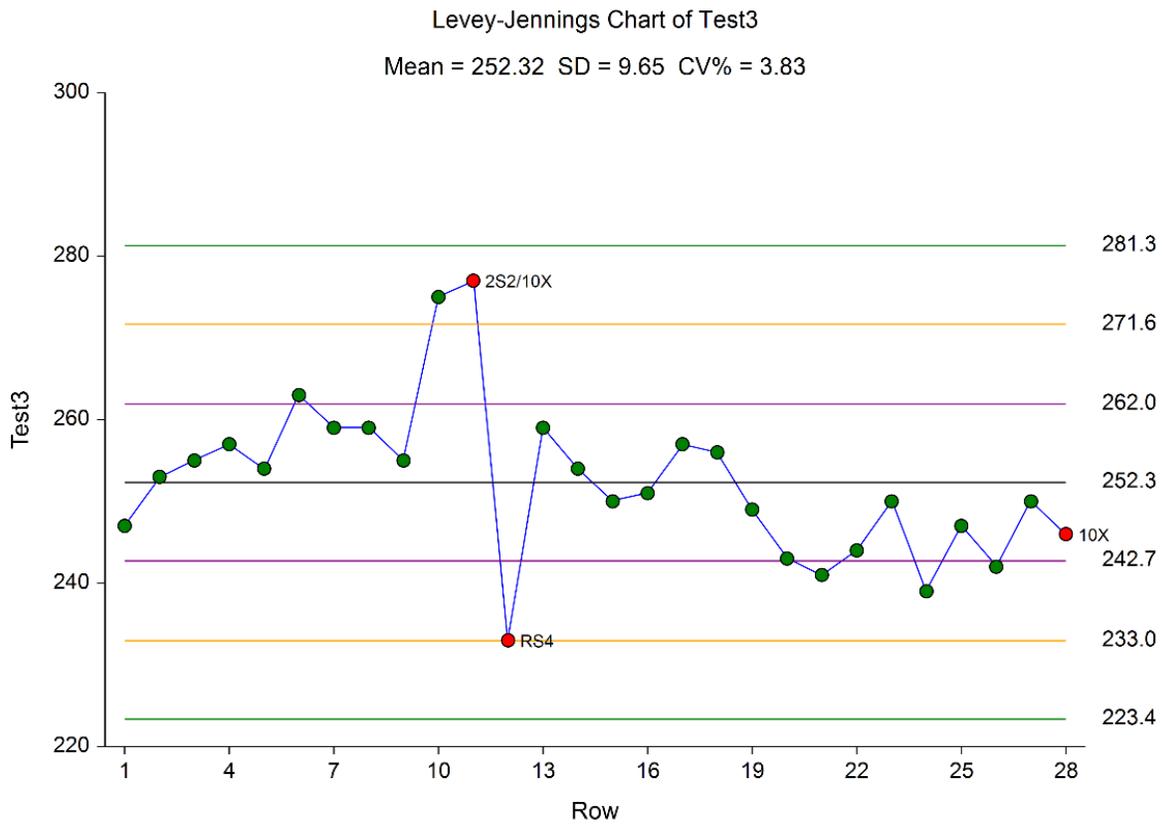


Chapter 252

# 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

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

where the mean is estimated using

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

Control limits are

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

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 example database. Often, variables are entered as pairs, but this is not necessary.

# Levey-Jennings Chart Format Window Options

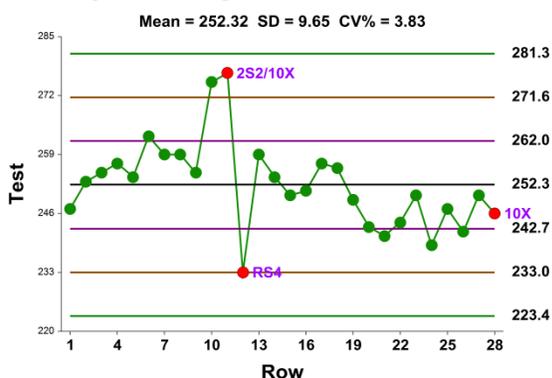
This section describes the specific options available on the Levey-Jennings Chart Format window, which is displayed when a Levey-Jennings Chart Format button is clicked. Common options, such as axes, labels, legends, and titles are documented in the Graphics Components chapter.

## Attribute Chart Tab

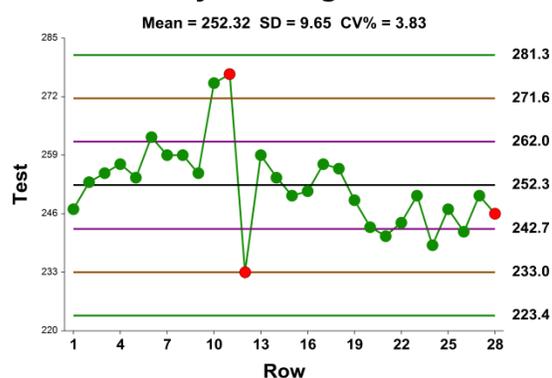
### Symbols Section

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

**Levey-Jennings with Outlier Labels**



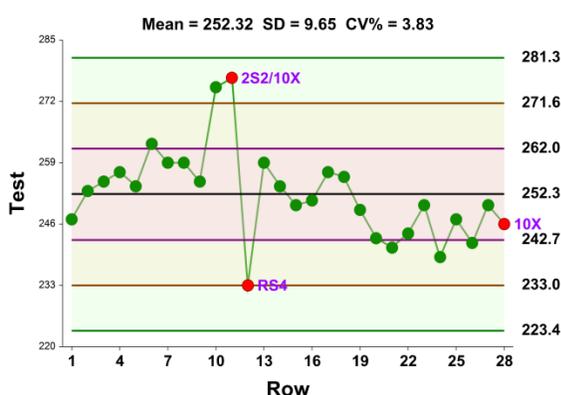
**Levey-Jennings Chart**



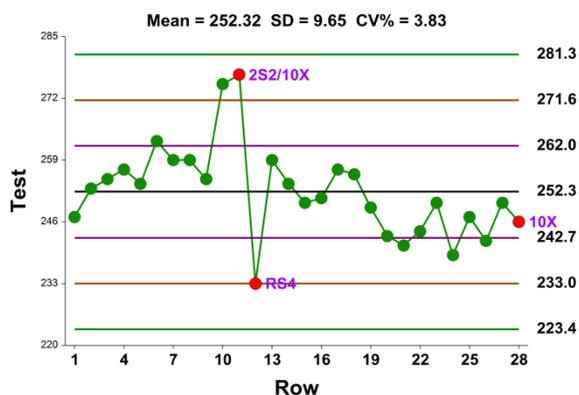
### Lines Section

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).

**Limits with Fill**



**Regular 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.

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## 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.

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### Setup

To run this example, complete the following steps:

#### 1 Open the Westgard example dataset

- From the File menu of the NCSS Data window, select **Open Example Data**.
- Select **Westgard** and click **OK**.

#### 2 Specify the Levey-Jennings Charts procedure options

- Find and open the **Levey-Jennings Charts** procedure using the menus or the Procedure Navigator.
- The settings for this example are listed below and are stored in the **Example 1** settings file. To load these settings to the procedure window, click **Open Example Settings File** in the Help Center or File menu.

Variables Tab

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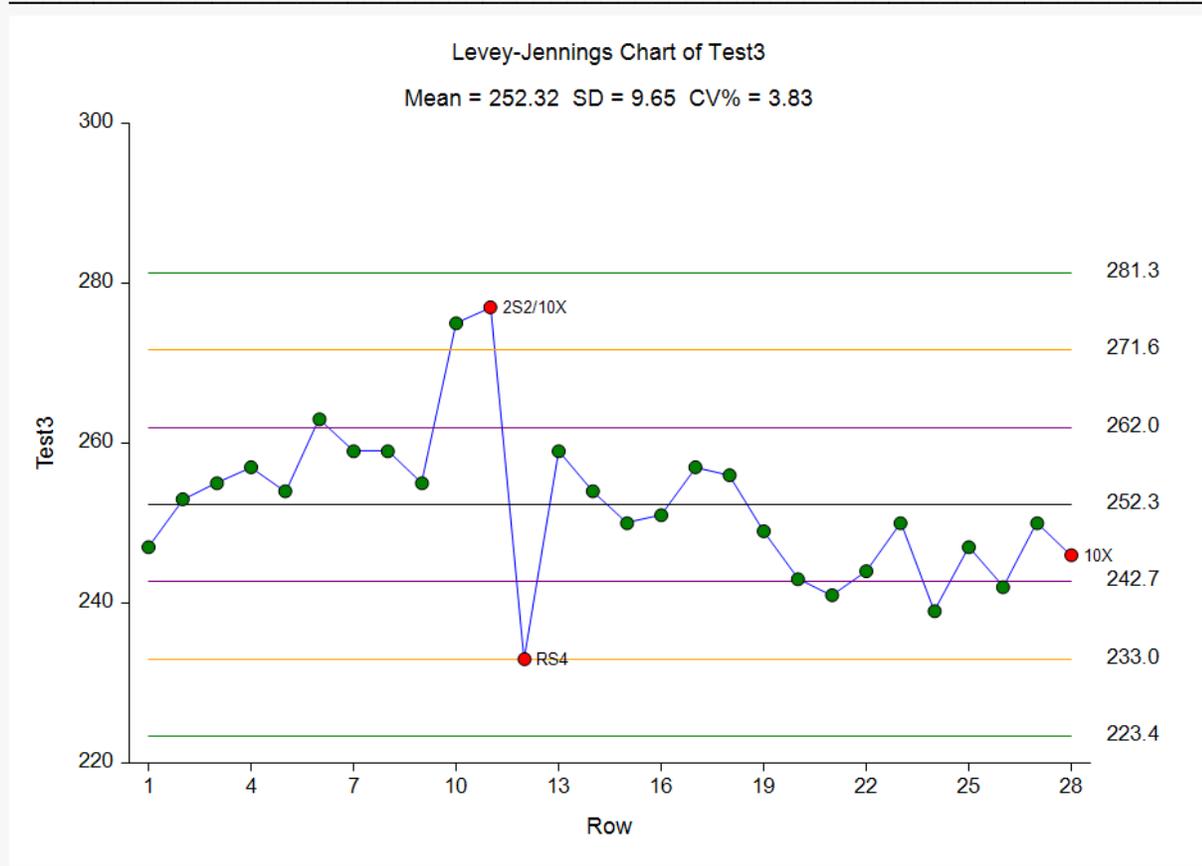
Data Variables ..... **Test3**

#### 3 Run the procedure

- Click the **Run** button to perform the calculations and generate the output.

# Levey-Jennings Control Chart

Levey-Jennings Control Chart for Rows 1 - 28



This plot displays the Levey-Jennings control chart. The overall mean (centerline) 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.

## Numeric Reports

### Descriptive Statistics for Test3

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

### Control Limits for Test3

Rows Used in Calculations	Mean	Control Limits			
		3-Sigma		2-Sigma	
		Lower	Upper	Lower	Upper
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.