

## SPC – Count Variable

This procedure creates control charts for data in the form of counts. Such charts are widely used to monitor attribute data, where the counts represent the number of defects or defective items in sequential samples. A sample may represent a group of  $n$  items, a fixed period of time, a specified number of square meters of fabric, or some other sampling unit.

The data for this analysis consist of  $m$  samples from a population detailing:

$c_j$  = number of nonconformities observed in sample  $j$

$n_j$  = size of sample  $j$  (optional)

Depending on the type of data provided, four types of charts can be created:

- **C Chart** – plots the number of nonconformities in each sample, based on a Poisson distribution. This chart is created if sample sizes are not provided, since it assumes that all sample sizes are equal.
- **U Chart** – plots the number of nonconformities per item. This chart is created if sample sizes are provided, since it allows for unequal sample sizes. The C Chart and U chart are commonly used when a single item can have more than one defect.
- **P Chart** – plots the proportion of defective items in each sample, based on a binomial distribution. It is used for items that are classified as either defective or not defective. It is offered only if no count exceeds its corresponding sample size.
- **NP Chart** – plots the number of defective items in each sample. It is offered in the same circumstances as the P chart.

### Access

**Highlight:** one *Count* column, or one *Count* column and one *Sample Size* column. A *Time index* column may also be selected to locate the points along the X axis.

**Select:** *SPC* from the main menu.

**Output Page 1:** A C chart if no *Sample Size* column is highlighted. Otherwise a U chart.

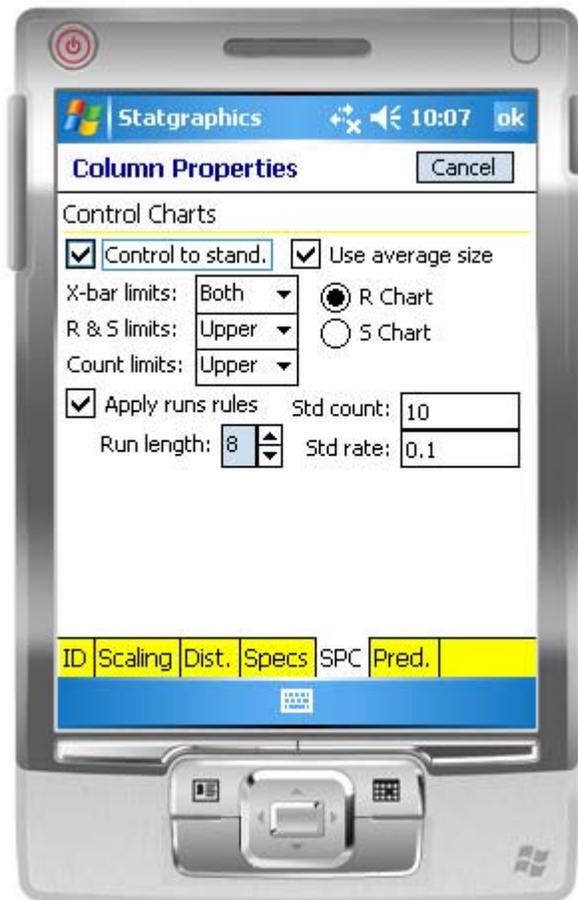
**Output Page 2:** A P chart if a *Sample Size* column is highlighted and all counts are less than or equal to their corresponding sample sizes.

**Output Page 3:** An NP chart if a *Sample Size* column is highlighted and all counts are less than or equal to their corresponding sample sizes.

## Options

Both *Phase I* (Initial Studies) and *Phase II* (Control to Standard) control charts can be created. In a Phase I control chart, the centerline and control limits are determined from the current data. In a Phase II control chart, the centerline and limits are determined from a user-specified standard. Phase I is the default. To create a Phase II control chart:

1. Access the *Properties* dialog box for the column containing the counts by double-clicking on the column header.
2. On the *SPC* tab, check the box labeled *Control to stand.*
3. Also on the *SPC* tab, enter values for *Std count* and *Std rate*. The *Std count* field sets the centerline for the C chart. The *Std rate* field is used to set the centerline for the U, P, and NP charts.



The *Count limits* pulldown list indicates whether lower and/or upper control limits should be plotted for the charts. The *Use average size* field indicates whether the average sample size should be used to generate horizontal control limits, or whether individual sample sizes should be used (resulting in jagged control limits if the sample sizes are not all equal).

If *Apply runs rules* is checked, any unusual sequences of points will be indicated, defined as follows:

1. Runs up or down of length greater than or equal to the number indicated in the *Run length* field.
2. Runs above or below the centerline of length greater than or equal to the number indicated in the *Run length* field.
3. 2 out of 3 points in a row beyond 2-sigma, on the same side of the centerline.
4. 4 out of 5 points in a row beyond 1-sigma, on the same side of the centerline.

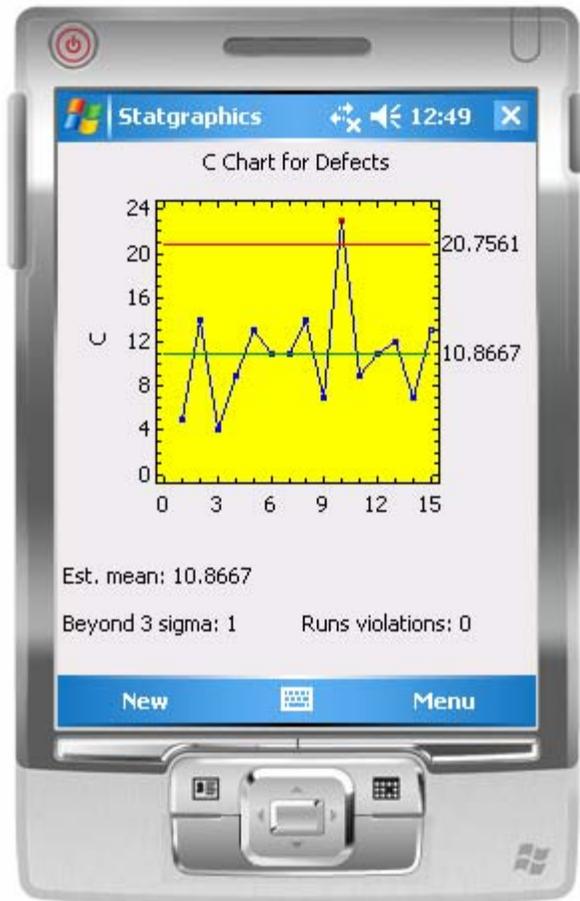
## Sample Data

The file *nonconform.sgm* contains data on  $m = 15$  samples, each consisting of a selected number of items. The data is shown below:

Sample	Defects	n
1	5	100
2	14	100
3	4	90
4	9	100
5	13	110
6	11	100
7	11	100
8	14	100
9	7	100
10	23	110
11	9	90
12	11	90
13	12	100
14	7	100
15	13	110

## C Chart

The *C Chart* plots the numbers of nonconformities  $c_j$ , assuming that all sample sizes are equal.



In Phase 1 (*Initial Studies*) mode, the centerline and control limits are determined from the data. The centerline is located at the sample mean number of nonconformities:

$$\bar{c} = \frac{\sum_{j=1}^m c_j}{m} \quad (1)$$

where  $m$  equals the number of samples. The control limits are placed above and below the centerline at:

$$\bar{c} \pm 3\sqrt{\bar{c}} \quad (2)$$

Any points beyond the control limits are flagged using the *Highlighting* point symbol. If runs rules are being applied, any point at which a violation occurs will also be highlighted.

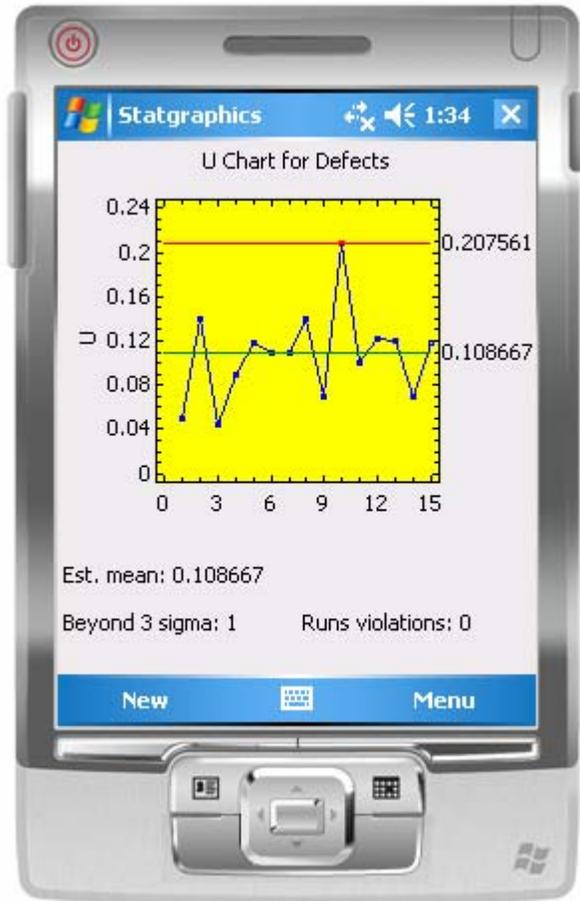
In control to standard mode, the centerline  $\bar{c}$  is replaced in the above equations by the specified *Std count*.



## U Chart

The U Chart plots the number of nonconformities per unit  $u_j$ , where

$$u_j = c_j / n_j \tag{3}$$



In Phase 1 (*Initial Studies*) mode, the centerline and control limits are determined from the data. The centerline is located at:

$$\bar{u} = \frac{\sum_{j=1}^m n_j u_j}{\sum_{j=1}^m n_j} \tag{4}$$

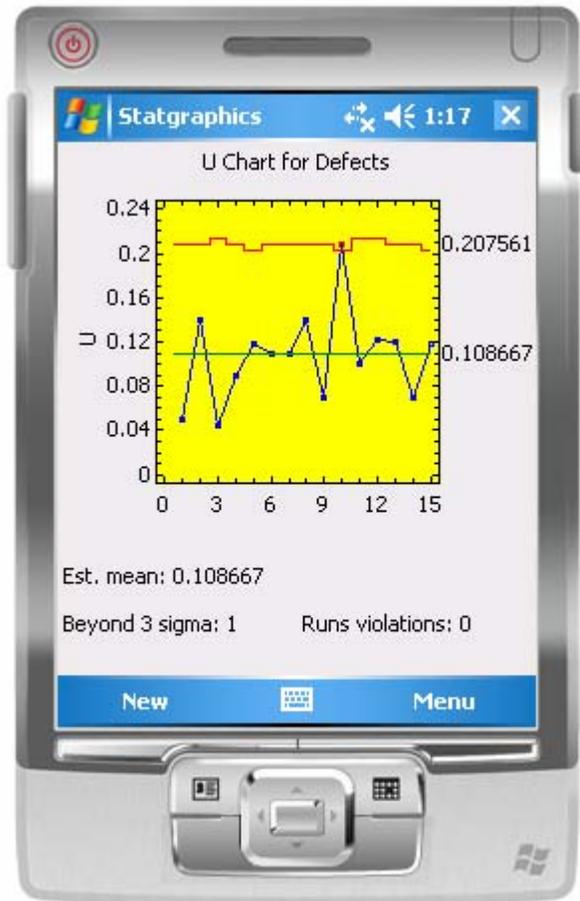
The control limits are placed above and below the centerline at:

$$\bar{u} \pm 3\sqrt{\bar{u}/n} \tag{5}$$

where  $n$  is the sample size. If the sample sizes are not equal, then  $n$  is replaced by either:

(1)  $\bar{n}$ , the average sample size. In this case, the control limits are the same for all samples.

(2)  $n_j$ , the individual sample sizes. In this case, the control limits are step functions, as shown below:

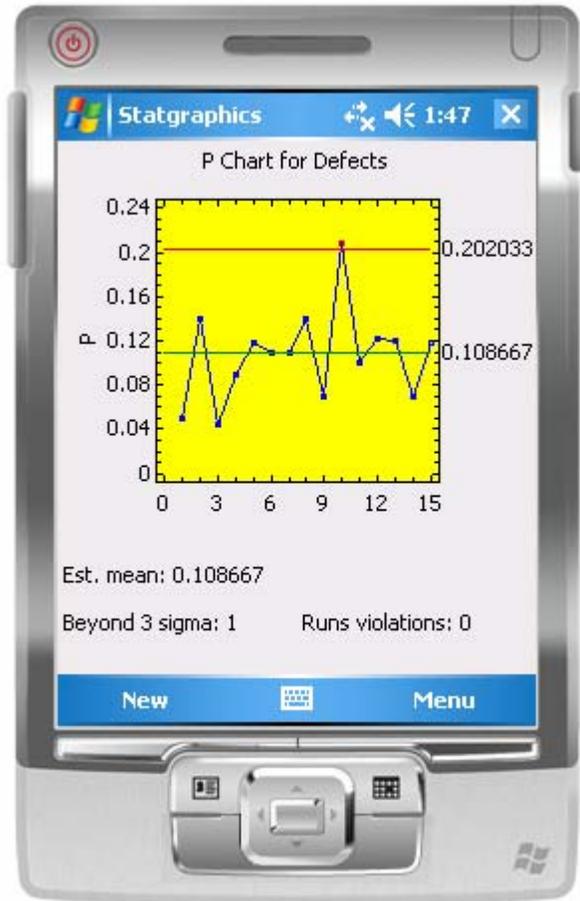


In control to standard mode, the centerline  $\bar{u}$  is replaced in the above equations by the specified *Std rate*.

## P Chart

The *P Chart* plots the proportion of defectives items in each sample  $p_j$ , where

$$p_j = \frac{c_j}{n_j} \quad (6)$$



In Phase 1 (*Initial Studies*) mode, the centerline and control limits are determined from the data. The centerline is located at the weighted average of the sample proportions:

$$\bar{p} = \frac{\sum_{j=1}^m n_j p_j}{\sum_{j=1}^m n_j} \quad (7)$$

The control limits are placed above and below the centerline at:

$$\bar{p} \pm 3 \sqrt{\frac{\bar{p}(1 - \bar{p})}{n}} \quad (8)$$

where  $n$  is replaced by either the average sample size or the individual samples sizes. In control to standard mode, the centerline  $\bar{p}$  is replaced in the above equations by the specified *Std rate*.

## NP Chart

The *NP Chart* plots the number of defective items in each sample  $c_j$ ,



In Phase 1 (*Initial Studies*) mode, the centerline and control limits are determined from the data. The centerline is located at:

$$CL = n\bar{p} \tag{9}$$

The control limits are placed above and below the centerline at:

$$CL \pm 3\sqrt{n\bar{p}(1 - \bar{p})} \tag{10}$$

where  $n$  is replaced by either the average sample size  $\bar{n}$  or the individual samples sizes. In control to standard mode, the centerline  $n\bar{p}$  is replaced in the above equations by  $\bar{n}$  times the specified *Std rate*.