Chapter 252

Levey-Jennings Charts

Introduction

This procedure generates Levey-Jennings control charts on single variables. It finds out-of-control points using the Westgard rules.

Levey-Jennings Control Charts

The Levey-Jennings control chart is a special case of the common Shewart Xbar (variables) chart in which there is only a single stream of data and sigma is estimated using the standard deviation of those data. The formula for the standard deviation *s* is

$$s = \sqrt{\frac{\sum_{k=1}^{n}\left(x_k - \bar{x}\right)^2}{n-1}}$$

where the mean is estimated using

$$\bar{x} = \frac{\sum_{k=1}^{n} x_k}{n}$$

Control limits are

$$\left(L_{low}, L_{high}\right) = \bar{x} \mp ms$$

where *m* is usually 1, 2, or 3.

Westgard Rules

Individual values are tested to determine if they are in, or out, of control using a set of five rules called the Westgard rules after their originator. They are specified in Westgard *et al.* (1981). These rules indicate which rows in a variable (column of numbers) are 'out-of-control'. When any of these rules is violated, the process behind the numbers is 'out-of-control' and should be stopped and investigated.

The Westgard Rules are

1S3: One value beyond 3*sigma from the mean.

2S2: Two consecutive values either greater than, or less than, 2*sigma from the mean.

RS4: A difference between consecutive values greater than 4*sigma.

4S1: Four consecutive values greater than, or less than, 1*sigma from the mean.

10X: Ten consecutive values all greater than, or less than, the mean.

Data Structure

The data are entered in a single variable (column) of the spreadsheet. As an example, you can look at the WESTGARD.S0 database. Often, variables are entered as pairs, but this is not necessary.

Procedure Options

This section describes the options available in this procedure. To find out more about using a procedure, turn to the Procedures chapter.

Variables Tab

This panel specifies the variables that will be used in the analysis.

Variables

Data Variables

These are the variables to be analyzed. A separate chart is generated for the values in each variable. Note that the rows represent the way the data were received through time. That is, row one gives the first value obtained, row two gives the second value, and so on.

Label Variable

An optional variable containing row labels for the horizontal axis of the chart.

You can use dates (like Jan-23-95) as labels. First, enter your dates using the standard date format (like 06/20/93). In the Variable Info screen, change the format of the date variable to something like *mmm-dd-yyyy* or *mm-dd-yy*. The labels will be displayed as labels. Without changing the variable format, the dates will be displayed as long integer values.

Specify Rows in Calculations

Specification Method

This option specifies how the rows that are used in the calculations are specified.

- **All Rows**
  All rows are used.
- **First Row - Last Row**
  The first and last row is specified.
- **First N Rows**
  The first N rows on the dataset are used. The value of N is specified below.
- **Last N Rows**
  The last N rows on the dataset are used. The value of N is specified below.
- **Row List**
  The rows used by in calculations are specified by the Row List box below.

First Row

This option designates the first row to be used. Rows before this row are ignored. This option is only used when Specification Method is set to First Row - Last Row.

Last Row

This option designates the last row to be used. Rows after this row are ignored. This option is only used when Specification Method is set to First Row - Last Row.

N

This option designates the value of N. This option is only used when Specification Method is set to First N Rows or Last N Rows.

Row List

Specify sets of rows to be used in calculations. A separate set of calculations will be carried out for each set. Example (with three sets): 1-50, 75-150, 175-Last. Note that Specification Method must be set to Row List.

Rows that are not included in this list will still be plotted if they are included in the list of charted rows.

Specify Rows in Charts

Specification Method

This option specifies how the rows that are used in the charts are specified.

- **All Rows**
  All rows are used.
- **First Row - Last Row**
  The first and last row is specified.
- **First N Rows**
  The first N rows on the dataset are used. The value of N is specified below.
- **Last N Rows**
  The last N rows on the dataset are used. The value of N is specified below.

First Row

This option designates the first row to be used. Rows before this row are ignored. This option is only used when Specification Method is set to First Row - Last Row.

Last Row

This option designates the last row to be used. Rows after this row are ignored. This option is only used when Specification Method is set to First Row - Last Row.

N

This option designates the value of N. This option is only used when Specification Method is set to First N Rows or Last N Rows.

Select Chart Attributes

Use Westgard Rule

Specify whether to include rows that violate this rule on the plot and in the exceptions report.

The codes are:

- **1S3**
  1 value beyond 3*sigma from the mean.
- **2S2**
  2 consecutive values >, or <, 2*sigma from the mean.
- **RS4**
  A difference between consecutive values > 4*sigma.
- **4S1**
  4 consecutive values >, or <, 1*sigma from the mean.
- **10X**
  10 consecutive values >, or <, the mean.

Options Tab

These options determine the type of chart that you want displayed.

General Chart Options

1-Sigma, 2-Sigma, and 3-Sigma Multipliers

This option specifies the multiplier of sigma for each set of control limits. Usually, the multipliers are set to 1, 2, and 3.

Mean Options

Mean From

This option specifies how the mean is determined. Usually, it is calculated from the data. But occasionally, a fixed value is used. Select Data to calculate the mean from the data, Constant to use the value in the Mean Constant box, or Variable to read the mean from a specific variable on the database.

Mean Constant

This value is used as the value of the mean when Mean From is set to Constant.

Mean Variable

Values in the rows of this variable (column) are used as the value of the means when Mean From is set to Variable.

Note that the value in row one is used for the variable in column 1 of the spreadsheet, the value in row two is used for the variable in column 2, and so on. If you have selected variables number 10 and 15 as your Data Variables, then rows 10 and 15 will contain the values of the fixed values of the means of these variables.

Sigma Options

Sigma From

This option specifies how sigma is determined. Usually, it is calculated from the data. But occasionally, a fixed value is used. Select Data to calculate sigma from the data, Constant to use the value in the Sigma Constant box, or Variable to read sigma from a specific variable on the database.

Sigma Constant

This value is used as the value of sigma when Sigma From is set to Constant.

Sigma Variable

Values in the rows of this variable (column) are used as the value of the sigma when Sigma From is set to Variable.

Note that the value in row one is used for the variable in column 1 of the spreadsheet, the value in row two is used for the variable in column 2, and so on. If you have selected variables number 10 and 15 as your Data Variables, then rows 10 and 15 will contain the values of the fixed values of sigma of these variables.

Specification Limits

Lower and Upper Spec Limit

These options specify specification limits for display on the Levey-Jennings chart.

Target Spec

This option specifies an optional target specification for display on the Levey-Jennings chart.

Reports Tab

The following options control the format of the reports.

Specify Reports

Numeric Reports – Out-of-Control List

Each of these options control the display of the corresponding report.

Report Options

Precision

Specify the precision of numbers in the report. A single-precision number will show seven-place accuracy, while a double-precision number will show thirteen-place accuracy. Note that the reports are formatted for single precision. If you select double precision, some numbers may run into others. Also note that all calculations are performed in double precision regardless of which option you select here. This is for reporting purposes only.

Variable Names

This option lets you select whether to display variable names, variable labels, or both.

Decimal Places

Set the number of decimal places displayed on the reports. For example, selected 2 here instructs the program to display the value 1.2362142 as 1.24.

Single displays an unformatted, seven-digit number. *Double* displays an unformatted, fourteen-digit number.

Page Title

This option specifies a title to appear at the top of each page.

Plots Tab

This panel sets the options used to define the appearance of the Levey-Jennings control chart.

Specify Charts

Levey-Jennings Chart

This chart is controlled by three form objects:

1. A checkbox to indicate whether the chart is displayed.
2. A format button used to call up the plot format window (see Levey-Jennings Chart Format Window Options below for more chart formatting details).
3. A second checkbox used to indicate whether the chart can be edited during the run.

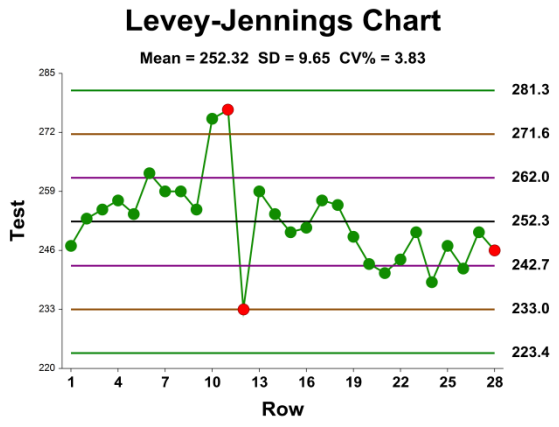
Levey-Jennings Chart Format Window Options

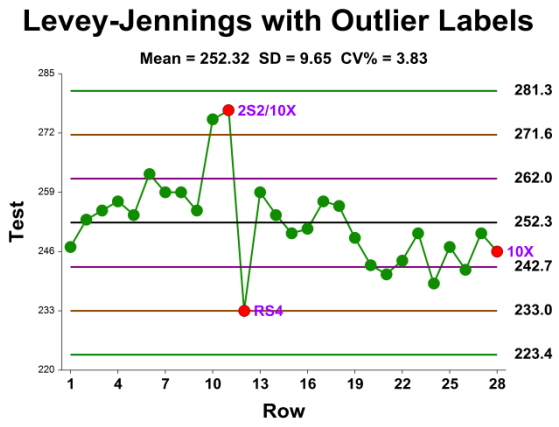
This section describes the specific options available on the Levey-Jennings Chart Format window, which is displayed when a Levey-Jennings Chart Format button is clicked. Common options, such as axes, labels, legends, and titles are documented in the Graphics Components chapter.

Attribute Chart Tab

Symbols Section

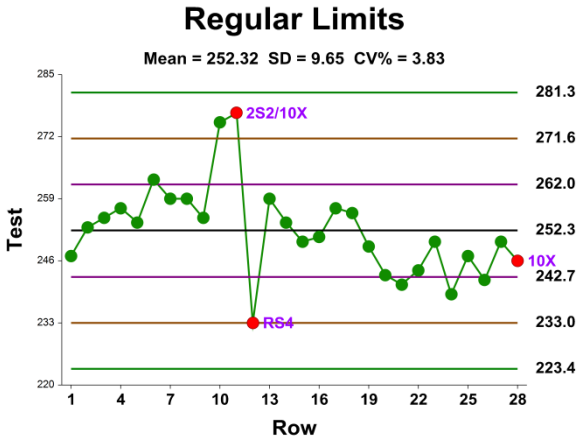
You can modify the attributes of the symbols using the options in this section.

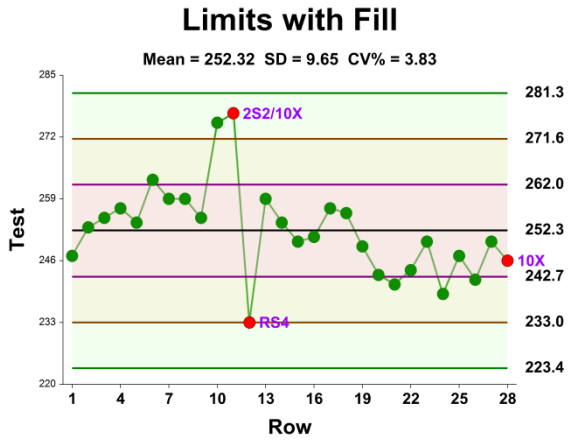




Lines Section

You can specify the format of the various lines using the options in this section. Note that when shading is desired, the fill will be to the bottom for single lines (such as the mean line), and between the lines for pairs of lines (such as primary limits).





Titles, Legend, Numeric Axis, Group Axis, Grid Lines, and Background Tabs

Details on setting the options in these tabs are given in the Graphics Components chapter.

Example 1 – Creating a Levey-Jennings Control Chart

This section presents an example of how to generate a Levey-Jennings control chart. The data are found in the Westgard dataset. We will analyze the variable Test3 on this dataset.

You may follow along here by making the appropriate entries or load the completed template **Example 1** by clicking on Open Example Template from the File menu of the Levey-Jennings Charts window.

1 Open the Westgard dataset.

- From the File menu of the NCSS Data window, select **Open Example Data**.
- Click on the file **Westgard.NCSS**.
- Click **Open**.

2 Open the Levey-Jennings Charts window.

- Using the Analysis or Graphics menu or the Procedure Navigator, find and select the **Levey-Jennings Charts** procedure.
- On the menus, select **File**, then **New Template**. This will fill the procedure with the default template.

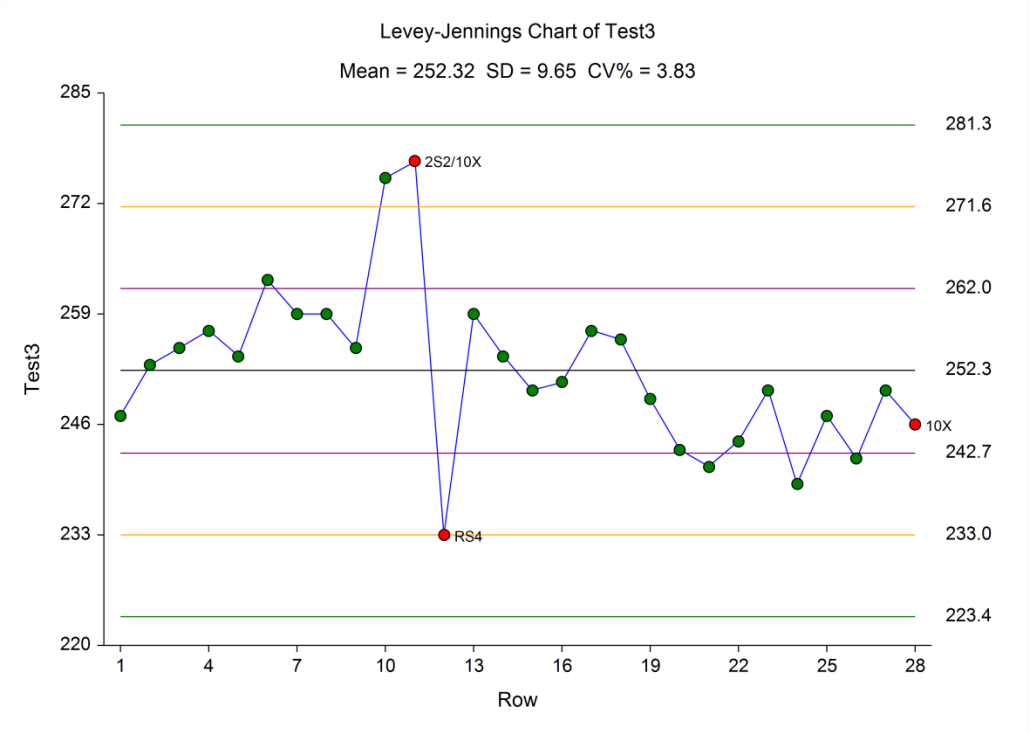
3 Specify the variables.

- On the Levey-Jennings Charts window, select the **Variables tab**.
- Set the **Data Variables** box to **Test3**.

4 Run the procedure.

- From the Run menu, select **Run Procedure**. Alternatively, just click the green Run button.

Levey-Jennings Control Chart



This plot displays the Levey-Jennings control chart. The overall mean (center-line) and three sets of control limits are shown. Notice that three rows are out of control. The next report gives the numerical details of the charts and lists those rows that failed at least one of the control tests.

Numerical Reports

Descriptive Statistics Section for Test3

Rows Used in Calculations	Mean	SD	CV%	Row Count
1-28	252.32	9.65	3.83	28

Control Limits Section for Test3

Rows Used in Calculations	Mean	Lower 3-Sigma	Upper 3-Sigma	Lower 2-Sigma	Upper 2-Sigma
1-28	252.32	223.36	281.28	233.01	271.63

Out-of-Control List for Test3

Row	Value	Reason
11	277	2S2: 2 consecutive values >, or <, 2 sigma
		10X: 10 consecutive values >, or <, mean
12	233	RS4: consecutive difference > 4 sigma
28	246	10X: 10 consecutive values >, or <, mean

The Descriptive Statistic section displays the values of the calculated mean, standard deviation, and coefficient of variation (which is expressed as a percentage). The Control Limits section displays the 2-sigma and 3-sigma control limits. The Out-of-Control List gives a list of all rows that failed at least one of the Westgard rules.