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How do I construct a Pareto chart? contd...

2. Choose the causes or problems that will be monitored, compared and rank ordered.

Suppose that the management decides to get feedback from the customers relating to the following quality characteristics of their pizza:

amount of sauce	service time
amount of cheese	topping selection
hardness of the crust	

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How do I construct a Pareto chart? contd...

3. Choose the most meaningful unit of measurement such as frequency or cost.

In this case, management selects frequency of complaint as the unit of measurement.

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How do I construct a Pareto chart? contd...

- Choose the time period for the study.

Choose a time period that is long enough to represent the situation. Make sure the scheduled time is typical in order to take into account seasonality.

Management wanted the results in a timely fashion, so they placed the surveys in the restaurant and planned to collect them over a two-week period.

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How do I construct a Pareto chart? contd...

- Gather the necessary data on each problem category either by “real time” or by reviewing historical data. Whether data is gathered in “real time” or historically, check sheets are the easiest method for collecting data.

In this case data is obtained through surveys and a check sheet is prepared showing number of complaints for each category or quality characteristic.

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How do I construct a Pareto chart? contd...

- Compare the relative frequency or cost of each problem category.

When the results for each complaint were totalled, here is what they obtained:

too much sauce	16
not enough cheese	38
crust too hard	87
service too long	5
poor topping selection	56

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How do I construct a Pareto chart? contd...

Frequency Table			
Category No	Category Description	Frequency	Percent (%)
1	Too much sauce	16	7,9
2	Not enough cheese	38	18,8
3	Crust too hard	87	43,1
4	Service too long	5	2,5
5	Poor topping selection	56	27,7
TOTAL		202	100,0

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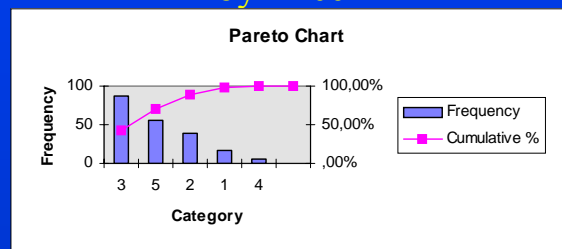
How do I construct a Pareto chart? contd

Cat.	Freq.	Cum. %	Cat.	Freq.	Cum. %
1	16	7,92%	3	87	43,07%
2	38	26,73%	5	56	70,79%
3	87	69,80%	2	38	89,60%
4	5	72,28%	1	16	97,52%
5	56	100,00%	4	5	100,00%
More	0	100,00%	More	0	100,00%

1 - too much sauce
2 - not enough cheese
3 - crust too hard
4 - service too long
5 - poor topping selection

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Here is the Pareto Chart prepared by Excel



Around 43% find the crust too hard

Around 28% find the topping selection poor

71 % of the complaints are about the above two categories

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CONTROL CHARTS

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Sources of Variation

- Variation is a natural phenomenon.
- Variation may be quite large and easily noticeable (height of people) or it may be very small and hardly noticeable by visual inspection (weight of ball point pens.)
- When variations are very small, the items may appear identical; however, precision instruments will show differences.

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Sources of Variation contd...

- In manufacturing there are three categories of variations:
 1. Within-piece variation
 2. Piece-to-piece variation
 3. Time-to-time variation
- The same is true for non-manufacturing situations.

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Sources of Variation contd...

- In manufacturing, variation occurs due to the following:
 - equipment
 - material
 - operator
 - environment
 - inspection or measurement
- Same factors lead to variation in non-manufacturing processes.

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Two Causes of Variation

1. *Common* or *chance* causes of variation
2. *Special* or *assignable* causes of variation

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Chance (common) causes of variation

These causes of variation are inherent in a process. They are essentially random causes. They are small in magnitude and are very difficult to detect or identify. Many times, common or chance causes of variation are either impossible or extremely costly to eliminate. If a process has variation which is due to chance causes only, this process is said to be in *statistical control*. Such a process is also labeled as a *stable process*.

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Special (assignable) causes of variation

A process may from time to time be subject to some additional variation, which is relatively large and is caused by some external factor(s). Examples are substandard material from a supplier, a machine that has been incorrectly set up, or usage of a wrong tool. If special causes of variation are present in a process, this process is said to be *out of control*.

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Control Charts

How do we know when a process is operating under *special causes* of variation? In other words, how do we know if a process is *out of control*?

The answer is

CONTROL CHARTS

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Control Charts contd..

- The control chart is a statistical method or device with a sound statistical base; it rests firmly on the *central limit theorem*.
- When we monitor a process by means of control charts, they tell us whether the process is out of control or not, i.e., whether the process is working under *chance causes* only or not.
- A control chart tells us when to leave a process alone and when to start hunting for special causes of variation.

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Concept of “variables” and “attributes”

- *Variables* are quality characteristics that can be measured and plotted on a continuous scale. Examples are weight, length, time, temperature, voltage (volts), tensile strength (psi), etc.
- *Attributes* are data that can be counted and plotted as discrete events or states. Examples are number of paint defects, number of pinholes on a length of electric cable, number of errors in invoices, etc.

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Types of control charts

- Control Charts for Variables
 - X-Bar and R chart
 - X-Bar and s chart
 - Median and R chart
 - Individuals and Moving Range chart
 - Others

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Types of control charts contd...

- Control Charts for Attributes
 - p-chart (fraction defective chart)
 - np-chart (number of defectives chart)
 - stabilized p-chart
 - c-chart (chart for number of defects)
 - u-chart (chart for number of defects per unit)

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