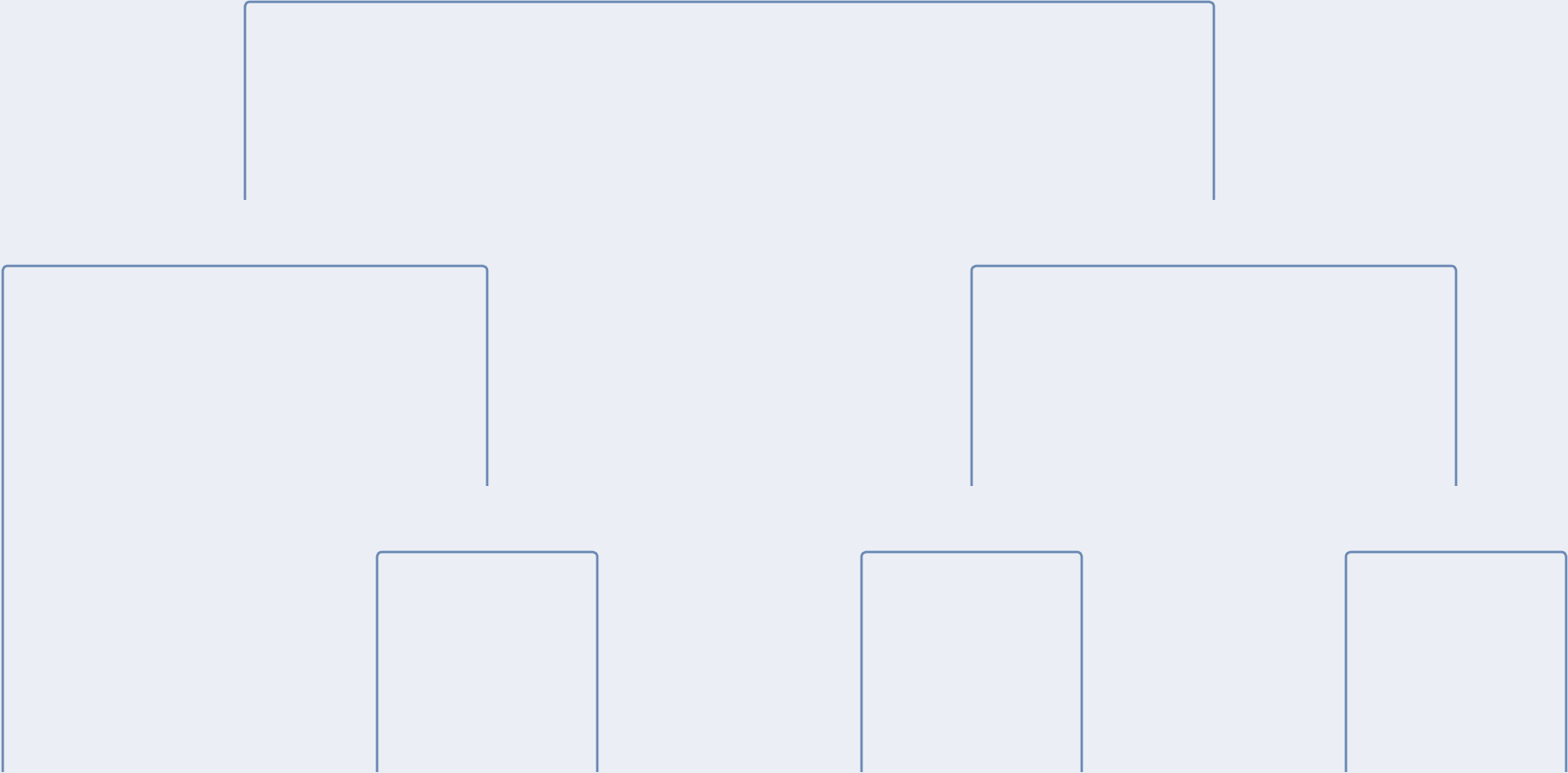
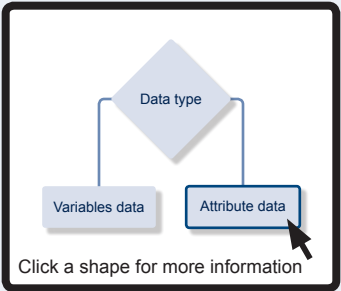


METHOD CHOOSER

**Minitab 15**  <sup>TM</sup>  
Statistical Software

# Control Charts

# Control Charts



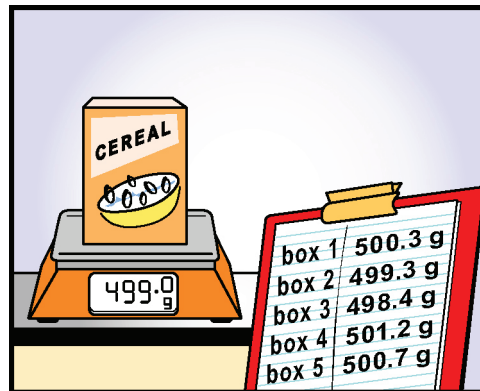
## Do you have variables data or attribute data?

Data type

Measures a characteristic of a part or process, such as length, weight, or temperature. The data often includes fractional (or decimal) values.

### Example

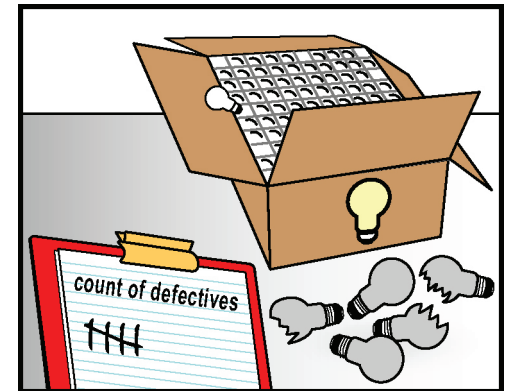
A food manufacturer wants to investigate whether the weight of a cereal product is consistent with the label on the box. To collect data, a quality analyst records the weights from a sample of cereal boxes.



Counts the presence of a characteristic, such as the number of defective units or defects per unit. The count data are whole numbers.

### Example

Inspectors examine each light bulb and assess whether it is broken. They count the number of broken bulbs (defective units) in a shipment.

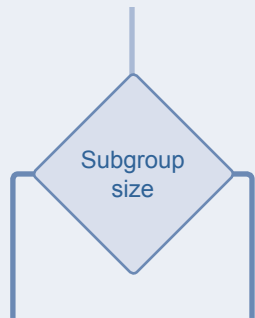


If possible, collect variables data because they provide more detailed information. However, sometimes attribute data adequately describe the quality of a part or a process. For example, if you are tracking broken light bulbs, you don't need to measure a characteristic of the bulb to evaluate whether it's broken or not. What matters is only the number of bulbs that are broken (counts).

Click a shape to move through the decision tree

Click this icon on any page to return to Start.

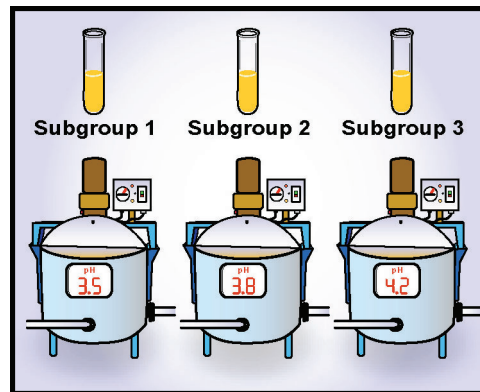
## How many observations are in each subgroup?



Only a single observation is sampled under the same conditions.

### Example

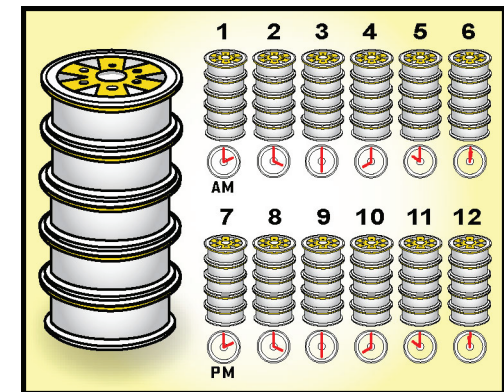
A quality analyst monitors the process mean and variation of the pH of multiple batches of liquid detergent. The analyst needs to collect only a single sample from each homogenous batch.



Multiple observations are sampled under the same conditions.

### Example

An auto parts manufacturer produces thousands of automobile wheel rims each day. Every two hours, a period of time when conditions vary minimally, inspectors sample 5 wheel rims. Over an entire day, they collect 12 subgroups of size 5.



Typically, you try to collect data so that each subgroup includes only the variation that is naturally inherent to the process (common cause variation). Using these *rational subgroups* helps you to better identify other sources of variation that adversely affect the process (special cause variation).

For many processes, you can form rational subgroups by sampling multiple observations that are close together in time. As you sample more observations for each subgroup, you are more likely to detect shifts in the mean and variation. Larger subgroups can also lessen problems due to nonnormality. But sometimes it isn't possible or desirable to have more than one observation in a subgroup. For example:

- You may need only one observation to adequately represent the product, such as a sample from a homogeneous batch.
- You can't collect more than one observation under the same conditions. Conditions may vary if a product has a lengthy production process, such as the manufacture of an aircraft engine, or if an activity occurs at different times.

# Control Charts

## I-MR Chart

### I-MR Chart



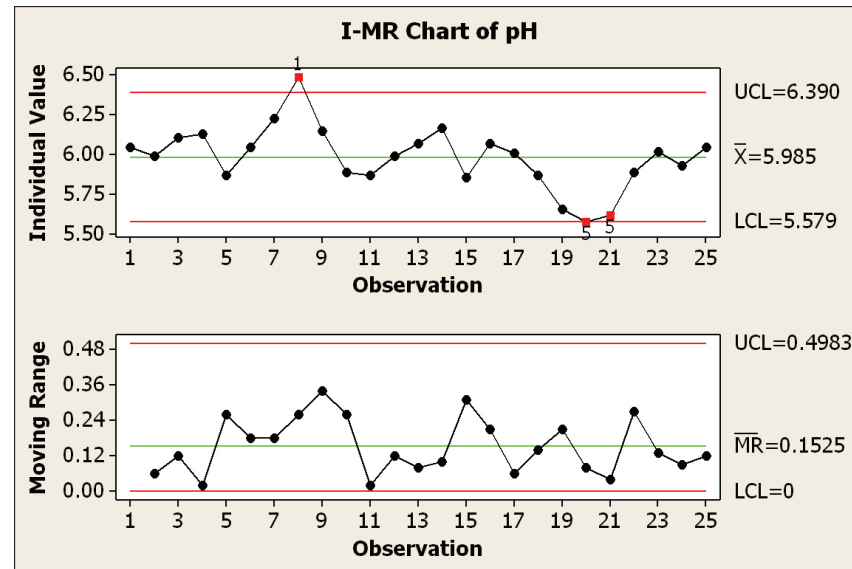
### I-MR Chart

The I-MR chart monitors the mean and the variation of a process.

#### Example

A quality analyst monitors the process mean and variation of the pH in batches of liquid detergent. Inspectors use an I-MR chart to determine whether the pH is consistent from batch to batch and whether the process is out of control.

To create an I-MR chart in Minitab, choose **Stat > Control Charts > Variables Charts for Individuals > I-MR**.

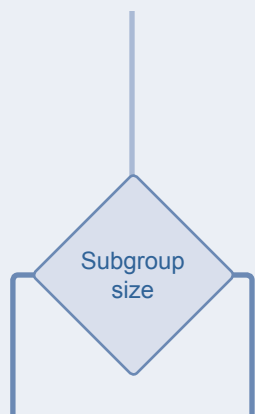


If your data are not normally distributed, the control limits on the I-MR chart may not be appropriate for evaluating the stability of the process. Consider transforming nonnormal data to make it normal before you use the I-MR chart.

For more specialized or advanced analyses, you may want to use other control charts to:

- Monitor products with varied specifications on short runs (Z-MR charts)
- Track multiple variables for a single process (multivariate charts)
- Detect small shifts in the mean more quickly (time-weighted charts)

## How many observations are in each subgroup?

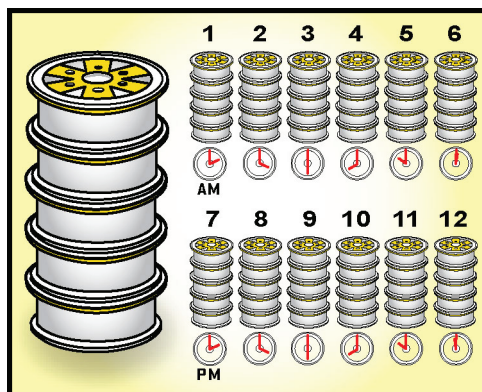


For smaller subgroups, you can use the range to estimate the process variation.

### Example

Inspectors at an auto parts company sample wheel rims and measure the diameter of each rim. They sample 5 wheel rims every 2 hours, which results in 12 subgroups of size 5 each day.

Because the subgroup size is 8 or less, the inspectors use the range to estimate the variation of the rim diameters.

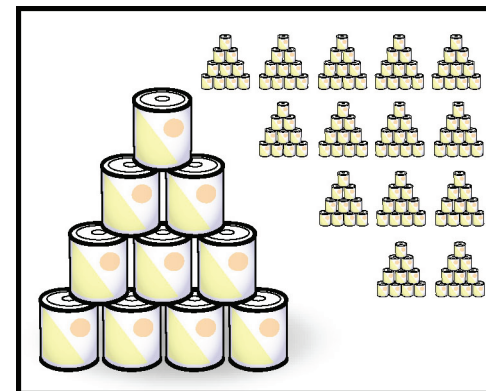


As the subgroup size increases, the standard deviation is an increasingly better estimator of the process variation than the range.

### Example

Inspectors at a canning company sample cans of food and weigh each can. They sample 10 cans every 30 minutes, which results in 15 subgroups of size 10 for each shift.

Because the subgroup size is greater than 8, the inspectors use the standard deviation to estimate the variation of the can weights.



If the number of observations in each subgroup varies, the standard deviation is a better estimator of the process variation than the range, even when subgroup sizes are small.

# Control Charts

## Xbar-R Chart

### Xbar-R Chart



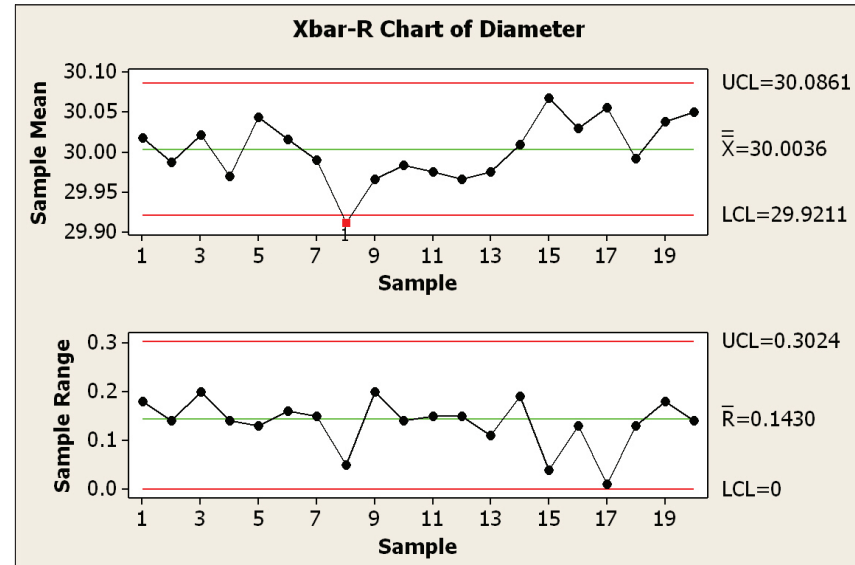
### Xbar-R Chart

The Xbar-R chart monitors the mean and the variation of a process.

#### Example

An auto parts manufacturer tracks the diameter of wheel rims. Inspectors use an Xbar-R chart to determine whether they consistently produce wheel rims with the same diameters and whether the manufacturing process is out of control.

To create an Xbar-R chart in Minitab, choose **Stat > Control Charts > Variables Charts for Subgroups > Xbar-R**.



When you monitor the process mean, you should also evaluate process variation to ensure that the process is stable. If the variation of a process is not in statistical control, then the control limits that are used to evaluate the process mean may not be appropriate.

If your subgroup size is 8 or less, you can use either the range or the standard deviation to estimate the process variation. Therefore, you can also use the Xbar-S to monitor the stability and variation of your process. Base your decision on personal or organizational preference.

For more specialized or advanced analyses, you may want to use other control charts to:

- Monitor batch processes (I-MR-R/S charts)
- Measure multiple variables for a single process (multivariate charts)
- Detect small shifts in the mean more quickly (time-weighted charts)

# Control Charts

## Xbar-S Chart

### Xbar-S Chart



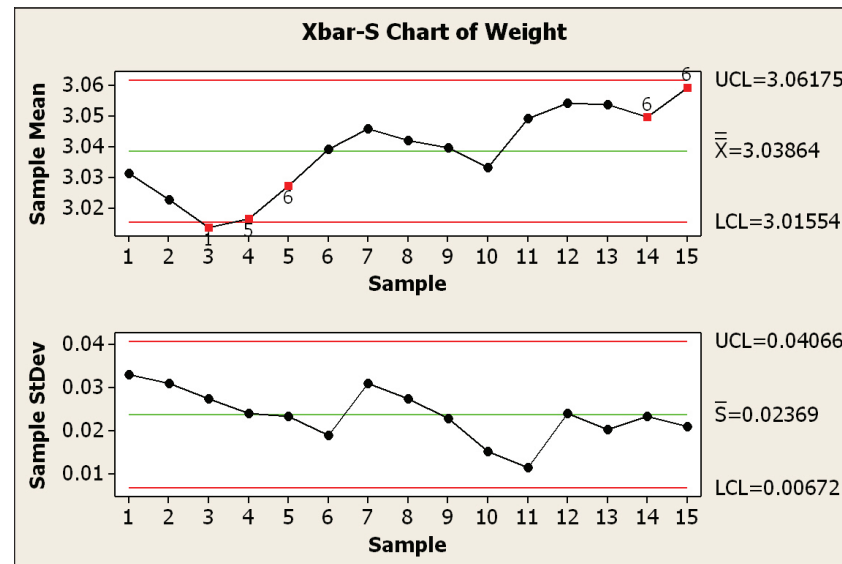
## Xbar-S Chart

The Xbar-S chart monitors the mean and the variation of a process.

### Example

A canning company tracks the weights of cans over one production shift. Inspectors use an Xbar-S chart to determine whether the canning process produces cans with consistent weights and whether the process is out of control.

To create an Xbar-S chart in Minitab, choose **Stat > Control Charts > Variables Charts for Subgroups > Xbar-S**.



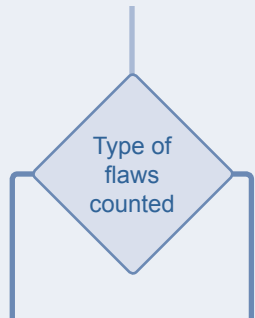
When you monitor the process mean, you should also evaluate process variation to ensure that the process is stable. If the variation of a process is not in statistical control, then the control limits that are used to evaluate the process mean may not be appropriate.

For more specialized or advanced analyses, you may want to use other control charts to:

- Monitor batch processes (I-MR-R/S charts)
- Measure multiple variables for a single process (multivariate charts)
- Detect small shifts in the mean more quickly (time-weighted charts)



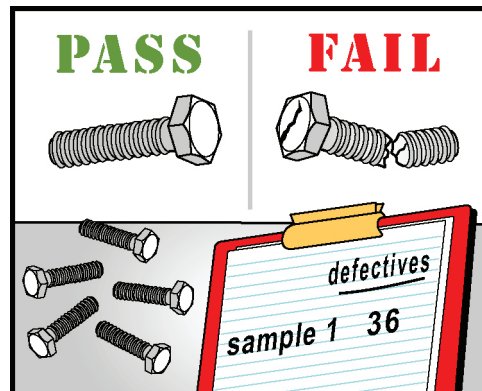
## Are you counting defective units or defects per unit?



Counts items that are classified into one of two categories such as pass/fail or go/no-go. Often used to calculate a proportion (%defective).

### Example

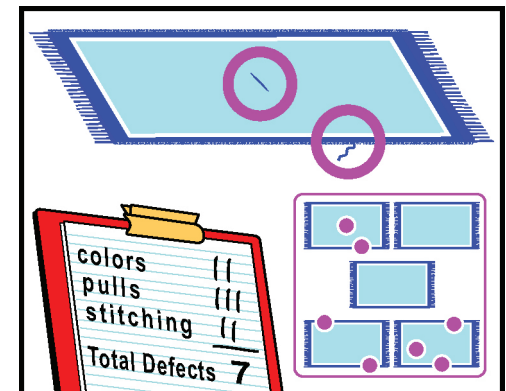
An automated inspection process examines samples of bolts for severe cracks that make the bolts unusable. For each sample, analysts record the number of bolts inspected and the number of bolts rejected.



Counts defects, or the presence of undesired characteristics or activities for each unit. Often used to determine an occurrence rate (defects per unit).

### Example

Inspectors sample 5 beach towels every hour and examine them for discolorations, pulls, and improper stitching. They record the total number of defects in the sample. Each towel can have more than one defect, such as 1 discoloration and 2 pulls (3 defects).

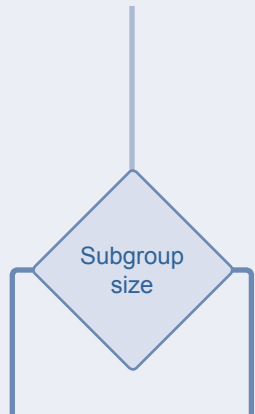


A defective unit (also called a defective or nonconforming unit) is a part with a flaw so severe that it is unacceptable for use, such as a broken light bulb or cracked bolt.

Defects (also called nonconformities) are flaws, such as scratches, dents, or bumps on the surface of a car hood. A part may have more than one defect, and the defects do not necessarily make the part unacceptable. You can count defects over a length of time (complaints received during an 8-hr shift), over an area (stains on every 50 yards of fabric), or over a set number of items (defects in a sample of 5 beach towels).

In some situations, you may want to define defectives or defects as successful occurrences rather than failures or flaws. For example, you may want to track the proportion of customers who respond to a mass mailing by applying for a credit card.

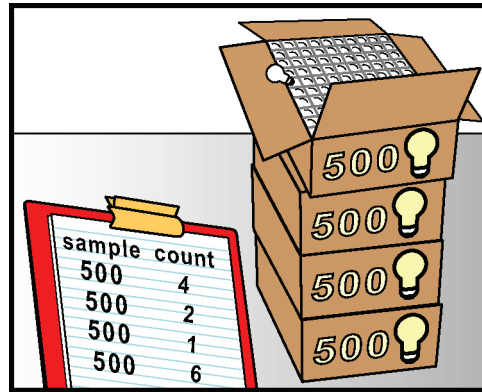
## Are all your subgroups the same size or are they different sizes?



The number of items in each subgroup is the same, which makes the number of defective units in each subgroup easy to compare and interpret.

### Example

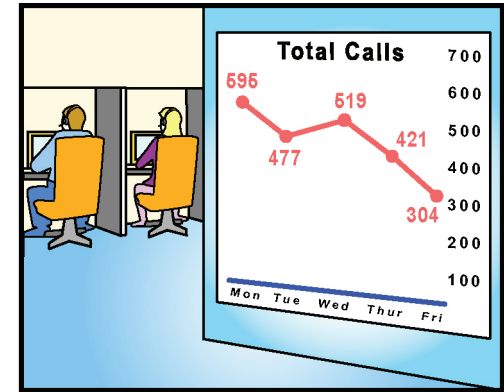
A manufacturer samples 500 light bulbs every hour and counts the number of bulbs that do not light (defective units). Because the sample size is constant, the manufacturer can easily compare the number of defective bulbs from sample to sample.



The number of items in each subgroup is not the same, which makes the number of defective units in each subgroup difficult to compare directly. To compare the defective units in each subgroup, you need to use a proportion.

### Example

A telephone service center counts unanswered calls each day. Because the number of calls handled by the center varies each day, proportions provide a better way to make day-to-day comparisons.



Sometimes it is not possible or desirable to have a constant subgroup size. For example:

- You want to inspect all items, and the number of items varies across subgroups.
- You cannot easily obtain samples of equal size.

If you compare processes or facilities that handle different volumes on separate control charts, you may also want to use a proportion rather than counts to compare defective units. For example, a call center that handles 10,000 calls a day might record many more unanswered calls than a facility that handles only 500 calls, but they may have the same proportion of unanswered calls.

# Control Charts

## NP Chart

NP Chart or P Chart



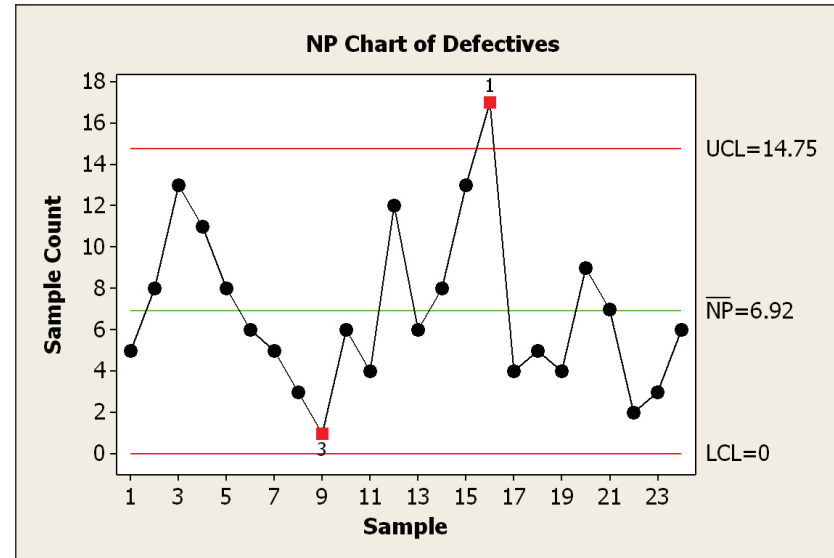
### NP Chart

The NP chart monitors the number of defective units per subgroup.

#### Example

A light bulb manufacturer tracks the number of defective bulbs in each sample. Quality engineers use an NP chart to determine whether the bulbs light consistently and whether the process is out of control.

To create an NP chart in Minitab, choose **Stat > Control Charts > Attributes Charts > NP**.



You can also use a P chart to monitor the proportion of defective units when the subgroup size is constant. In some cases, the P chart may be more informative or easier to interpret. For example, if you assess the number of faulty toothpicks produced in a week, you may prefer to use the proportion of defective units (2%) rather than the total number of defective toothpicks (3453).

# Control Charts

## P Chart

P Chart



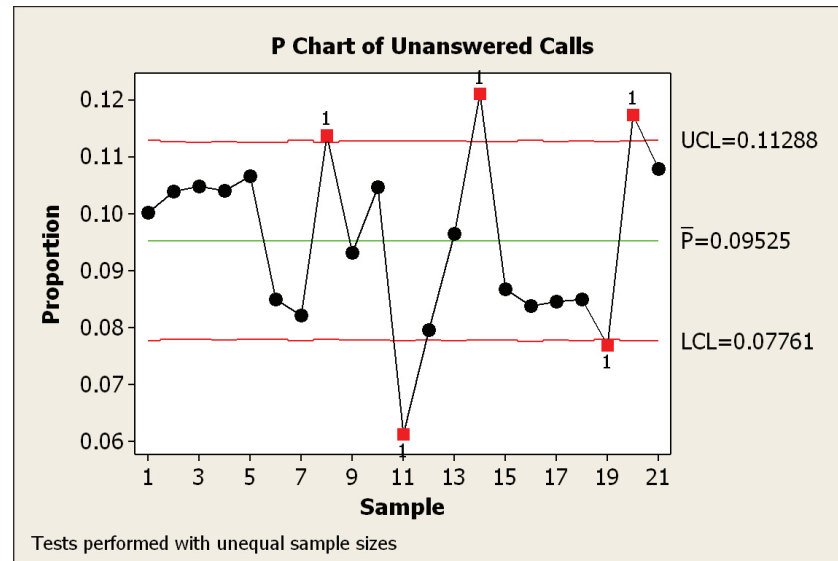
### P Chart

The P chart monitors the proportion of defective units.

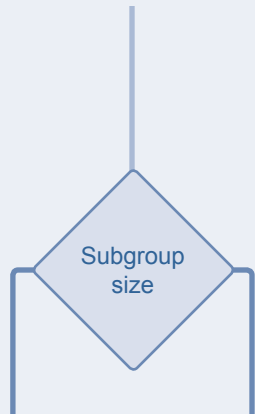
#### Example

A telephone service center tracks the number of unanswered calls per day. A quality manager uses a P chart to determine whether the center performs consistently and whether the process is out of control.

To create a P chart in Minitab, choose **Stat > Control Charts > Attributes Charts > P**.



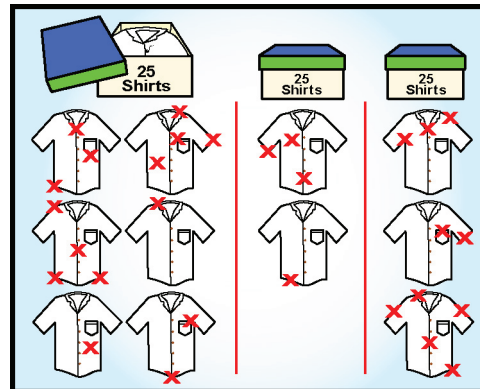
## Are all your subgroups the same size or are they different sizes?



The number of items in each subgroup is the same, which makes the total count of defects in each subgroup easy to compare and interpret.

### Example

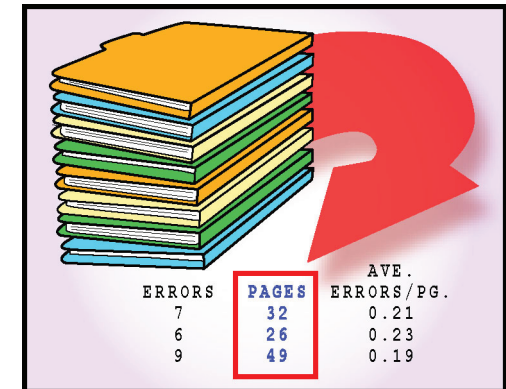
A clothing retailer wants to assess the quality of shirts from its primary supplier. An inspector counts the total number of flaws across all of the shirts in each box. Each box contains 25 shirts. Because the number of shirts per box is the same, the retailer can easily compare the number of flaws from box to box.



The number of items in each subgroup is not the same, which makes the total count of defects in each subgroup difficult to compare directly. To compare the defects in each subgroup, you need to use a rate.

### Example

A transcription company wants to assess its accuracy. An analyst samples transcribed documents and counts the number of errors. Because the number of pages in each document differs, comparing the number of errors across documents is misleading. Instead, the analyst compares the average errors per page.



Sometimes it is not possible or desirable to have a constant subgroup size. For example:

- You want to inspect all items, and the number of items varies across subgroups.
- You cannot easily obtain samples of equal size.

If you compare processes or facilities that handle different volumes on separate control charts, you may also want to use a rate rather than counts to compare defects per unit. For example, a hotel that accommodates 500 guests a day might receive many more customer complaints than a hotel that handles only 100 guests, but it may have the same rate of customer complaints.

# Control Charts

## C Chart

C Chart or U Chart



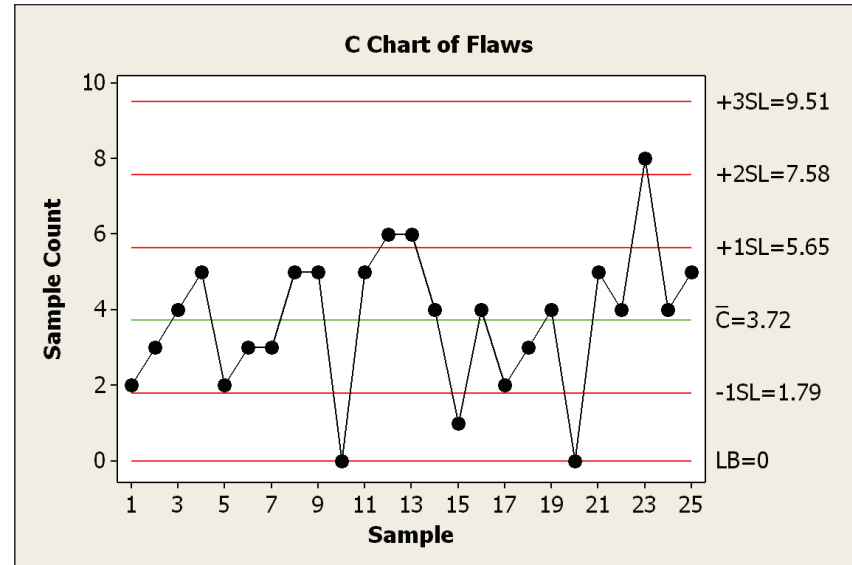
### C Chart

The C chart monitors the total number of defects per subgroup.

#### Example

A clothing retailer tracks the total number of flaws in each box of shirts. An inspector uses a C chart to determine whether the manufacturer supplies shirts that are of consistent quality and whether the process is out of control.

To create a C chart in Minitab, choose **Stat > Control Charts > Attributes Charts > C**.



You can also use a U chart to monitor the average defects per unit when the subgroup size is constant. In some cases, the U chart may be more informative or easier to interpret. For example, a large travel agency handles thousands of hotel and airline reservations each week. To assess the number of weekly errors, such as misrecording of customer information, the agency may prefer to use the average number of defects per reservation (0.01) rather than the total number of errors each week (289).

# Control Charts

## U Chart

### U Chart



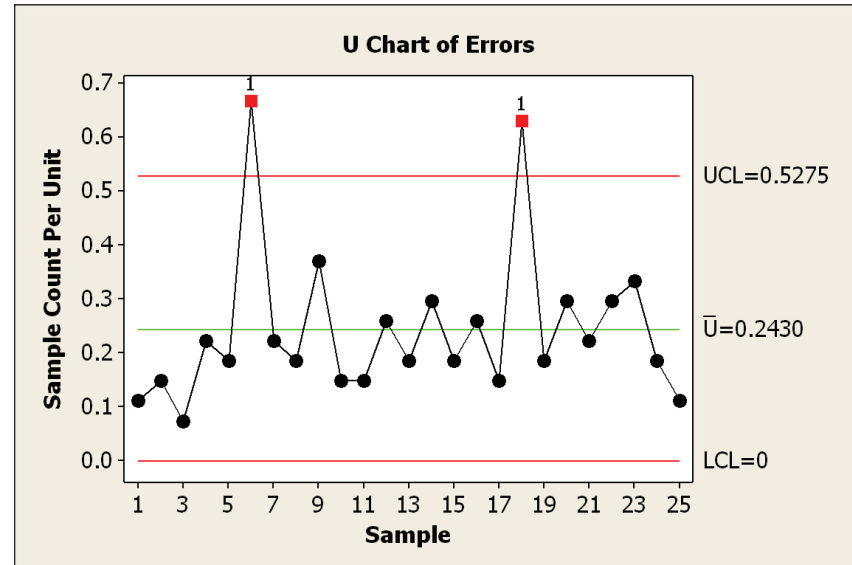
### U Chart

The U chart monitors the average defects per unit.

#### Example

A transcription company tracks the average errors per page for 25 documents. An analyst uses a U chart to determine whether the accuracy of the transcription is consistent and whether the process is out of control.

To create a U chart in Minitab, choose **Stat > Control Charts > Attributes Charts > U**.



# Contacts

## Minitab World Headquarters

### Minitab Inc.

Quality Plaza  
1829 Pine Hall Road  
State College, PA 16801-3008  
USA

Minitab is a global company with subsidiaries and representatives around the world. To find a Minitab partner in your country, visit [www.minitab.com/contacts](http://www.minitab.com/contacts).

### Training

Phone: +1 814.238.3280 x3236  
Fax: +1 814.238.4383  
Email: [training@minitab.com](mailto:training@minitab.com)  
[www.minitab.com/training](http://www.minitab.com/training)

Training by Minitab™ maximizes your ability to improve quality. It helps you make more effective business decisions by teaching you how to analyze your data with Minitab® Statistical Software and manage your projects using Quality Companion by Minitab™.

### Technical Support

Phone: +1 814.231.2682  
[www.minitab.com/support](http://www.minitab.com/support);  
[customer.minitab.com](http://customer.minitab.com) to log a question

Our specialists are highly skilled in Minitab software, statistics, quality improvement, and computer systems. Minitab subsidiaries and Independent Local Representatives around the world offer technical support by phone in their local language.

### Mentoring

Phone: +1 814.238.3280 x3236  
Email: [mentoring@minitab.com](mailto:mentoring@minitab.com)  
[www.minitab.com/training/mentoring/](http://www.minitab.com/training/mentoring/)

Mentoring by Minitab™ makes it easier to implement cost-saving quality improvement initiatives by providing the statistical support you need, just when you need it. We even begin with a free consultation.

© 2009 Minitab, Inc. All rights reserved. The contents of this publication may not be reproduced without permission.

MINITAB® and all other trademarks and logos for the Company's products and services are the exclusive property of Minitab, Inc. All other marks referenced remain the property of their respective owners. See [www.minitab.com](http://www.minitab.com) for more information.