Module 1. Minitab basics

Presented by: QE NPI Andrés Ruelas

Speaker: Andrés Ruelas

- Quality and New Product Introduction Engineer
- Medical sector (Cardinal Health, Medtronic, Stryker)
- Specialized in molding, extrusion, sealing with Urania and Multivac equipment, and automatic inspection systems
- 2 published textbooks, available at Amazon
  - Quality Engineering for Recent College Graduates (Enginerring / Quality)
  - Guía Para la inversión utilizando Cetes Directo (Finance / Costs)

- Cetys Universidad: Diploma in Medical Manufacturing Engineering
- Cetys Universidad: Diploma in Cost Engineering
- Cetys Universidad: Diploma in Project Management
- Eje Instituto: Seminar in Scientific Molding
- Trained for Certified Quality Engineer Exam
- Minitab YouTube channel with more than 10,000 views and 1,200 of training hours given

Training and Courses Given

- YouTube Channel: CUSUM – Training For Professionals
- Views: +10,000 People
- Videos: 6 Videos focused on Minitab
- Hours given: 1,200 hours

Design of Experiments (DOE) - Minitab Masters Module 5

Instructor at Academia Lean Six Sigma – Bit Center

Courses given

- Root Cause Analysis in Minitab (RCA)
- Statistical Analysis for Validations with Minitab

Training and Courses Given

In-person CUSUM course

23 de Mayo 2019

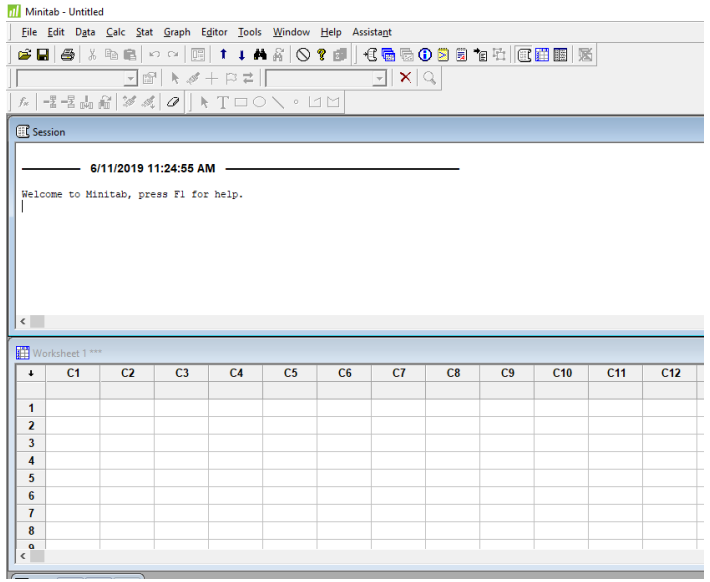
Design of Experiments (DOE) with Minitab

Note on Minitab 19

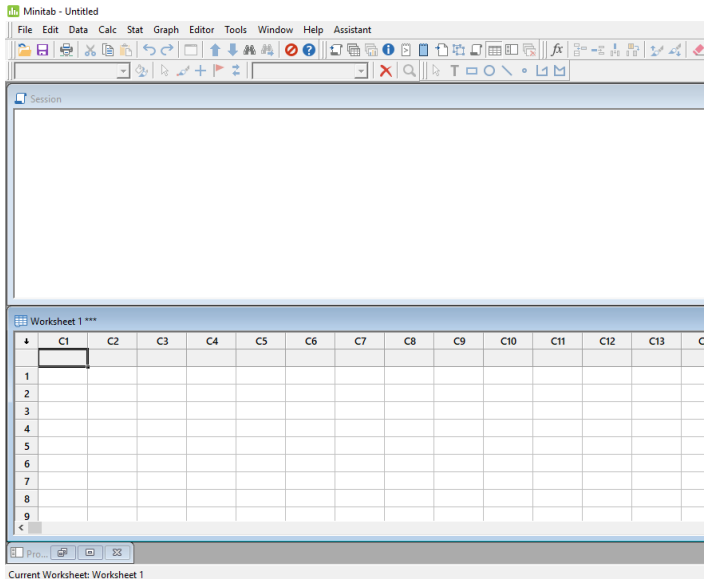
- To this date, there are multiple Minitab versions available (16, 17, 18 and 19)
- All of them contain the same features, though the arrangement can be slightly different.
- Minitab 19 has been just launched on June 1, 2019, and is not currently being used by most companies. However, the interface and analyses are very similar. The distinctions will be apparent through the course.

Minitab Versions

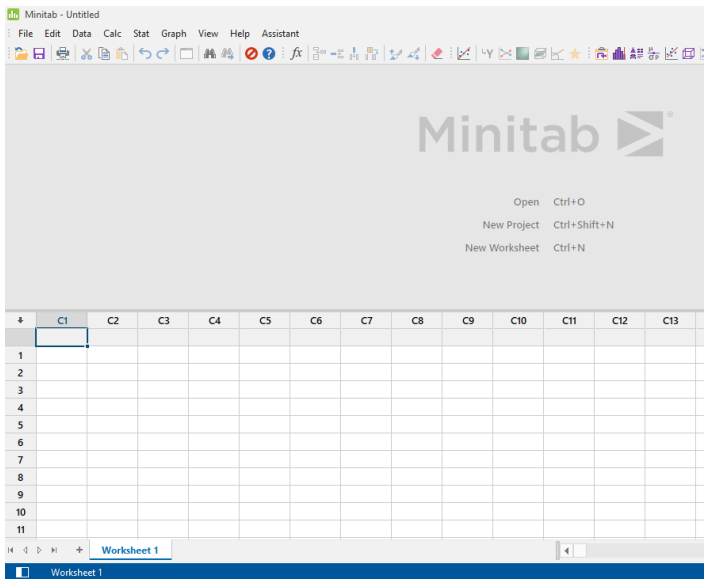
Minitab 16 (2013)
Minitab 17 (2015)



Minitab 18 (2017)



Minitab 19 (2019)



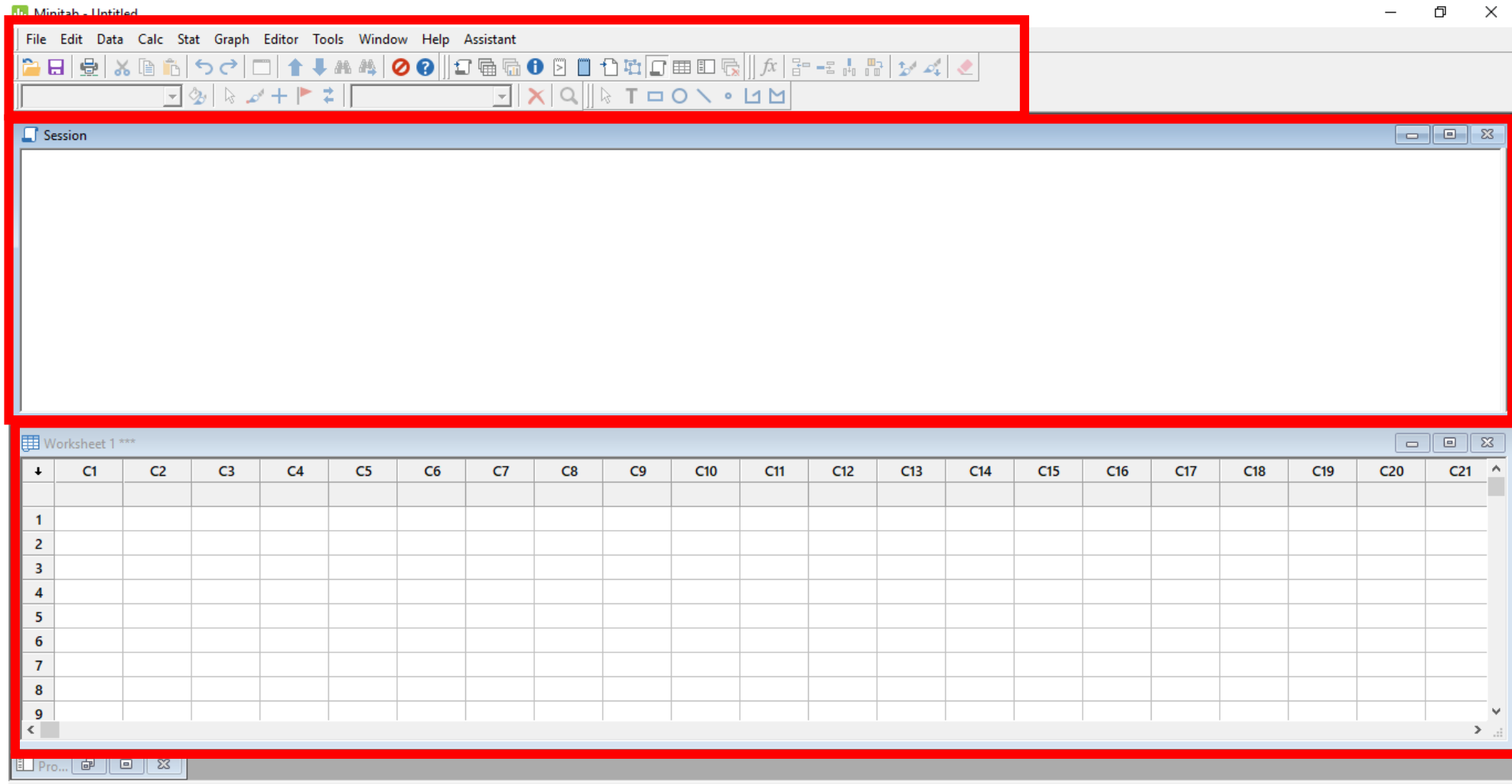
Minitab launches a new version every 2 years. Since version 16 (2013), there hasn't been any significant change in the studies. The main additions are in the assistant, which is not required for this course.

Minitab Interface

Toolbars

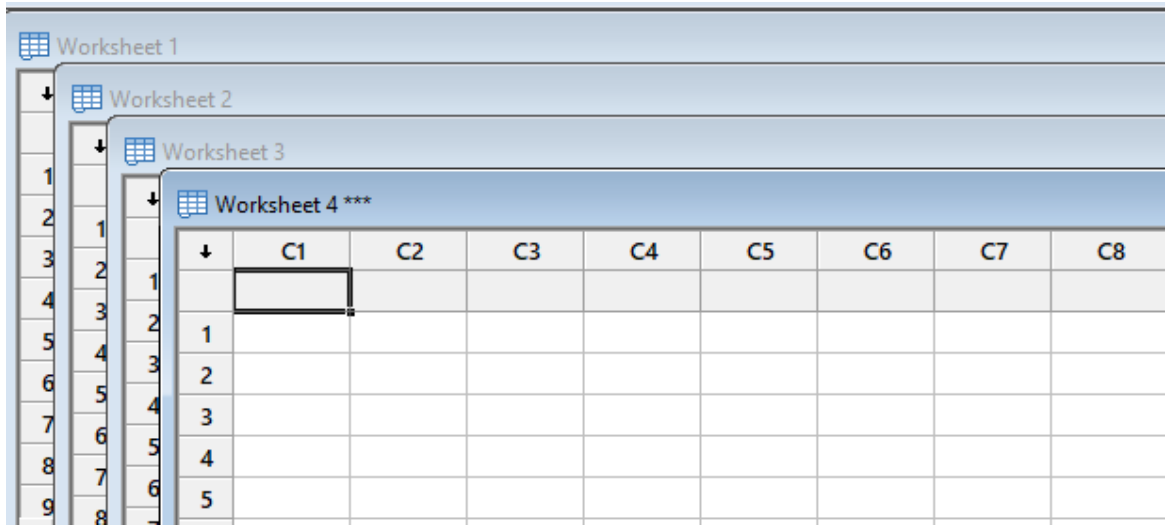
Session window

Worksheet

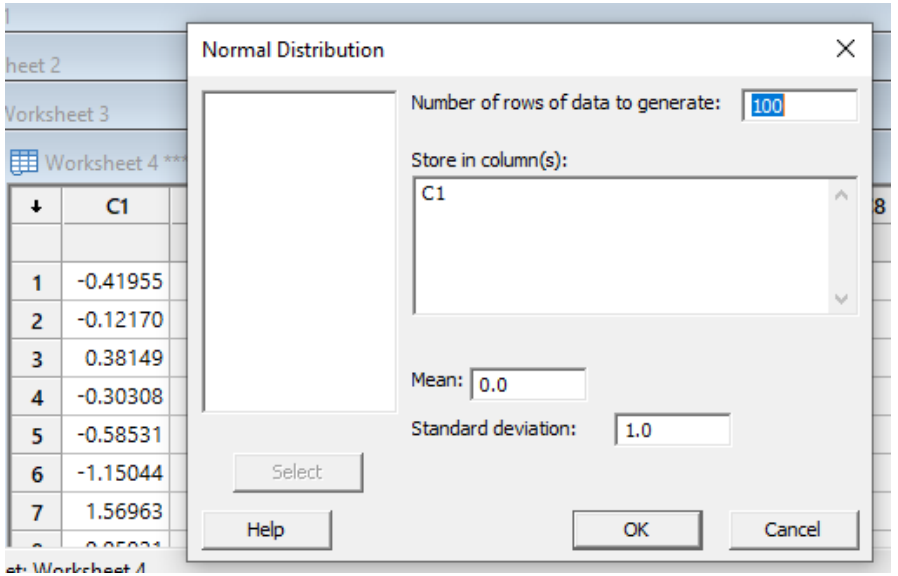


Worksheet Creation

Press Ctrl + N
To create a new worksheet/project



Press Ctrl + E
To repeat the last done analysis



Types of Data in Minitab

Minitab manages all of its data though the use of columns. The columns are arranged as C1, C2, C3.... etc.

The names of the columns inform you of the type of data being contained. Observe the columns C5, C6 and C7.

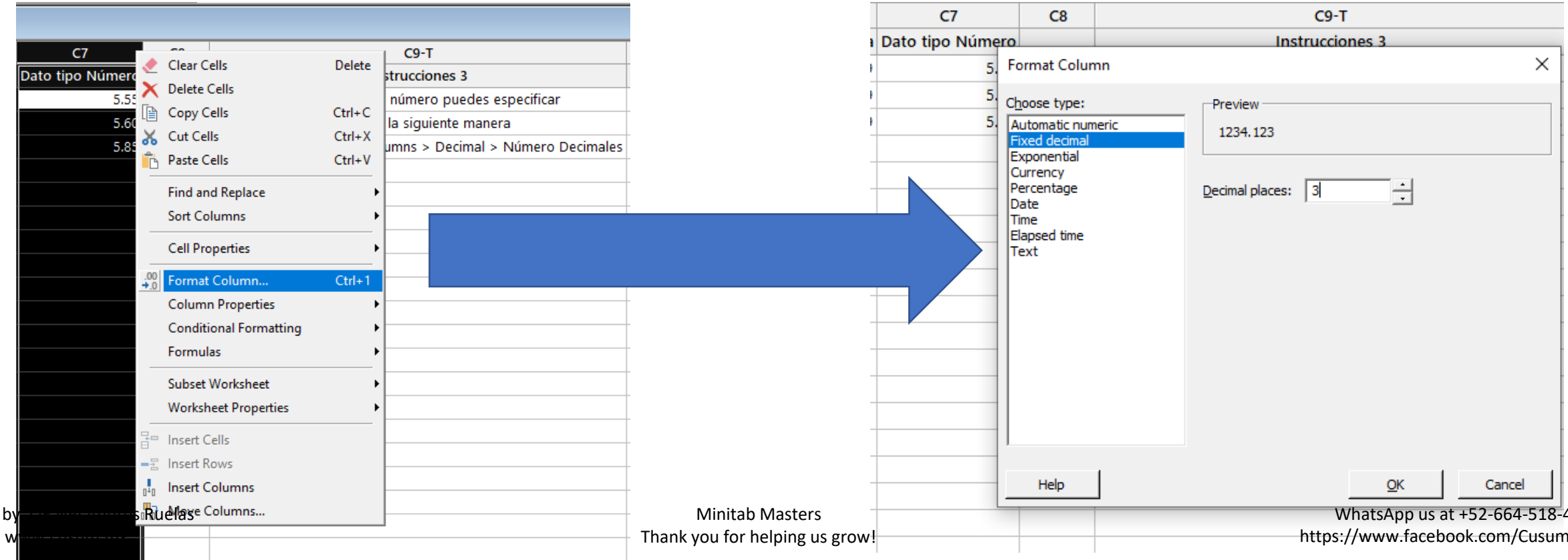
Notice that column C5 includes a T, column C6 includes a D, and column C7 doesn't include any letter.

C5-T	C6-D	C7
Dato tipo Texto	Dato Tipo Fecha	Dato tipo Número
Andres	5/21/2019	5.55
Eduardo	5/22/2019	5.60
Gabriela	5/23/2019	5.85

Types of Data in Minitab

In the case of number type data, it is posible to specify the number of decimal places in the following way:

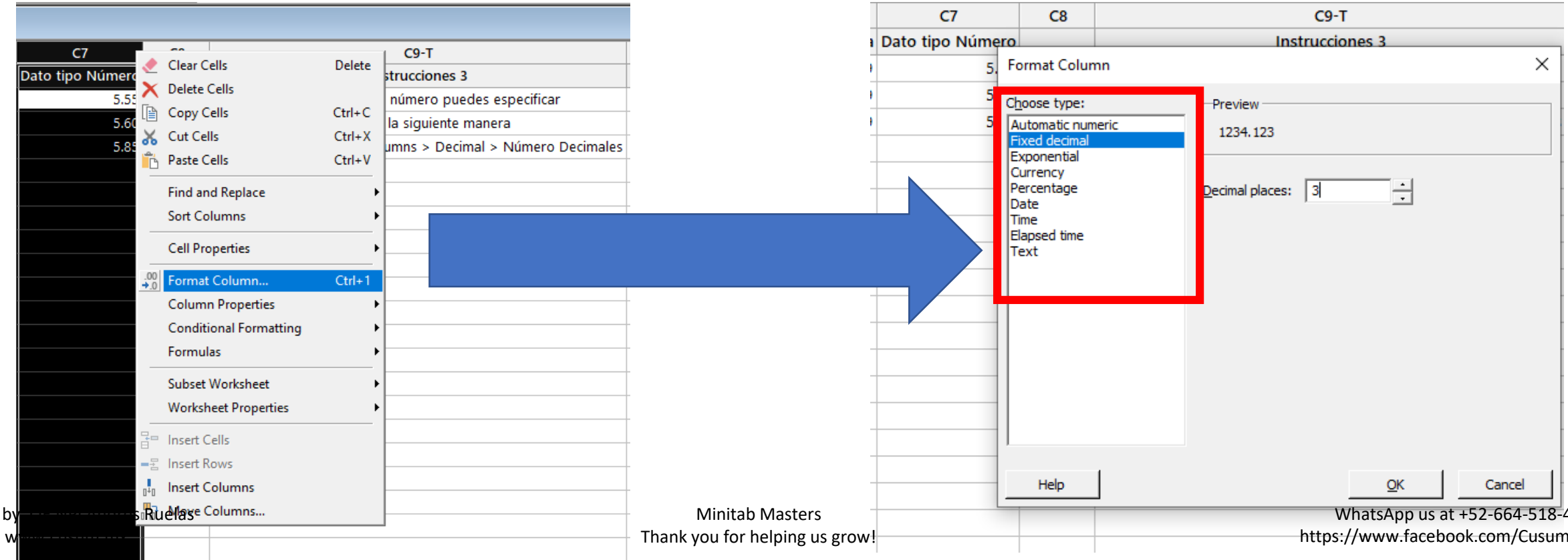
Right click > Format Column… > Fixed decimal > Decimal places



Types of Data in Minitab

You can also specify date and currency format (e.g. Dollars):

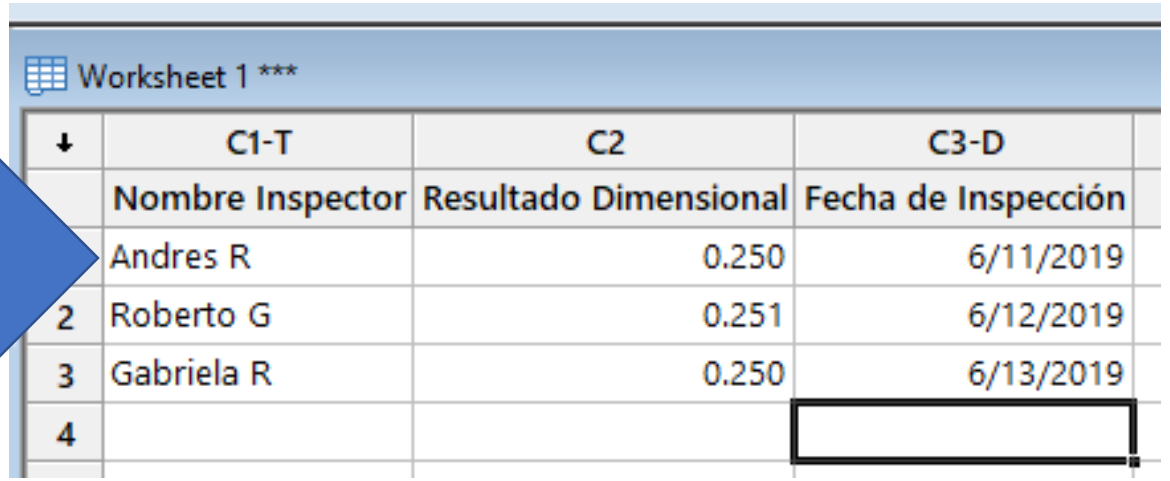
Right click > Format Column… > Date > Date format
Right click > Format Column… > Currency > Currency format



Types of Data in Minitab

Exercise: Input the following data in Minitab.

Nombre Inspector	Resultado Dimensional	Fecha de Inspección
Andres R	0.250	06/11/19
Roberto G	0.251	06/12/19
Gabriela R	0.250	06/13/19



Answer: Data must look like in the previous image.
Excellent! It is that easy to capture data in Minitab, just like in Excel.
Now, onto the next chapter.

Organizing Data in Minitab

Notice that the worksheet has a name. In this case, it is called “Worksheet 1”. You can assign a unique name to this worksheet through the Project Manager.

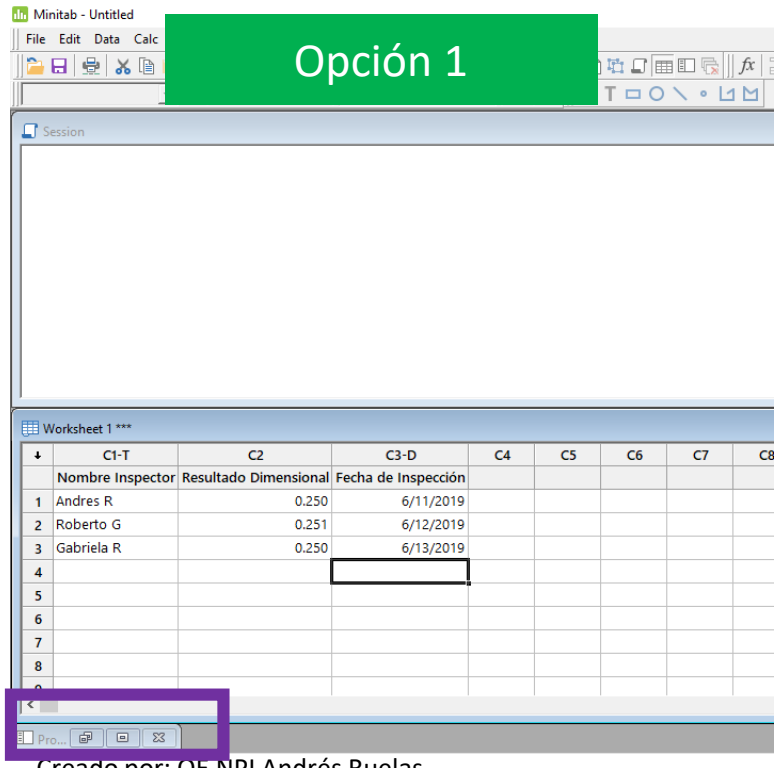
Worksheet 1 ***

	C1-T	C2	C3-D
	Nombre Inspector	Resultado Dimensional	Fecha de Inspección
1	Andres R	0.250	6/11/2019
2	Roberto G	0.251	6/12/2019
3	Gabriela R	0.250	6/13/2019
4			

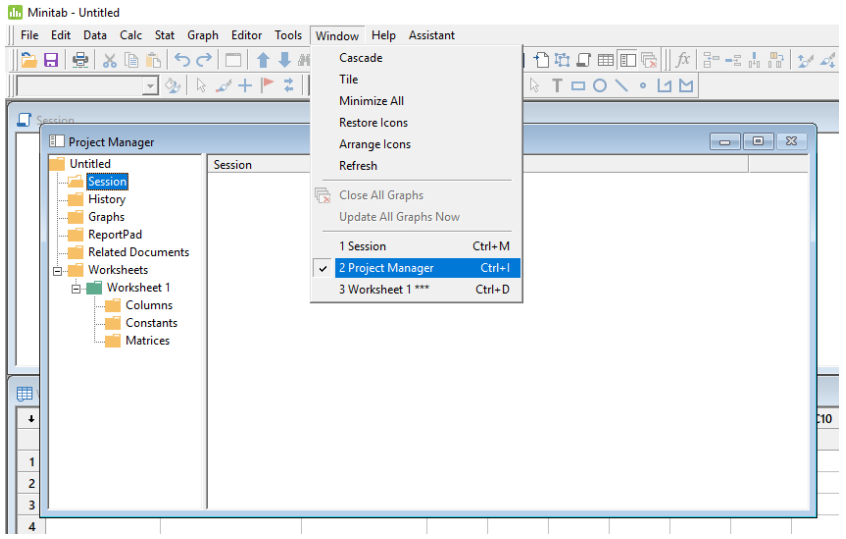
Organizing Data in Minitab

The Project Manager is minimized by default. You can maximize it by clicking the corresponding button. In case it is missing, you can also click “Window > Project Manager”. In the case of Minitab 19, you just need to double click the worksheet name “Worksheet 1”.

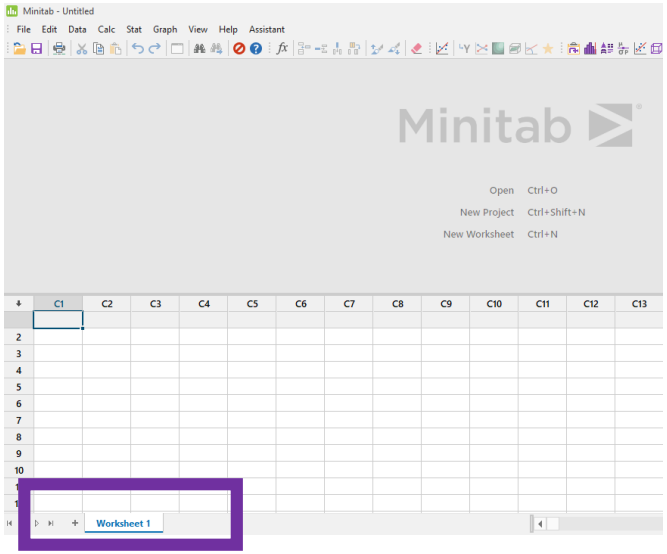
Opción 1



Opción 2

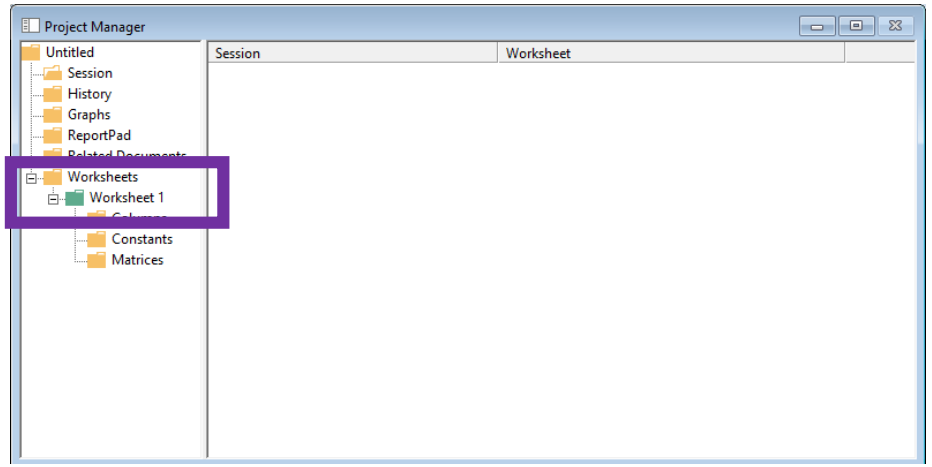


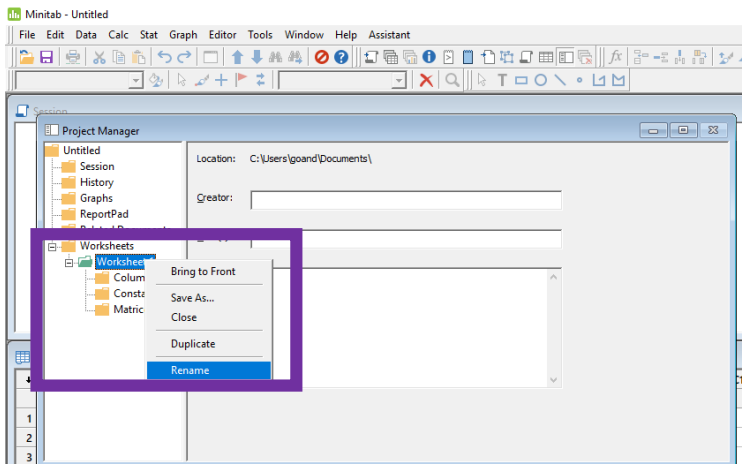
Minitab 19

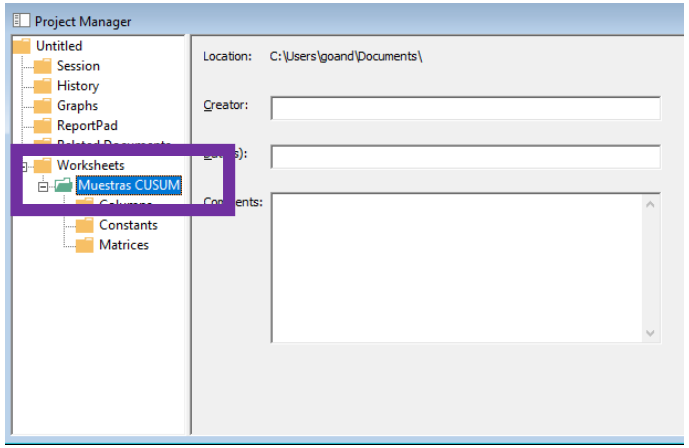


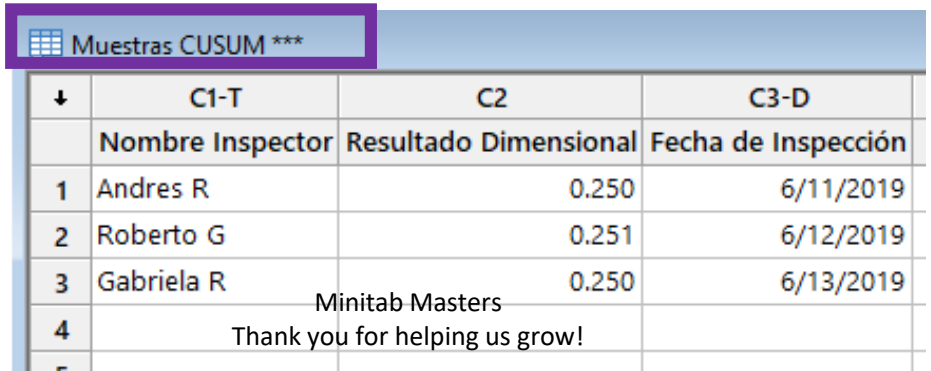
Organizing Data in Minitab

Now, inside the Project Manager, select the worksheet named “Worksheet 1” and right click. Select “Rename” and input the desired name (e.g. Muestras CUSUM). Notice how the title “Worksheet 1” changed to “Muestras CUSUM”.








Muestras CUSUM ***

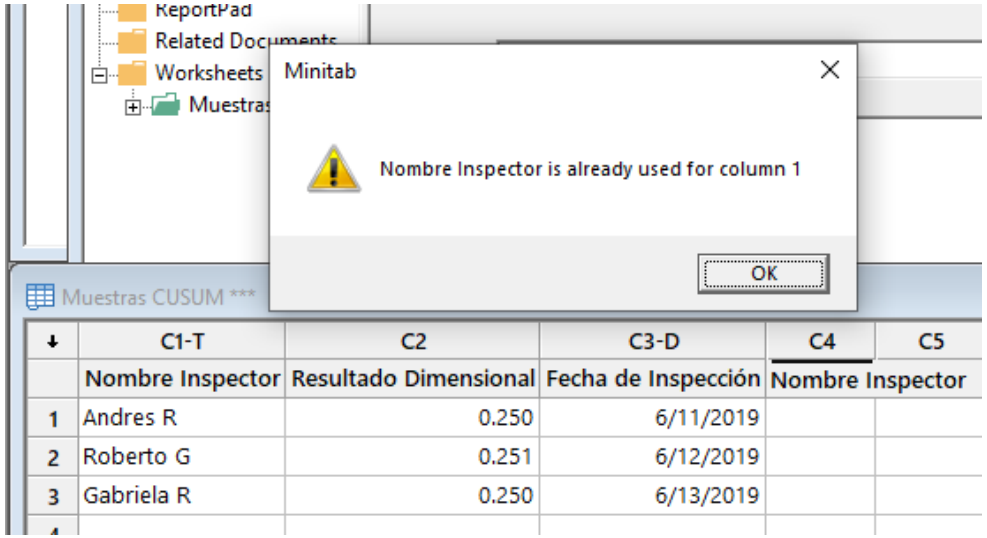
	C1-T	C2	C3-D
	Nombre Inspector	Resultado Dimensional	Fecha de Inspección
1	Andres R	0.250	6/11/2019
2	Roberto G	0.251	6/12/2019
3	Gabriela R	0.250	6/13/2019
4			

Organizing Data in Minitab

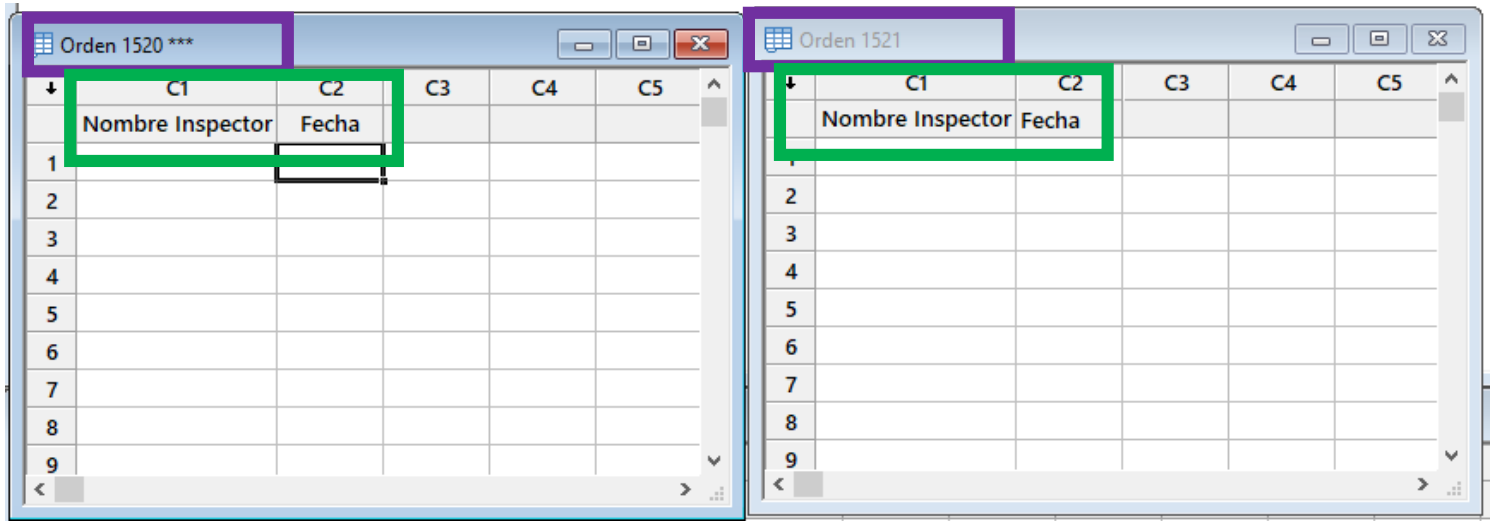
This is important, since Minitab doesn't allow for two or more columns, on a same worksheet, to have the same name.

Try to write the name "Inspector" in C4 and notice that Minitab shows an error.

If you're interested in capturing information with the same column name again, it is preferred to create a new worksheet and name it in a different manner. (e.g. "Order #", "Product #", etc.)

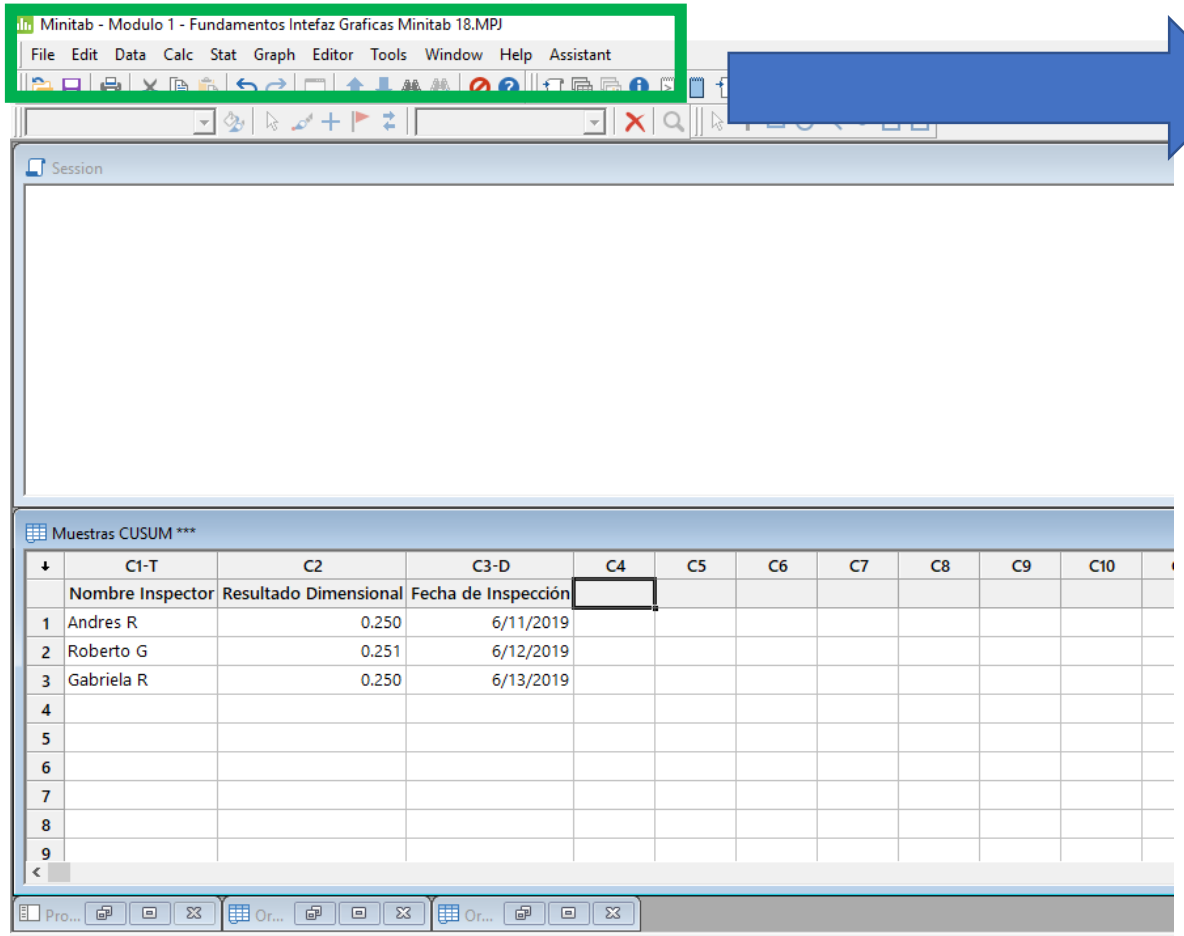


	C1-T	C2	C3-D	C4	C5
	Nombre Inspector	Resultado Dimensional	Fecha de Inspección	Nombre Inspector	
1	Andres R	0.250	6/11/2019		
2	Roberto G	0.251	6/12/2019		
3	Gabriela R	0.250	6/13/2019		

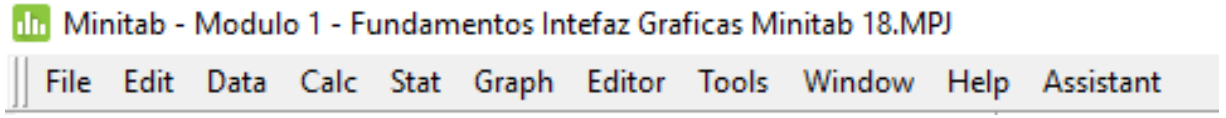


Understanding Basic Analyses

Minitab is a program designed to perform statistical analyses. The top menu includes all analyses available in Minitab, grouped in categories.



	C1-T	C2	C3-D	C4	C5	C6	C7	C8	C9	C10
	Nombre Inspector	Resultado Dimensional	Fecha de Inspección							
1	Andres R	0.250	6/11/2019							
2	Roberto G	0.251	6/12/2019							
3	Gabriela R	0.250	6/13/2019							
4										
5										
6										
7										
8										
9										



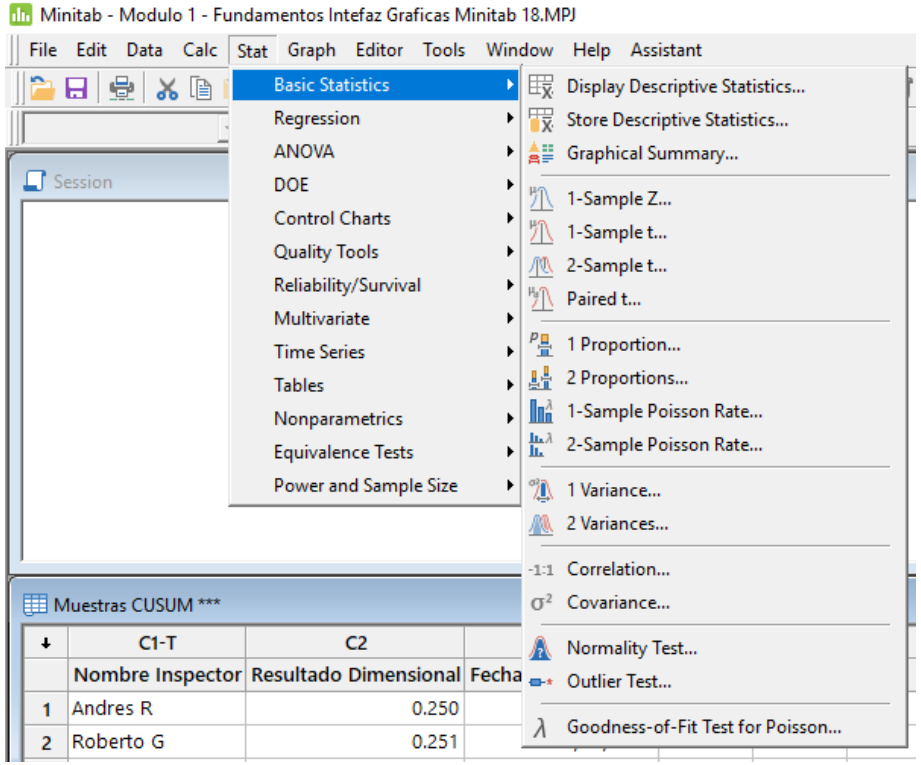
The main menus to run analyses in Minitab are Stat and Graph.

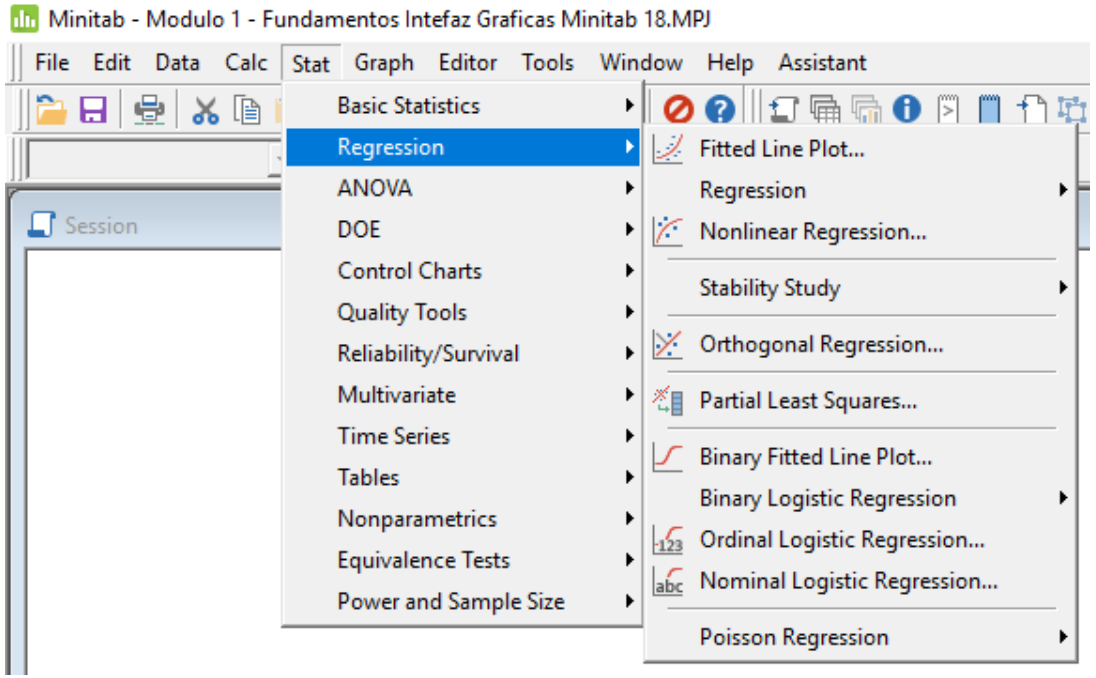
In summary, the menus contain the following options:

- File and Edit: Tools to open and configure files
- Data and Calc: Tools to configure columns
- Stat: Tools to run statistical analyses
- Graph: Tools to create visual graphs
- Editor and Tools: Seldom used, mainly for macros
- Window and Help: If a window minimizes and you can't find it, you can select it by using "Window".
- Assistant: It's a tool that guides you, step by step, to create basic analyses (DOE, ANOVA, Regression), it is limited, but useful in case of doubt.

Understanding Basic Analyses

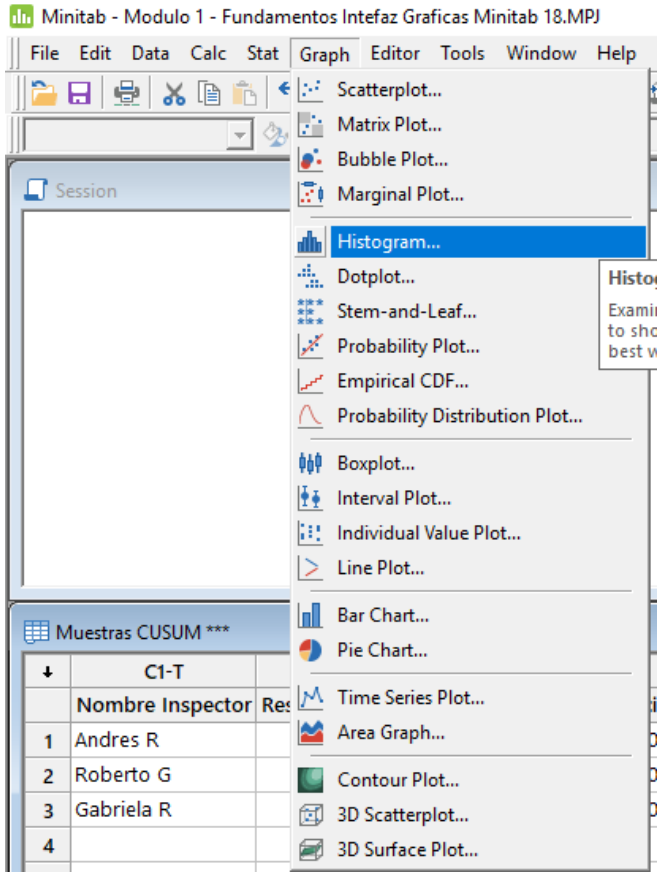
Each tool will be explained as soon as it is required. As of now, you can observe that the “Stat” menu contains many submenus, and these can contain other submenus.





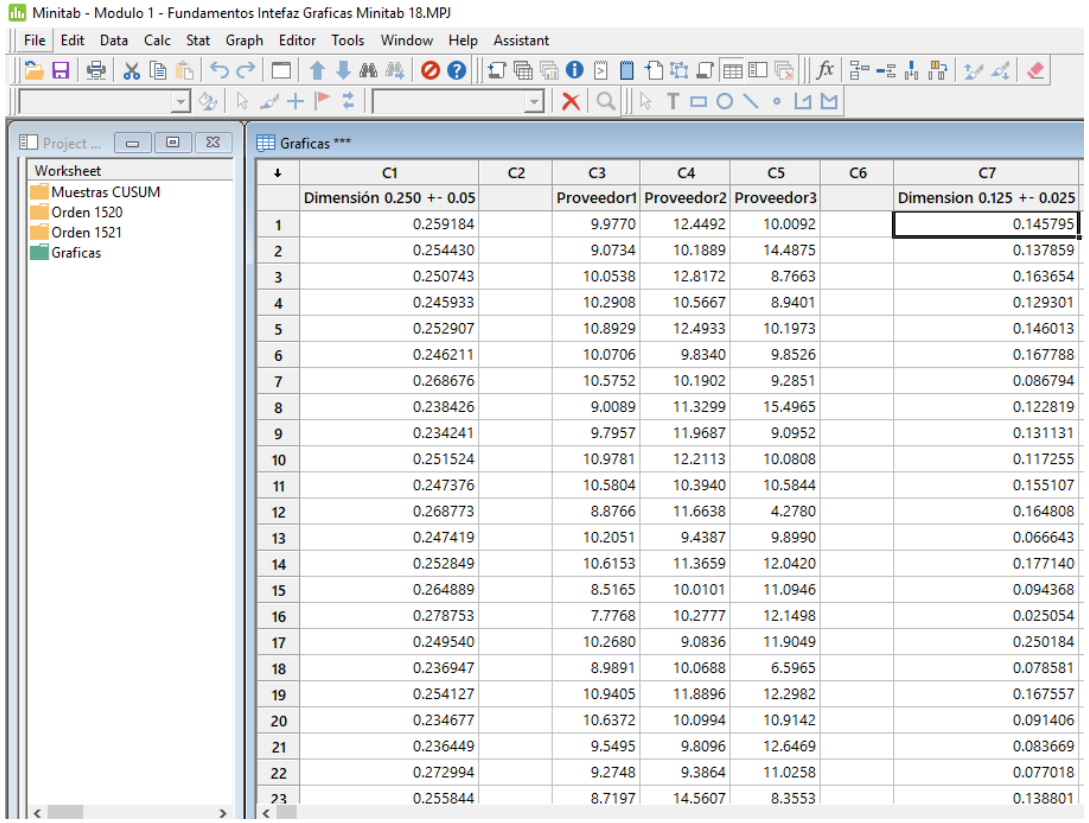
Understanding Basic Analyses

The “Graph” menu contains the most common graphs (e.g. histograms, boxplots, interval plots, bar charts and pie charts).



Creating Graphs - Histogram

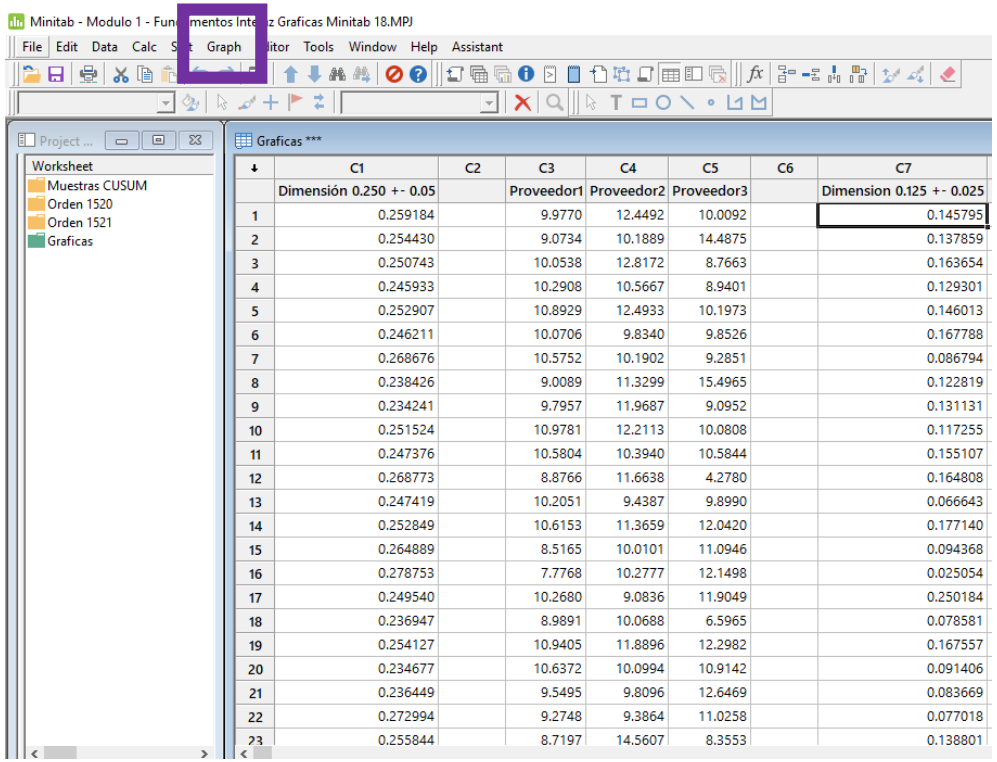
A histogram is a visual representation of your data, where your data is grouped based on value ranges (Bines / Columns). Open the worksheet “Gráficas” and observe it contains data in C1, C3-C5 and C7.



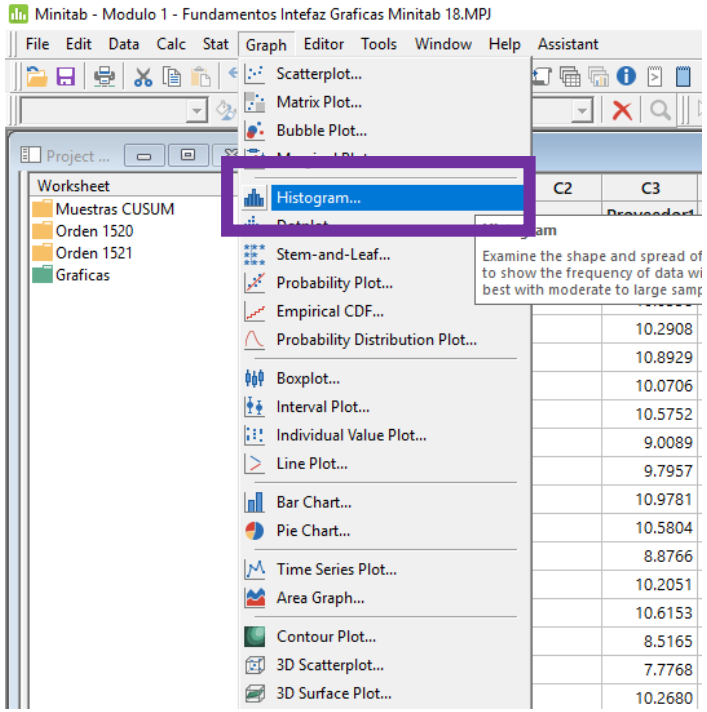
	C1	C2	C3	C4	C5	C6	C7
	Dimensión 0.250 +- 0.05		Proveedor1	Proveedor2	Proveedor3		Dimension 0.125 +- 0.025
1	0.259184		9.9770	12.4492	10.0092		0.145795
2	0.254430		9.0734	10.1889	14.4875		0.137859
3	0.250743		10.0538	12.8172	8.7663		0.163654
4	0.245933		10.2908	10.5667	8.9401		0.129301
5	0.252907		10.8929	12.4933	10.1973		0.146013
6	0.246211		10.0706	9.8340	9.8526		0.167788
7	0.268676		10.5752	10.1902	9.2851		0.086794
8	0.238426		9.0089	11.3299	15.4965		0.122819
9	0.234241		9.7957	11.9687	9.0952		0.131131
10	0.251524		10.9781	12.2113	10.0808		0.117255
11	0.247376		10.5804	10.3940	10.5844		0.155107
12	0.268773		8.8766	11.6638	4.2780		0.164808
13	0.247419		10.2051	9.4387	9.8990		0.066643
14	0.252849		10.6153	11.3659	12.0420		0.177140
15	0.264889		8.5165	10.0101	11.0946		0.094368
16	0.278753		7.7768	10.2777	12.1498		0.025054
17	0.249540		10.2680	9.0836	11.9049		0.250184
18	0.236947		8.9891	10.0688	6.5965		0.078581
19	0.254127		10.9405	11.8896	12.2982		0.167557
20	0.234677		10.6372	10.0994	10.9142		0.091406
21	0.236449		9.5495	9.8096	12.6469		0.083669
22	0.272994		9.2748	9.3864	11.0258		0.077018
23	0.255844		8.7197	14.5607	8.3553		0.138801

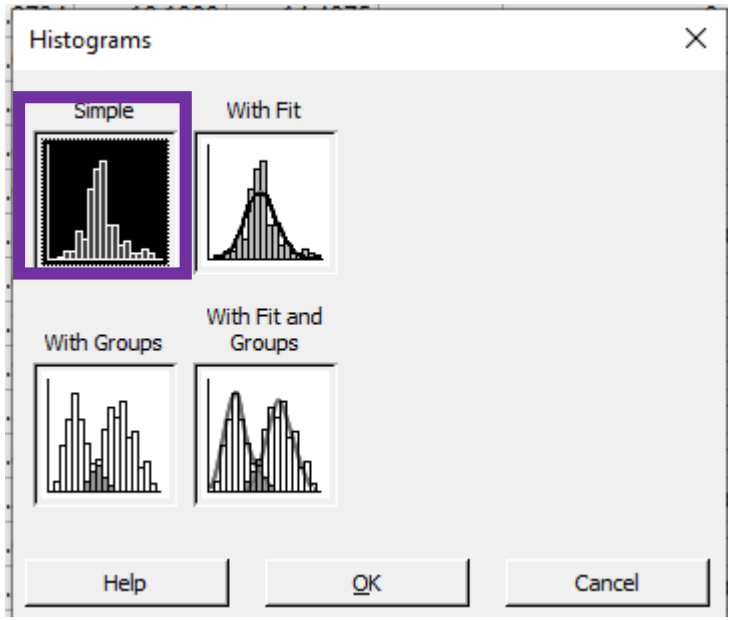
Creating Graphs - Histogram

The first step consists in creating a histogram using column C1 data. To do this, just click “Graph > Histogram”. A window will open, click “Simple” and then, “OK”.



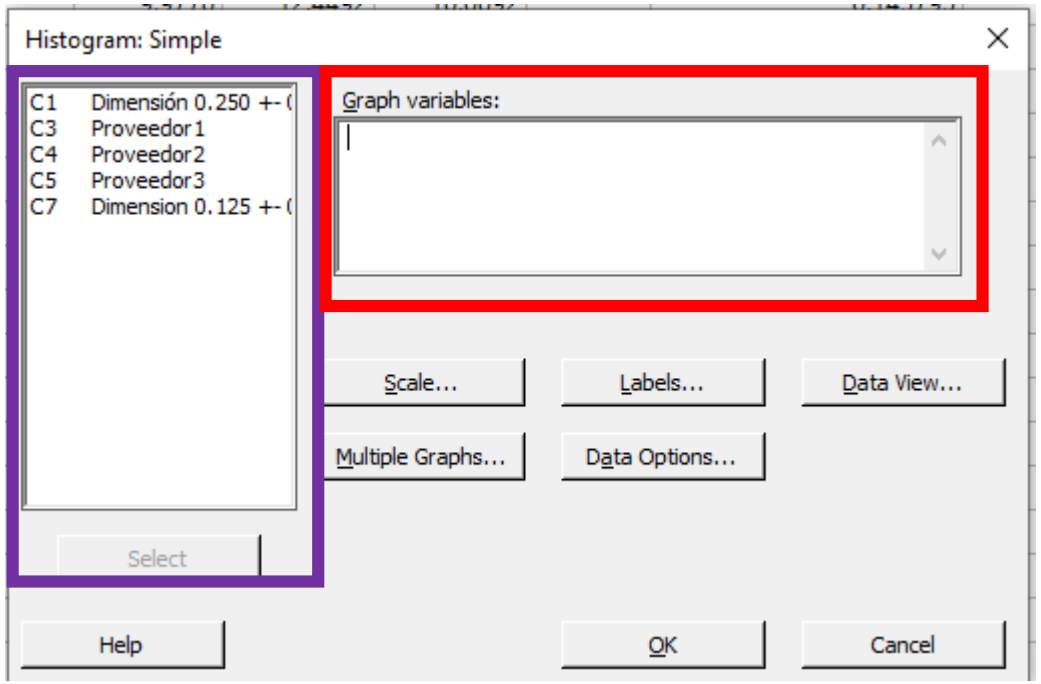
	C1	C2	C3	C4	C5	C6	C7
	Dimensión 0.250 +- 0.05		Proveedor1	Proveedor2	Proveedor3		Dimension 0.125 +- 0.025
1	0.259184		9.9770	12.4492	10.0092		0.145795
2	0.254430		9.0734	10.1889	14.4875		0.137859
3	0.250743		10.0538	12.8172	8.7663		0.163654
4	0.245933		10.2908	10.5667	8.9401		0.129301
5	0.252907		10.8929	12.4933	10.1973		0.146013
6	0.246211		10.0706	9.8340	9.8526		0.167788
7	0.268676		10.5752	10.1902	9.2851		0.086794
8	0.238426		9.0089	11.3299	15.4965		0.122819
9	0.234241		9.7957	11.9687	9.0952		0.131131
10	0.251524		10.9781	12.2113	10.0808		0.117255
11	0.247376		10.5804	10.3940	10.5844		0.155107
12	0.268773		8.8766	11.6638	4.2780		0.164808
13	0.247419		10.2051	9.4387	9.8990		0.066643
14	0.252849		10.6153	11.3659	12.0420		0.177140
15	0.264889		8.5165	10.0101	11.0946		0.094368
16	0.278753		7.7768	10.2777	12.1498		0.025054
17	0.249540		10.2680	9.0836	11.9049		0.250184
18	0.236947		8.9891	10.0688	6.5965		0.078581
19	0.254127		10.9405	11.8896	12.2982		0.167557
20	0.234677		10.6372	10.0994	10.9142		0.091406
21	0.236449		9.5495	9.8096	12.6469		0.083669
22	0.272994		9.2748	9.3864	11.0258		0.077018
23	0.255844		8.7197	14.5607	8.3553		0.138801





Creating Graphs - Histogram

Now, Minitab will show a settings window. All of these windows follow the same format. The information can change slightly, but they are very similar to each other.

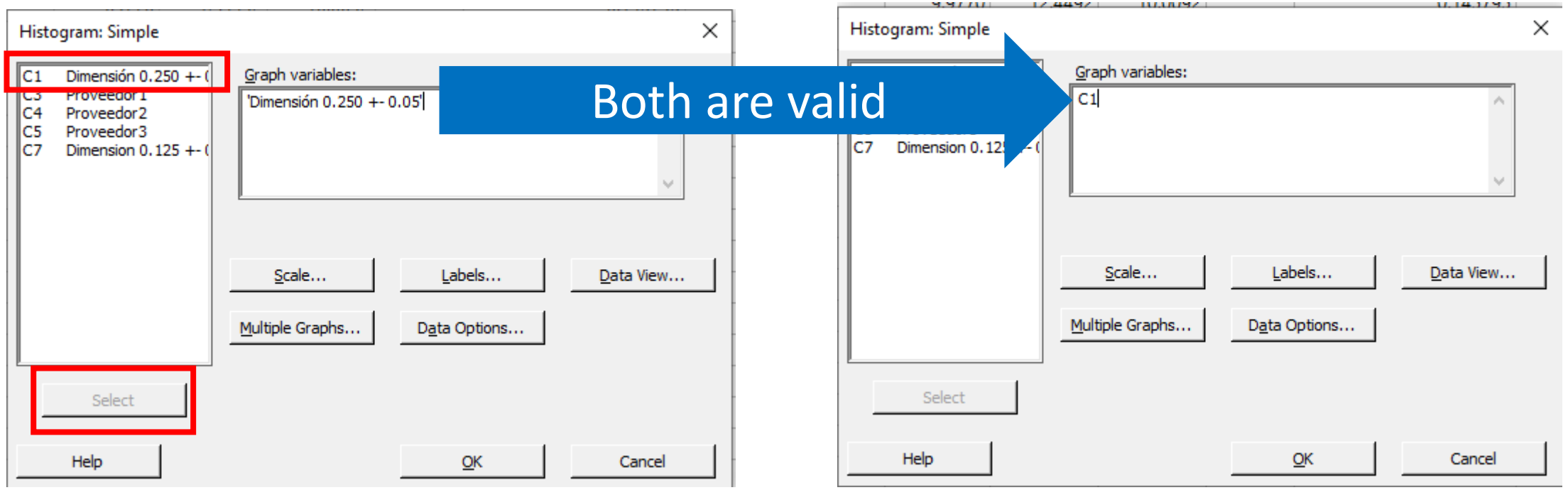


The left section shows the columns with data that can be analyzed.

The right section shows the variable that will be analyzed.

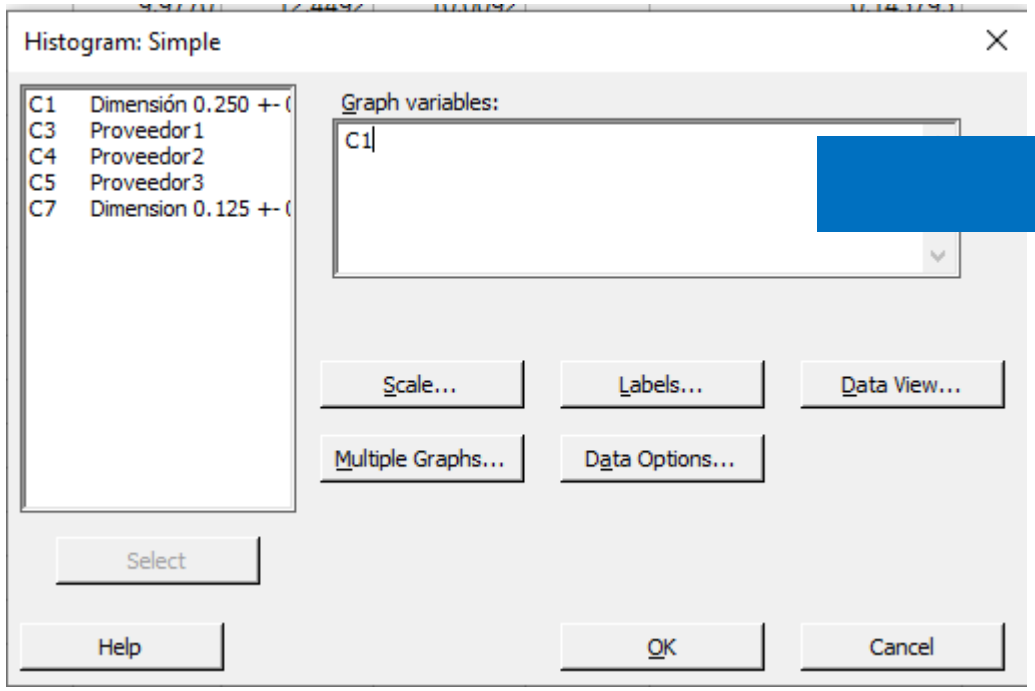
Creating Graphs - Histogram

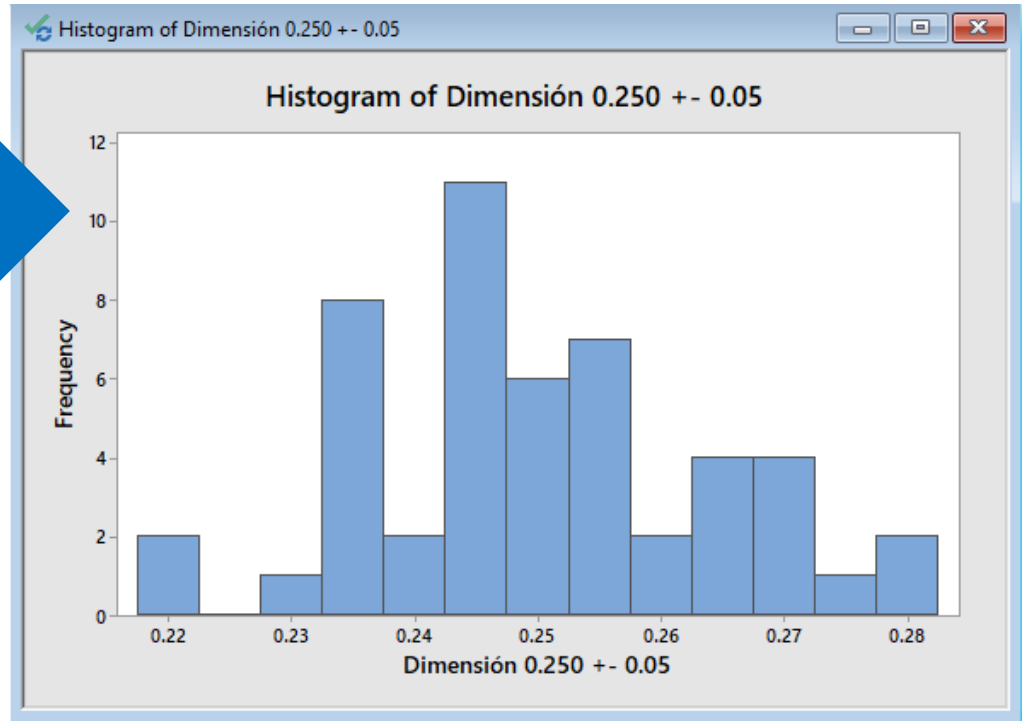
Now, select C1 in the left section by double clicking or clicking “Select”. This will add the column to the variables section. Notice that the name captured is the column title. You can also write it as C1, and Minitab will recognize it successfully. By doing all of this, you are telling Minitab to create a graph of the column C1.



Creating Graphs - Histogram

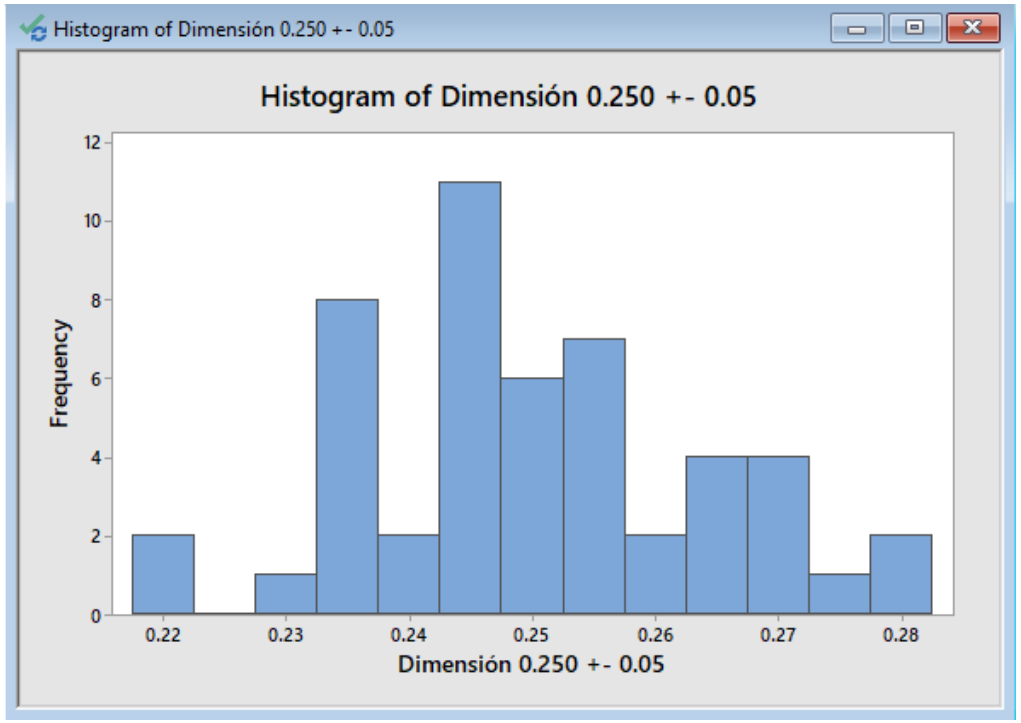
Select “OK”. The graph will be created automatically. The usefulness of an histogram is in that it can show you where your data is grouped. The taller the bar, the more data there is in the corresponding range. Observe that the histogram shows that there’s data from 0.22 to 0.28.

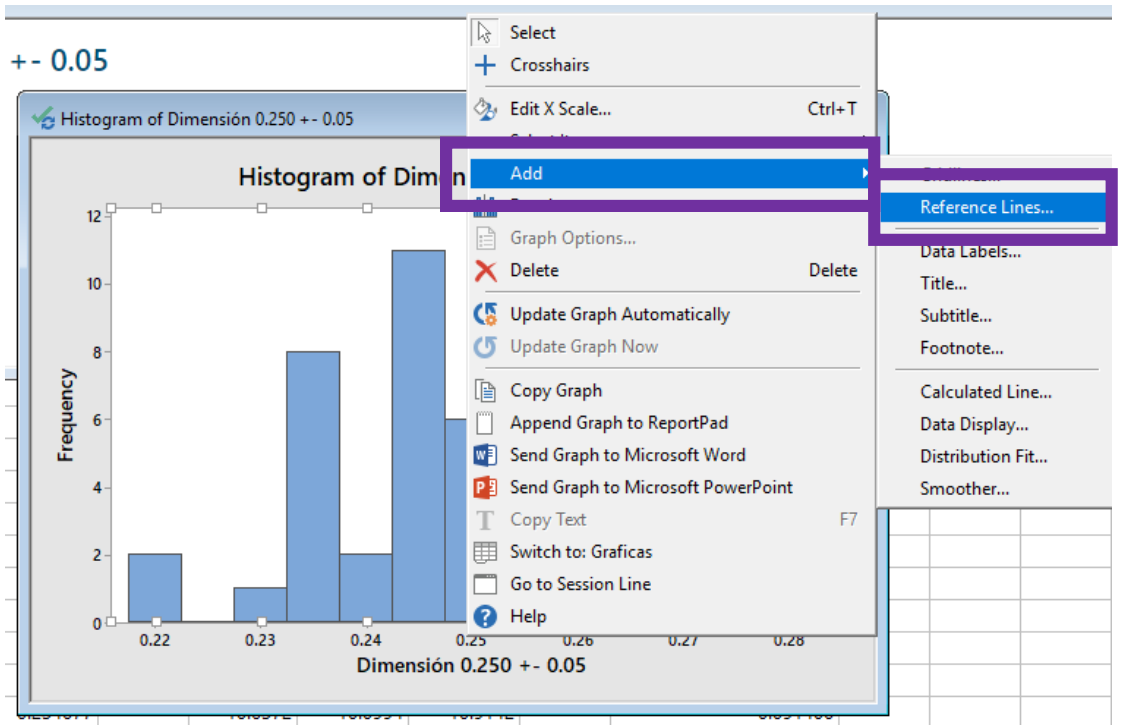




Creating Graphs - Histogram

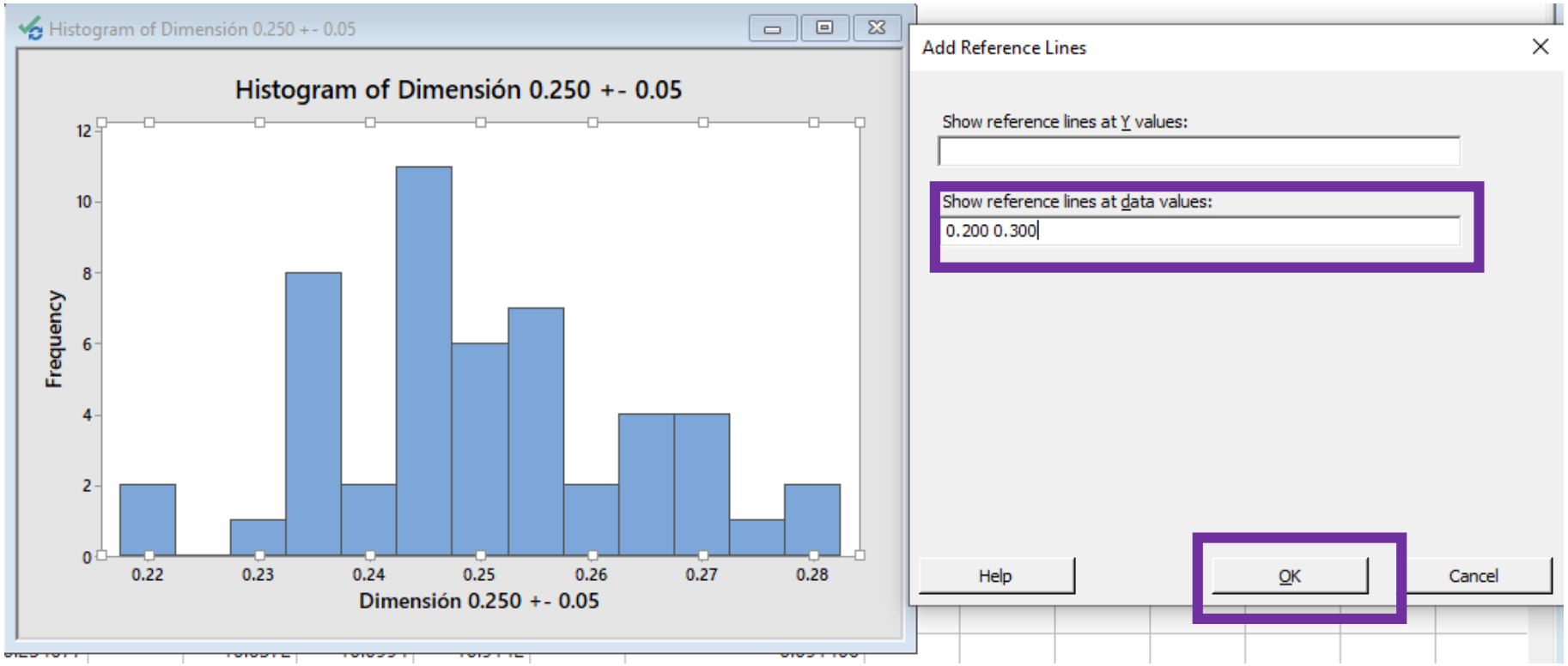
Now, this data was pulled using a specification of 0.250 +- 0.05. This means that the data is acceptable as long its values are between 0.200 and 0.300. To add this information to the data, right click the graph and select “Add > Reference Lines”.





Creating Graphs - Histogram

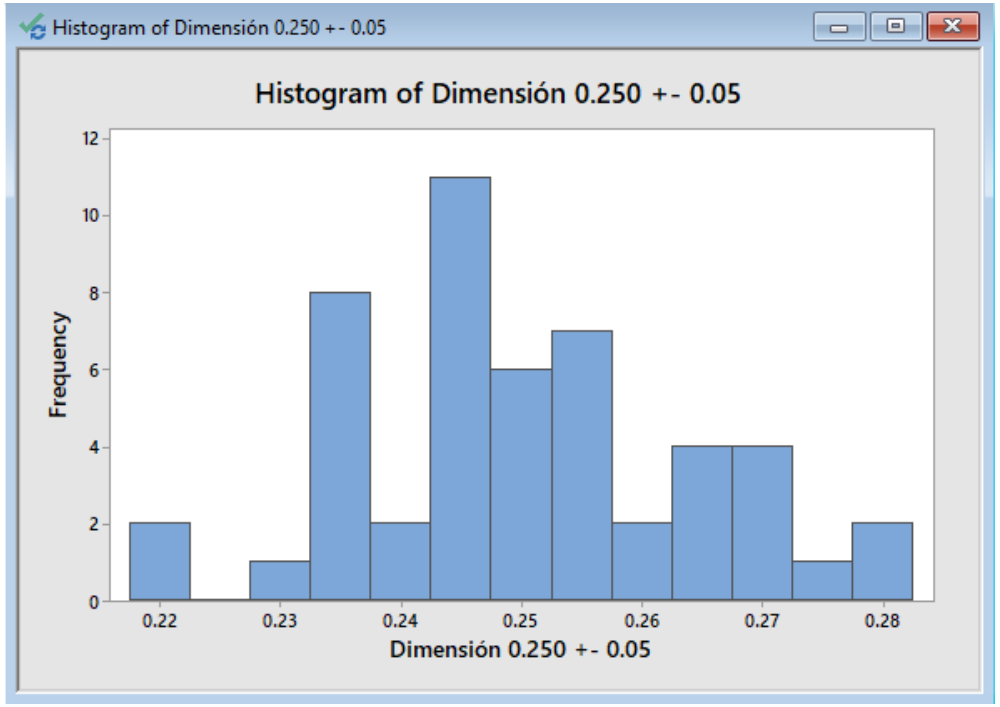
In the next window, select the X axis and type “0.200” followed by a space and “0.300”. The values must look like in the following image. Once you completed this step, press “OK”.



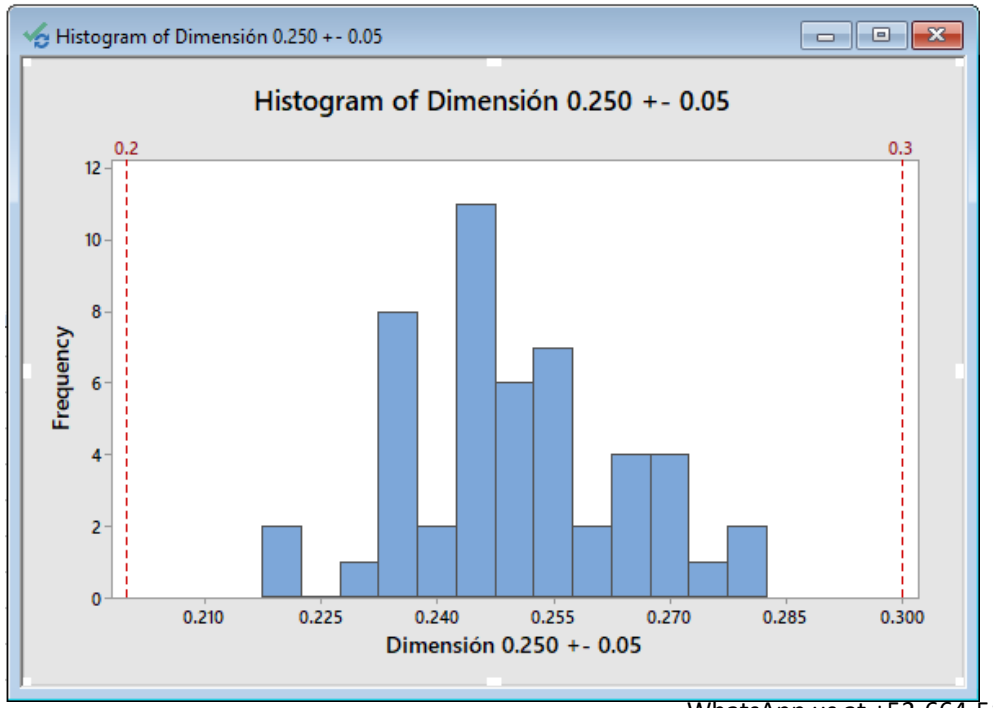
Creating Graphs - Histogram

Observe how two reference lines have been added. Compare this histogram with the original. As a general rule, adding reference lines allows you to see if the process analyzed complies or not with your specification.

Original

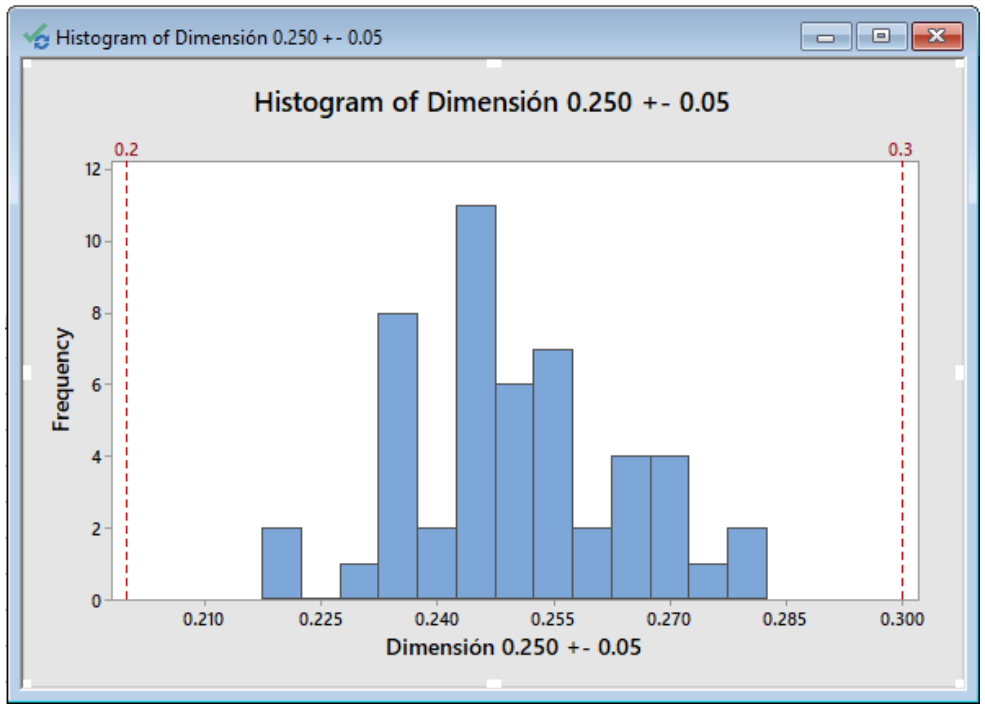


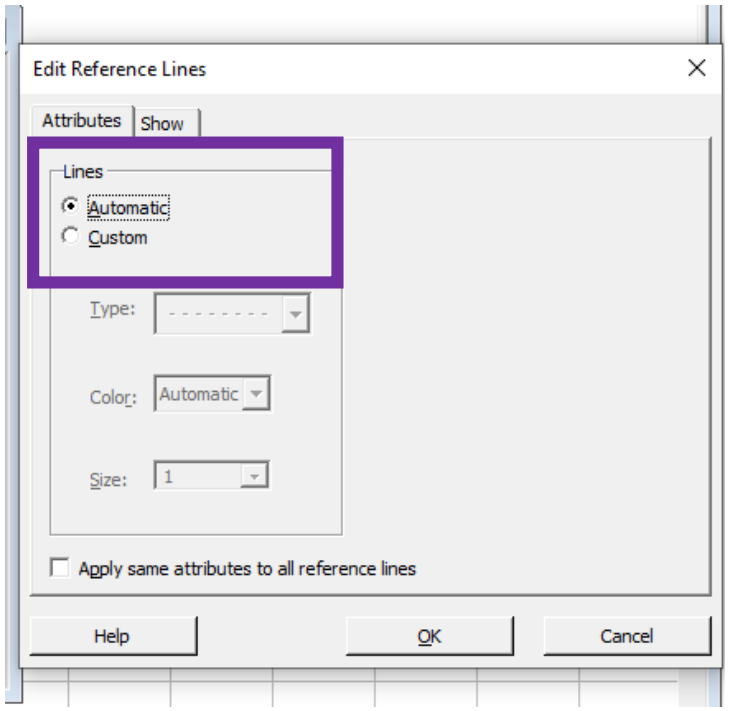
New

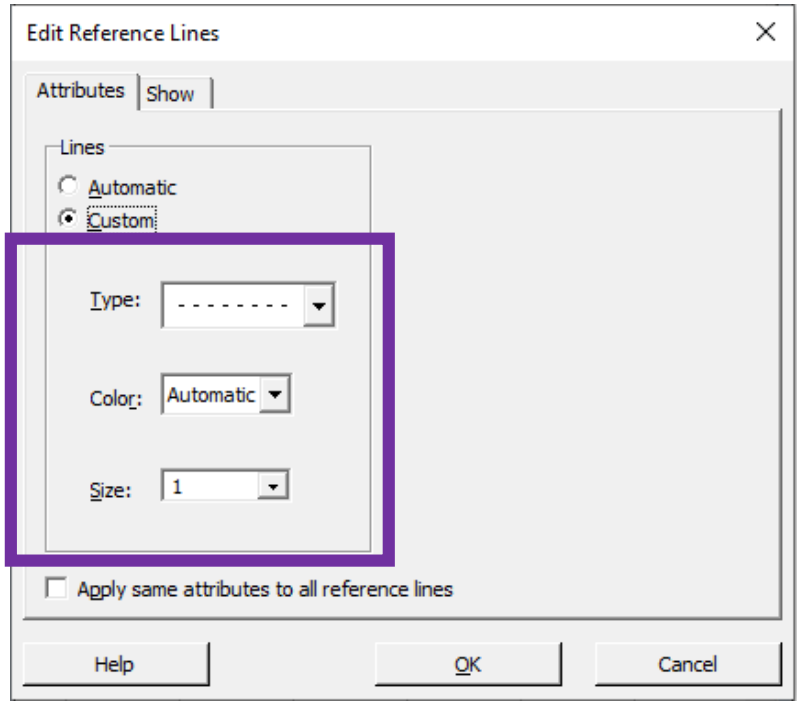


Creating Graphs - Histogram

This new graph can be great to show your management team that your process complies with the specification. Now, you can change the reference line from red to any other color. To do this, just select it by double clicking it. A new window will show up. Change the “Lines” option from “Automatic” to “Custom”.

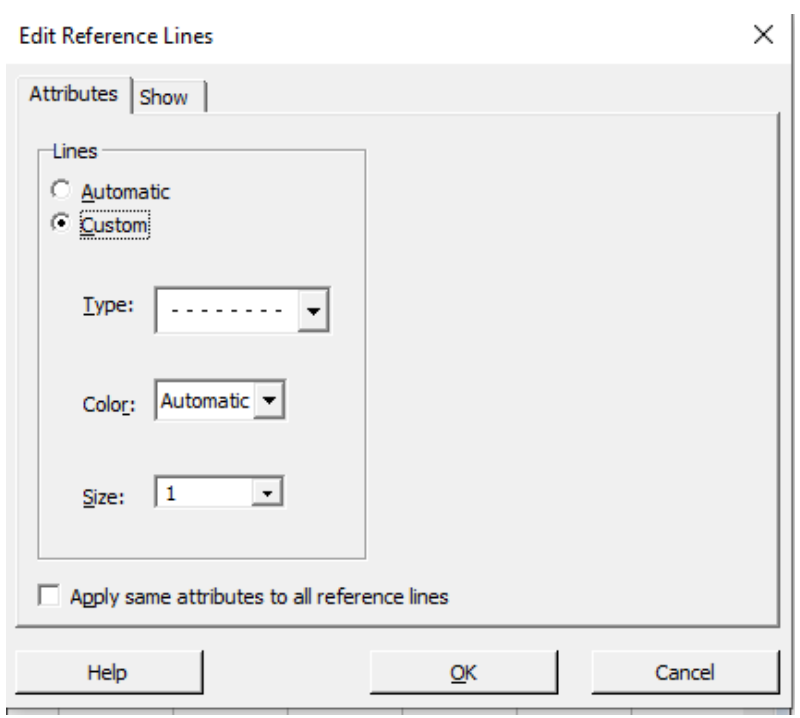


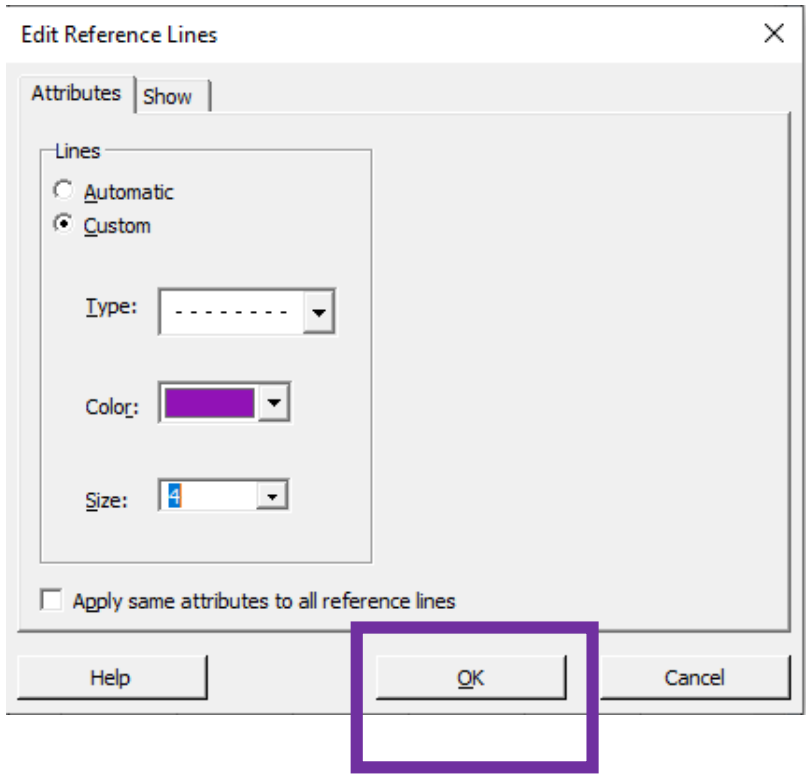


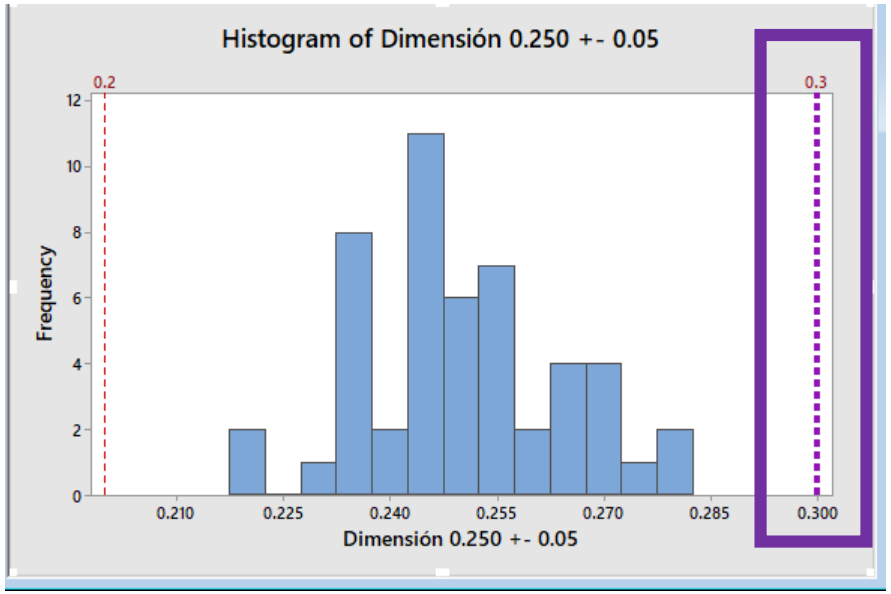


Creating Graphs - Histogram

Changing the setting to “Custom” allows you to change the line type, color and size. Select the color purple and a size of 4, then press “OK”. Notice how the line now is thicker (size) and its color has changed to purple.

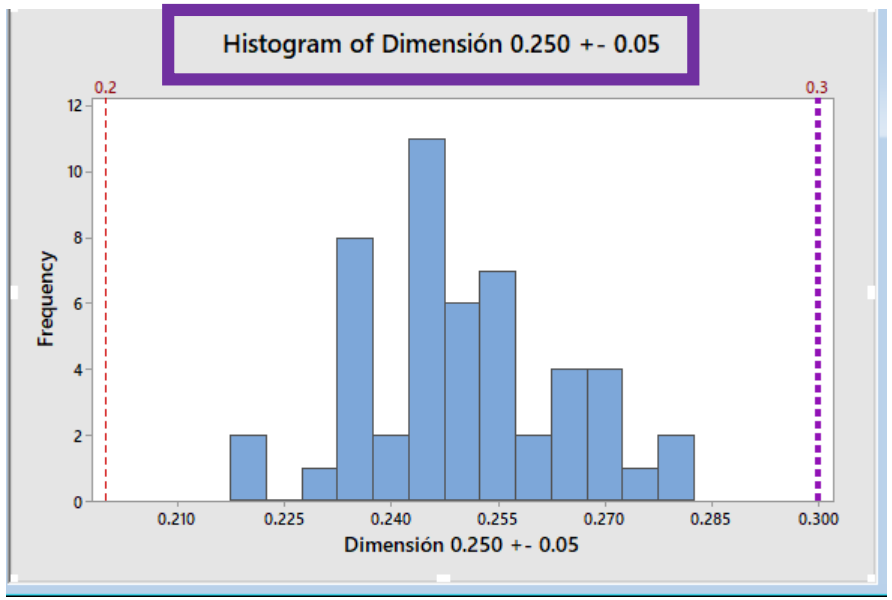


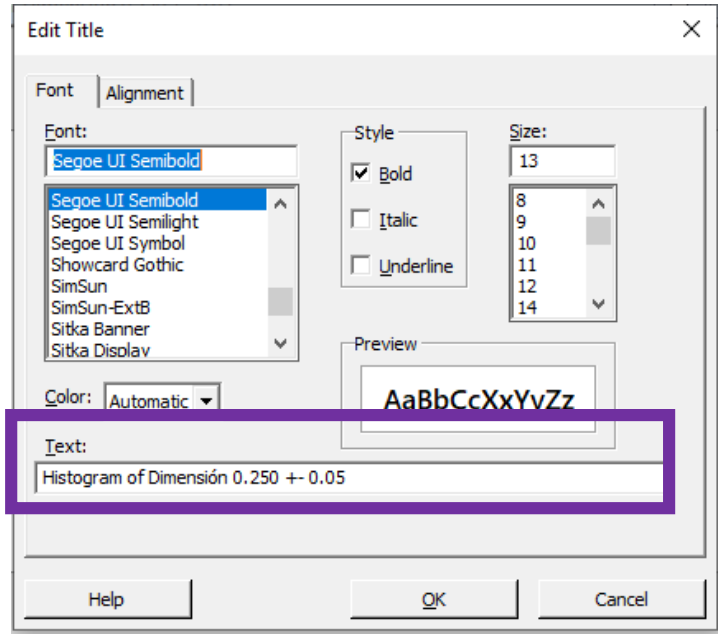




Creating Graphs - Histogram

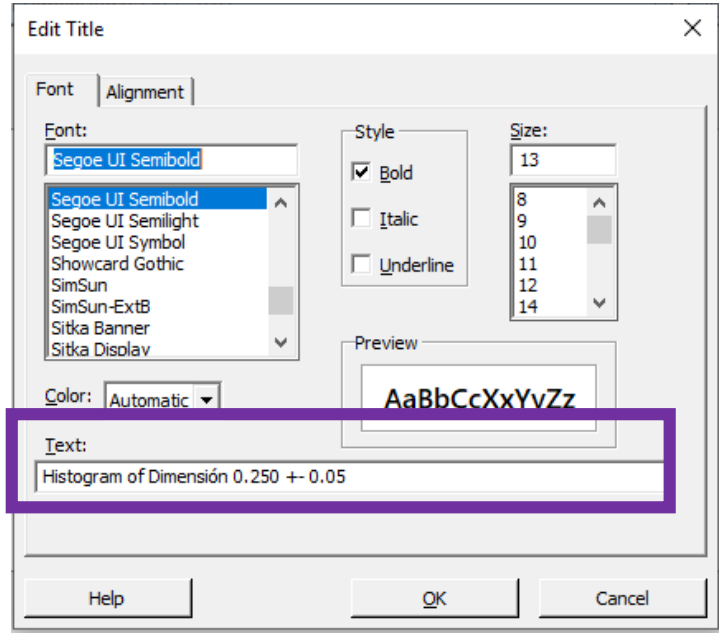
These reference lines can be added to all sorts of graphs, not just histograms. Now, the text in the graph can be edited, too. For example, the title “Histogram of Dimensión 0.250 +- 0.05” can be changed by selecting it with a double click. In the new window you can change the font, size and content of the title.

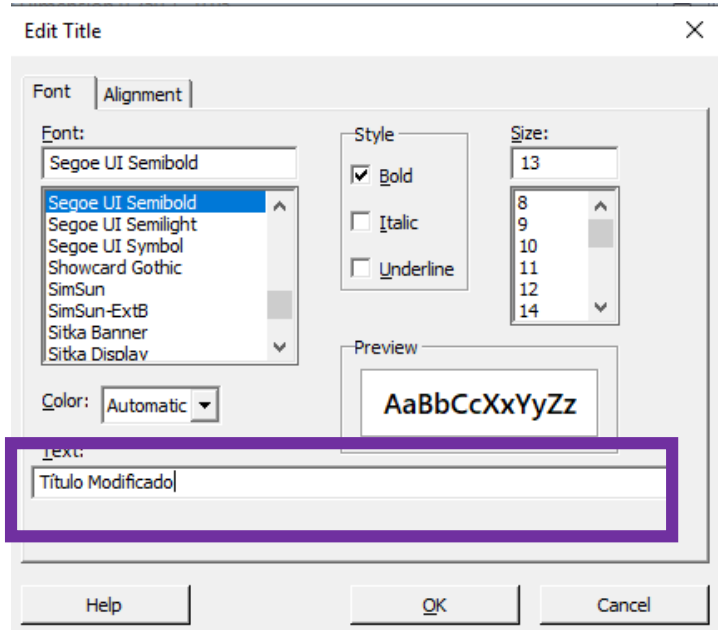


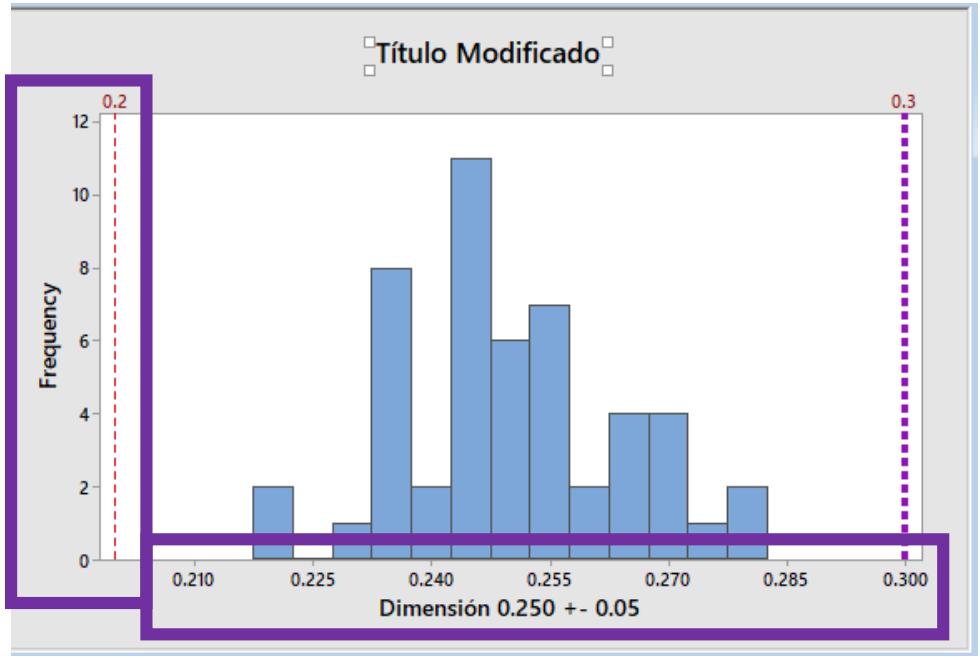


Creating Graphs - Histogram

Once you're done making the necessary changes, just select "OK" and observe the result. You can repeat this process for any of the text in the graph. Just select it by double clicking it.

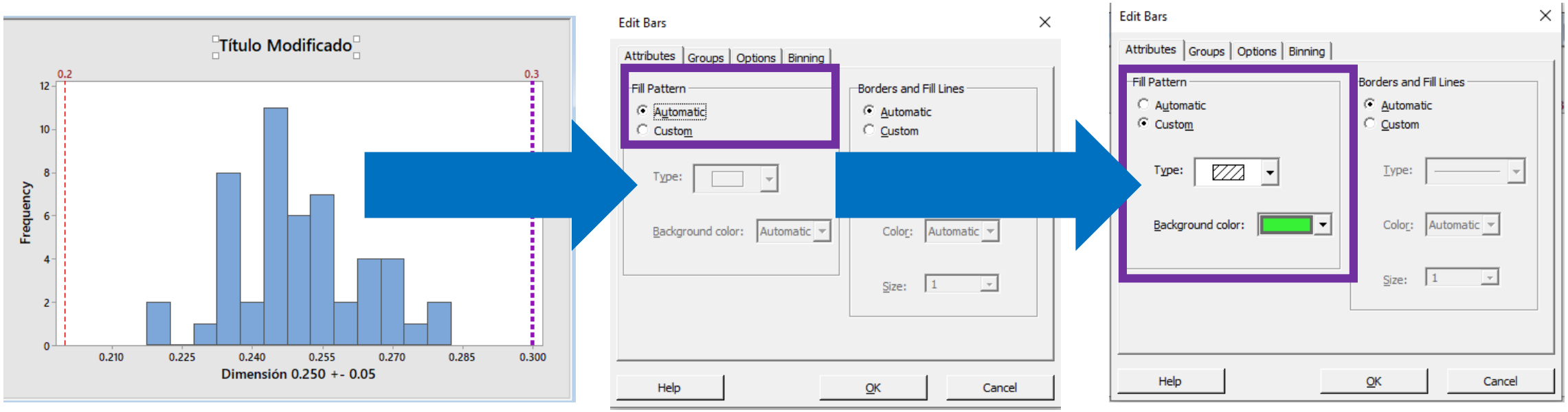






Creating Graphs - Histogram

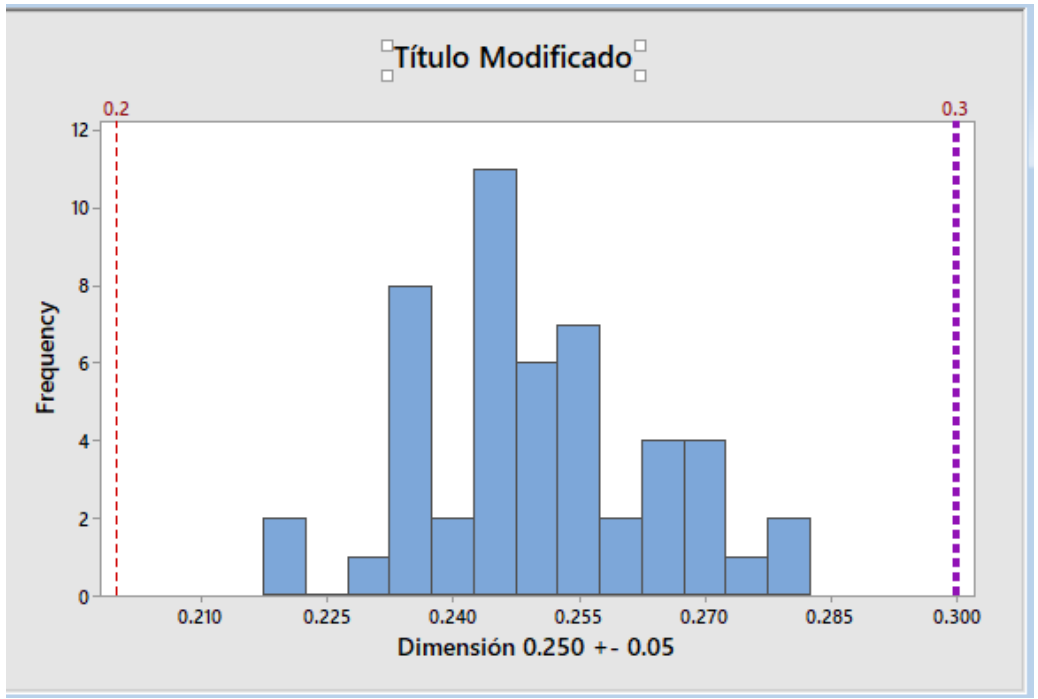
You can also edit the bar color by double clicking it. In the “Fill Pattern” section, select “Custom”. Select a new pattern and a new color. Once you completed this step, just click “OK”.



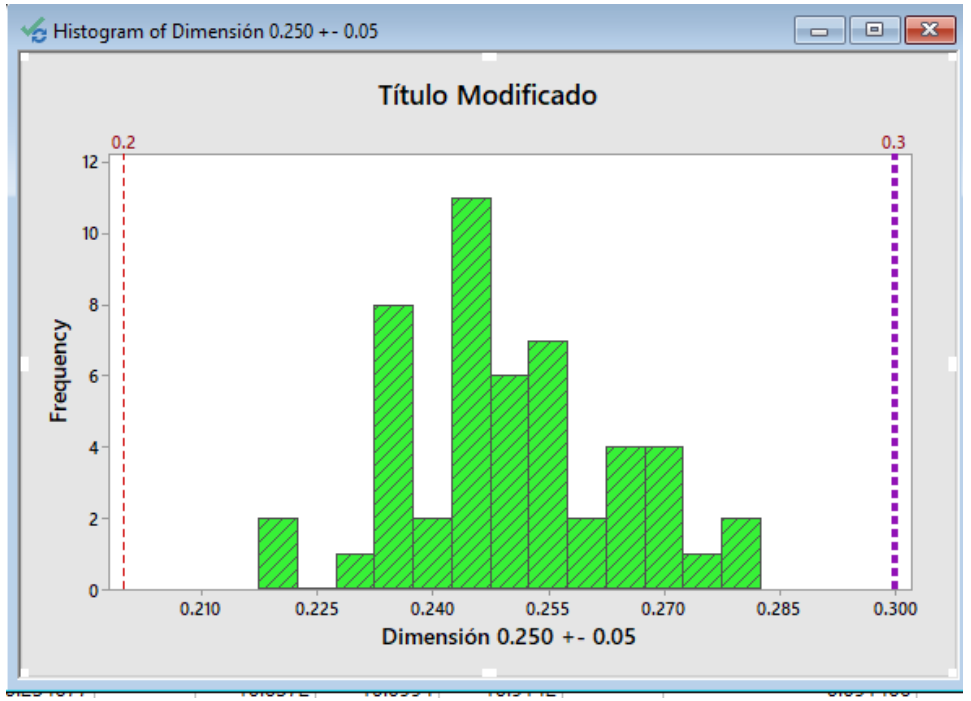
Creating Graphs - Histogram

Observe how the bar color has changed. This aesthetic changes are not unique to the histogram. More about this in the next chapter.

Original



New



Creating Graphs - Boxplots

The next basic graph is the boxplot. The boxplot graph is used when you want to know how disperse is your data. You can also use it to compare two or more providers, clients, processes, etc.

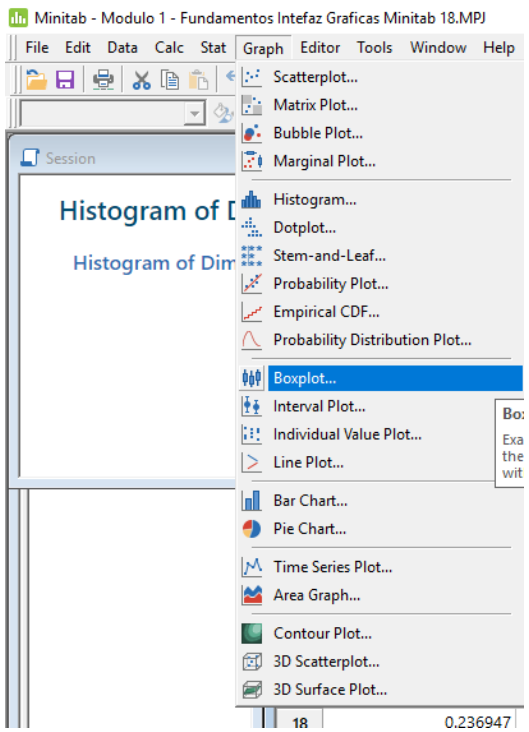
Observe the data contained in C3, C4 and C5.

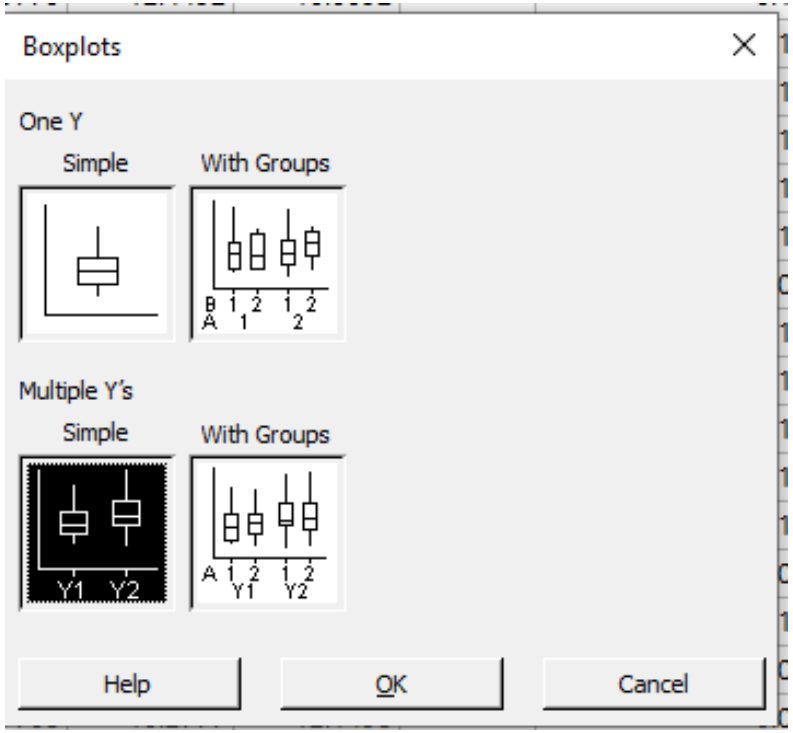
Graficas ***

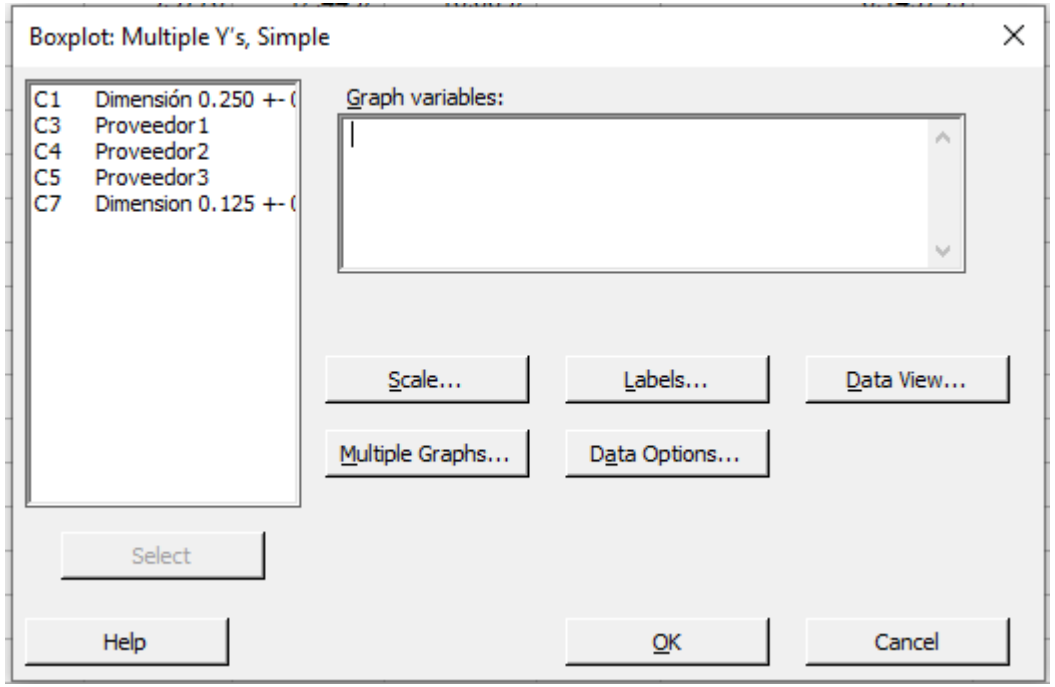
↓	C1	C2	C3	C4	C5	C6	C7
	Dimensión 0.250 +- 0.05		Proveedor1	Proveedor2	Proveedor3		Dimension 0.125 +- 0.025
1	0.259184		9.9770	12.4492	10.0092		0.145795
2	0.254430		9.0734	10.1889	14.4875		0.137859
3	0.250743		10.0538	12.8172	8.7663		0.163654
4	0.245933		10.2908	10.5667	8.9401		0.129301
5	0.252907		10.8929	12.4933	10.1973		0.146013
6	0.246211		10.0706	9.8340	9.8526		0.167788
7	0.268676		10.5752	10.1902	9.2851		0.086794
8	0.238426		9.0089	11.3299	15.4965		0.122819
9	0.234241		9.7957	11.9687	9.0952		0.131131
10	0.251524		10.9781	12.2113	10.0808		0.117255
11	0.247376		10.5804	10.3940	10.5844		0.155107
12	0.268773		8.8766	11.6638	4.2780		0.164808
13	0.247419		10.2051	9.4387	9.8990		0.066643
14	0.252849		10.6153	11.3659	12.0420		0.177140
15	0.264889		8.5165	10.0101	11.0946		0.094368
16	0.278753		7.7768	10.2777	12.1498		0.025054

Creating Graphs - Boxplots

Imagine these three providers are interested in being selected to supply you a new component. Suppose this component is a wooden stick that must measure between 8 and 12 meters long (i.e. 10 meters +- 2 meters). To create a boxplot graph, select “Graph > Boxplot > Multiple Y”

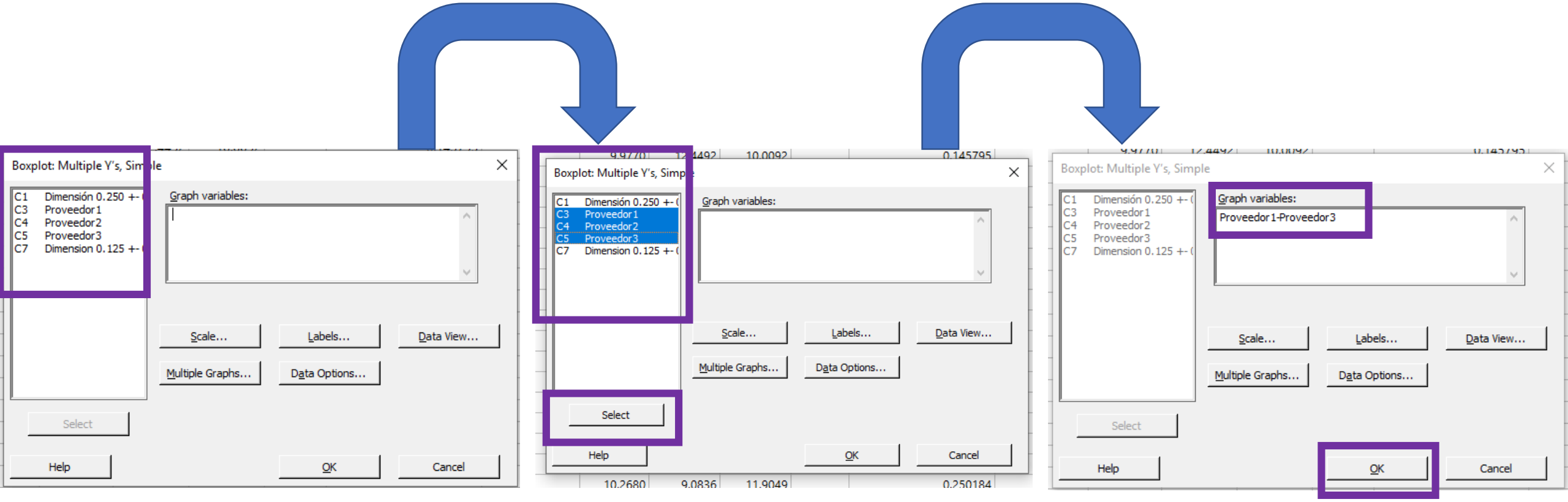






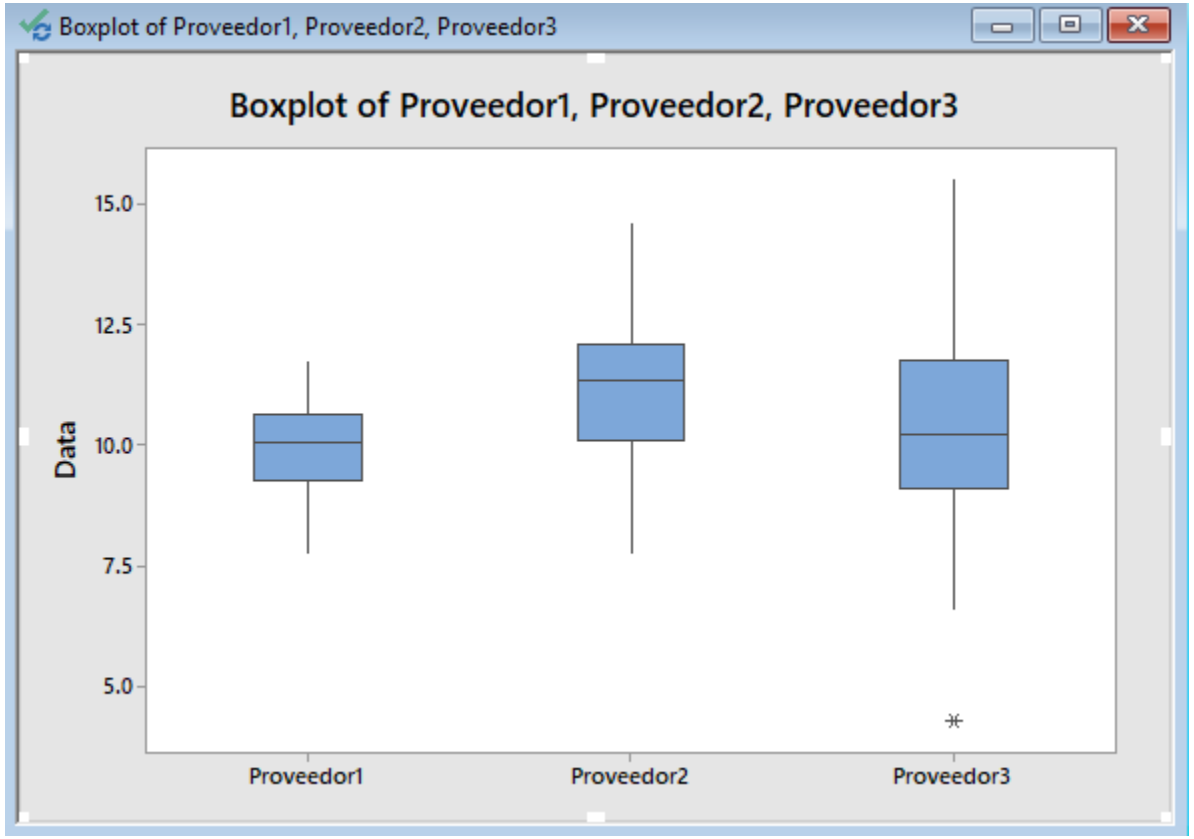
Creating Graphs - Boxplots

Now, select the three providers and add it to ”Graph Variables”. Once you’re done, press ”OK”.



Creating Graphs - Boxplots

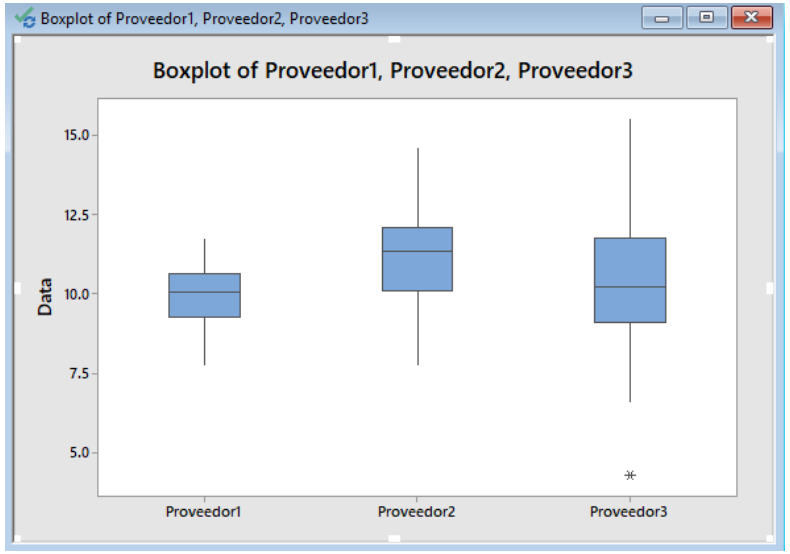
Once the process is completed, a boxplot graph like in the following image will be generated. This graph is a visual representation of your data, grouped in quartiles (more on this later).

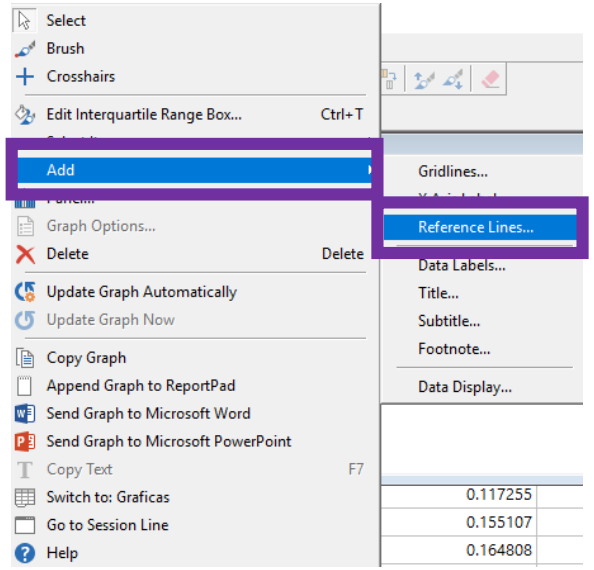


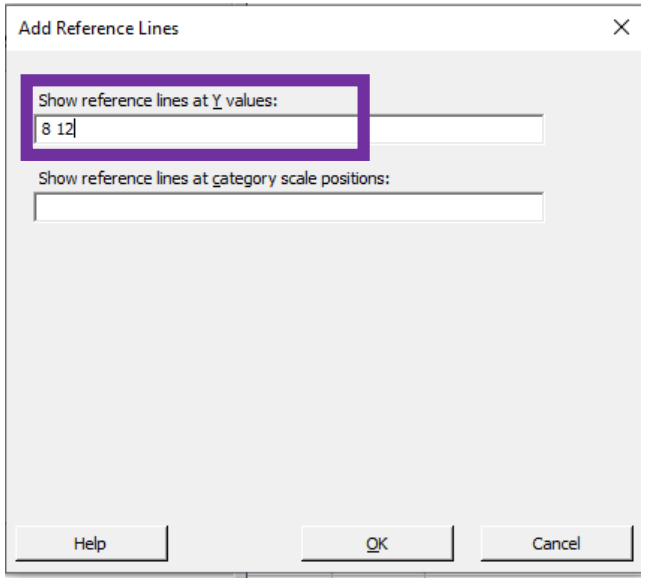
Creating Graphs - Boxplots

Now, the purpose of this graph is to compare which of the providers gives the better results. We know the specification is between 8 meters and 12 meters. You can add this specification by using reference lines.

Remember: Right click > Add > Reference Lines > Y Axis > 8 12 > OK

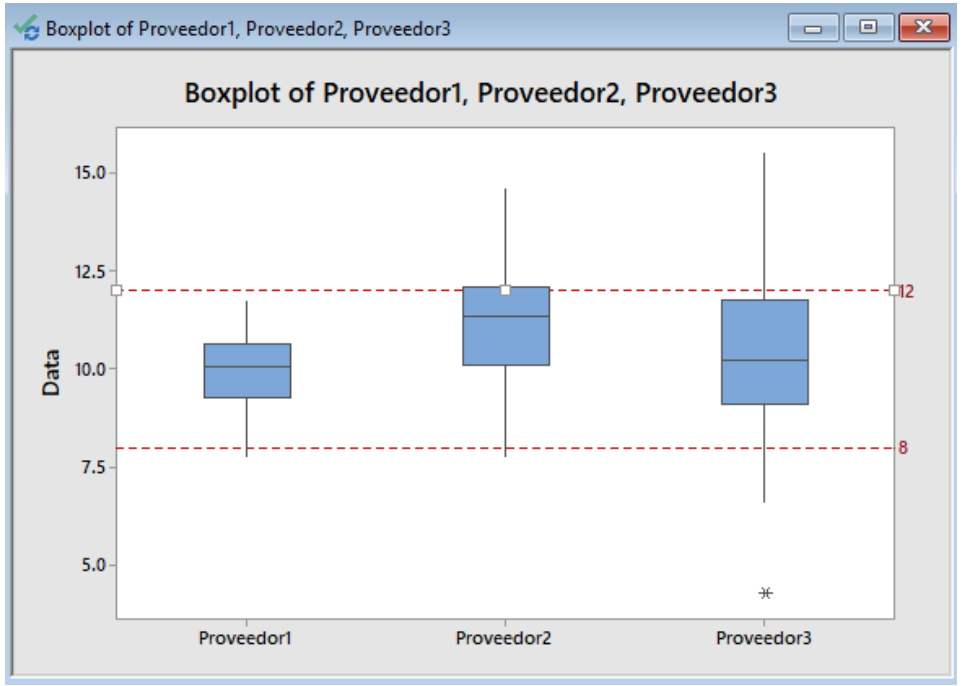






Creating Graphs - Boxplots

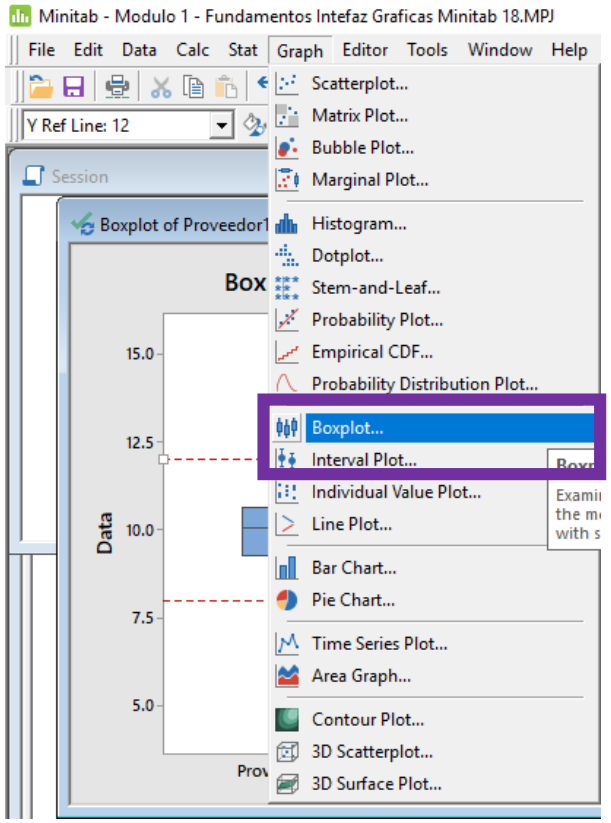
Observe how the reference lines quickly show how the provider “Proveedor 2” and “Proveedor 3” exceed the specification limits whereas the provider “Proveedor 1” supplies most of its product within this specification, with a little portion touching the lower limit.

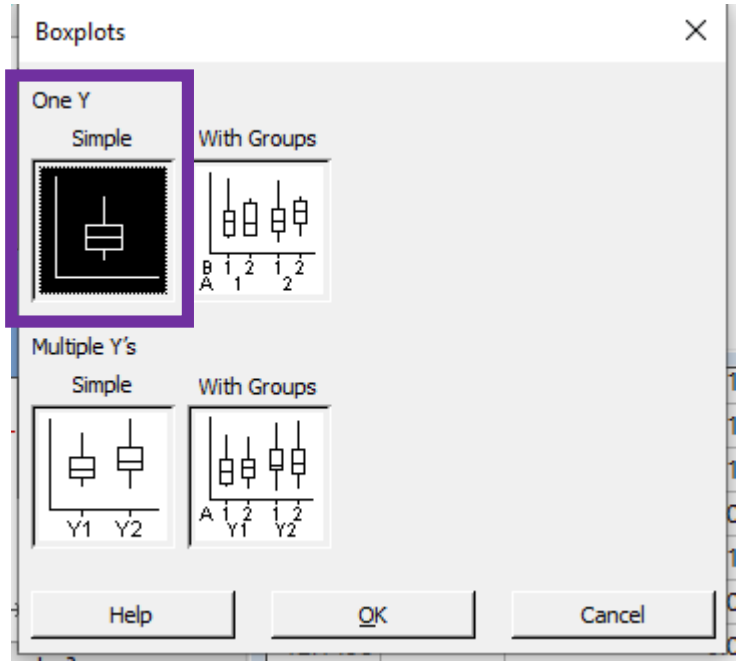


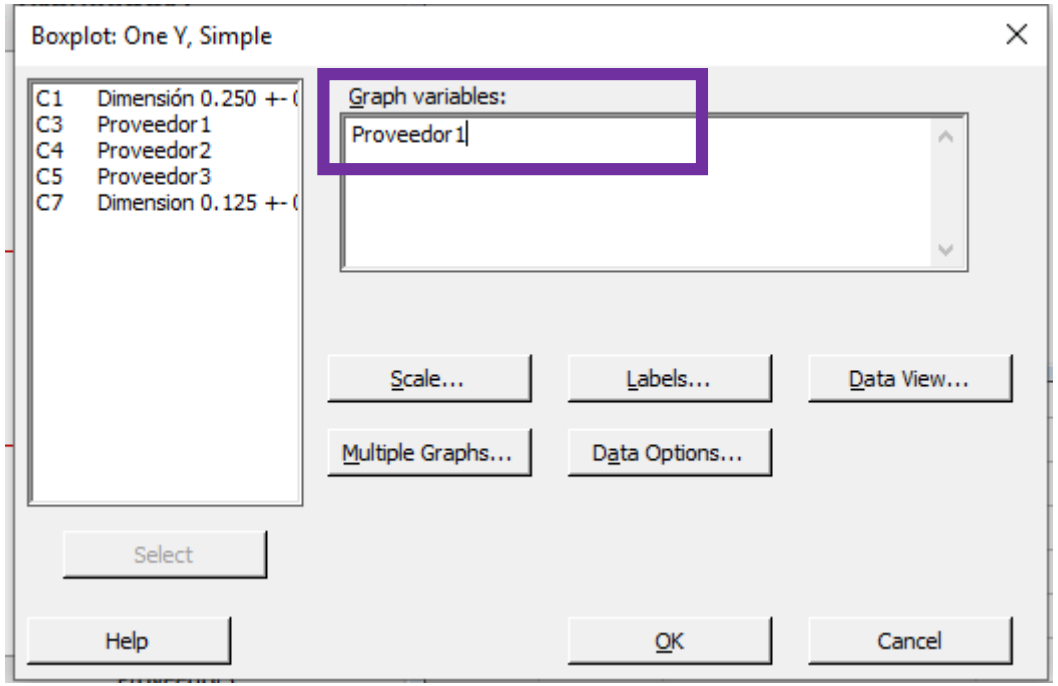
Creating Graphs - Boxplots

Now, what does the bloxplot graph represent? Simply the data dispersion. Create a simple boxplot using the data from the provider “Proveedor 1”.

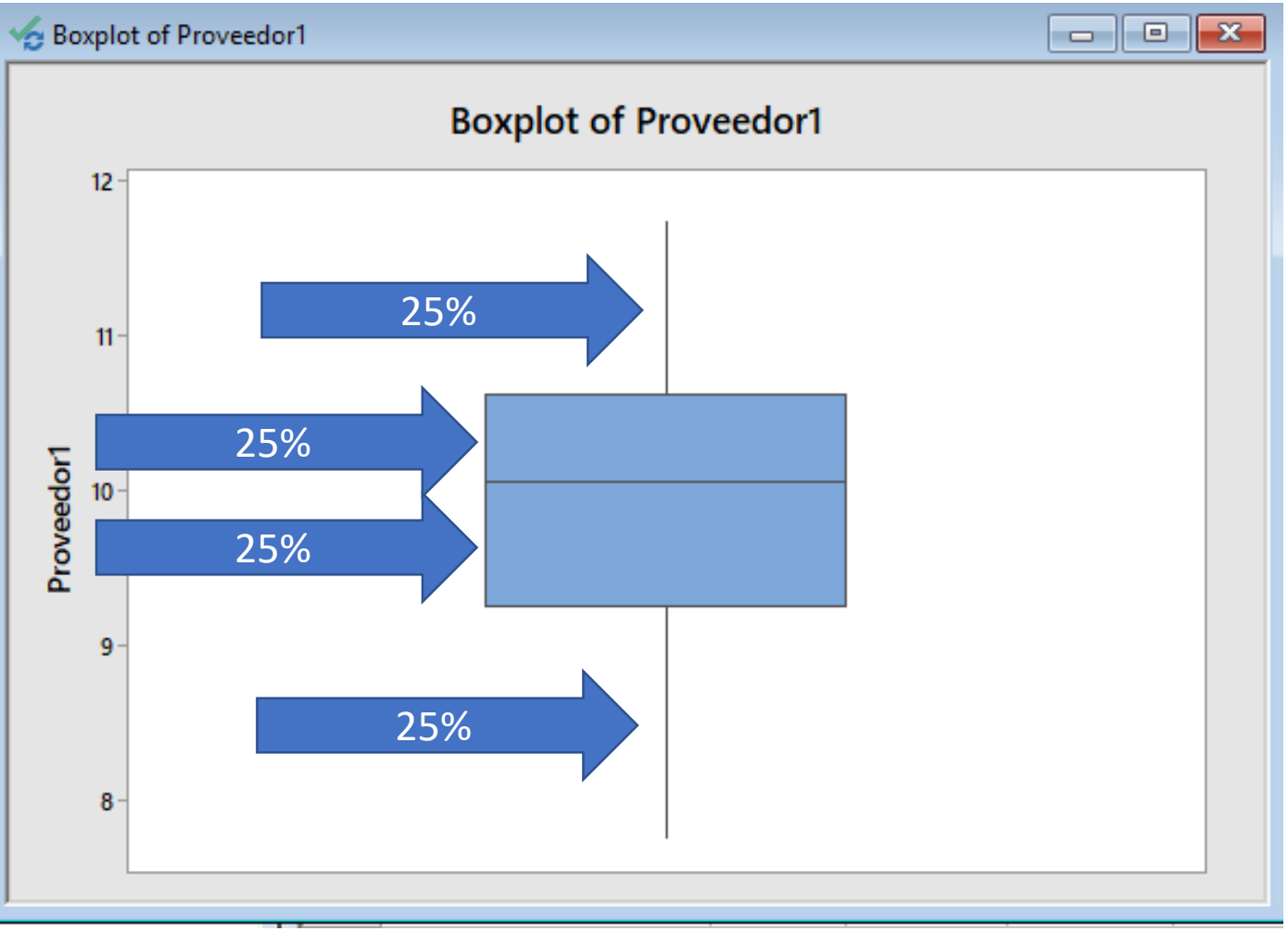
Select “Graph > Boxplot > One Y > Simple”







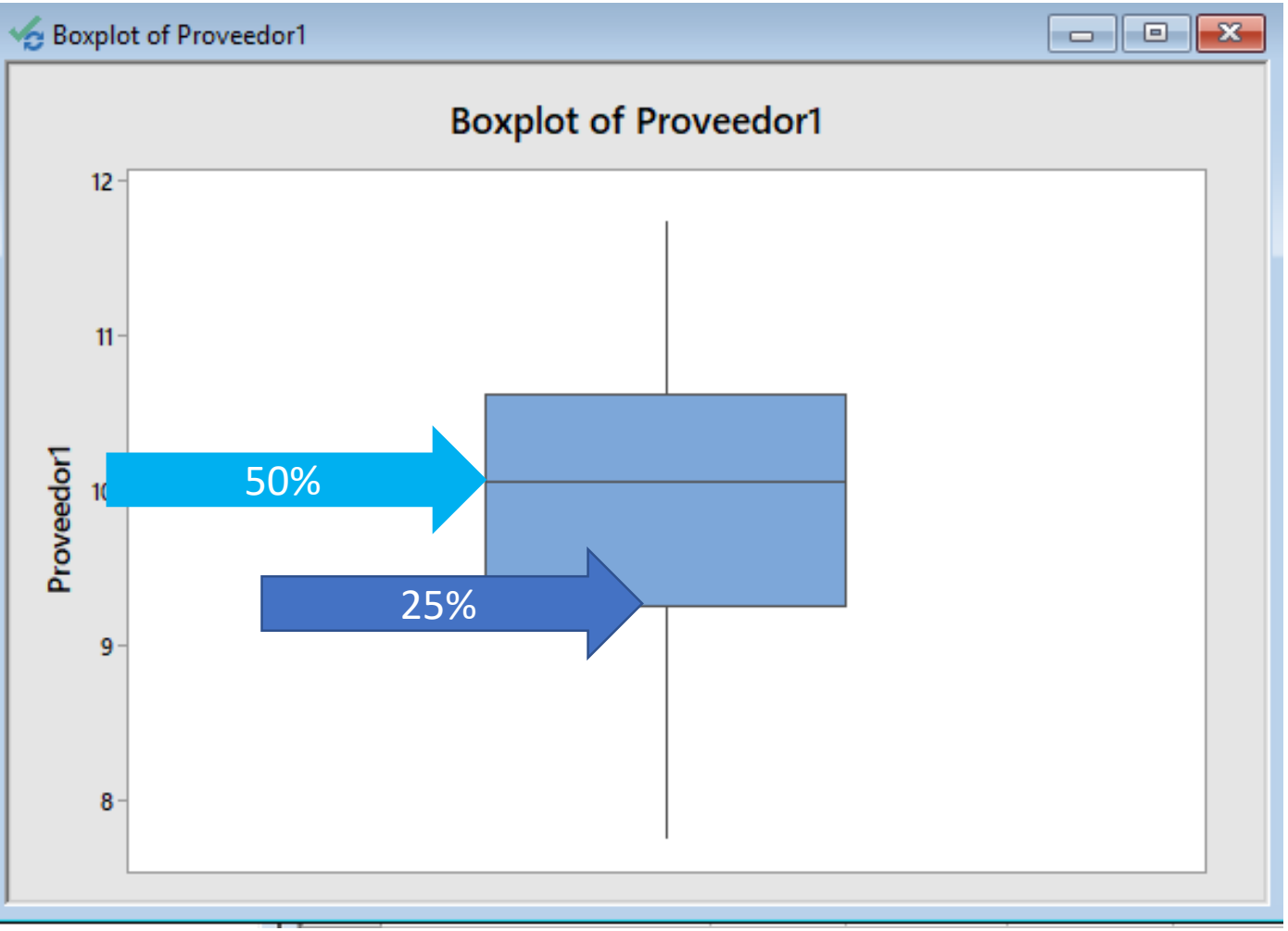
Creating Graphs - Boxplots



Observe the graph created.
The first part represents the first 25% of the data (the 1st quartile).
The second part represents the next 25% (the 2nd quartile).
The third part, the next 25% (the 3rd quartile).
The last part represents the last 25% of the data (the 4th quartile).

In total, these four quartiles represent the 100% of the data.

Creating Graphs - Boxplots



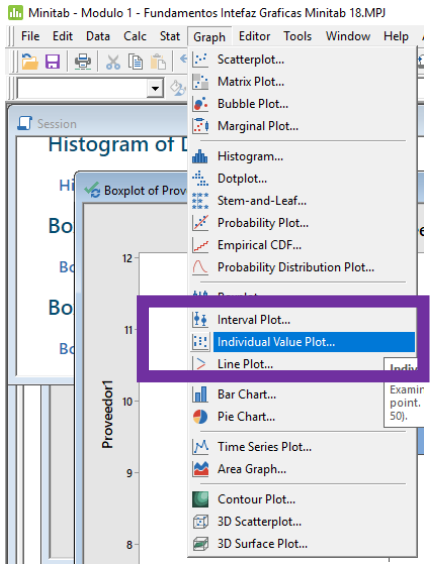
Now, the boxplot graph can show you where is your data, and how far it spreads.

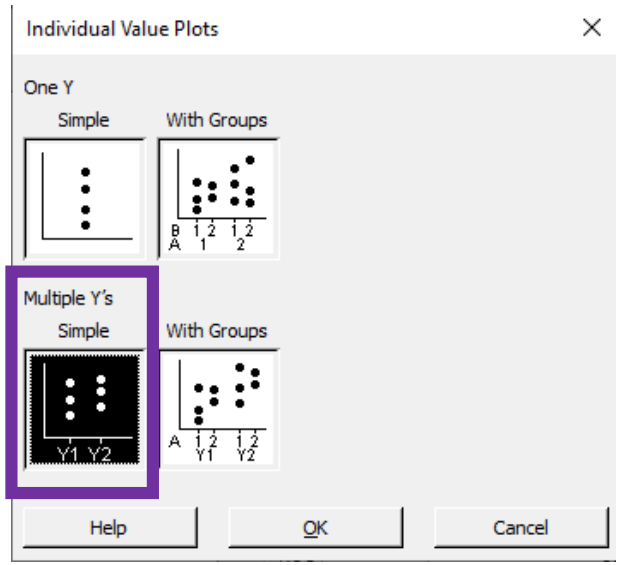
You can also make conclusions like the following:

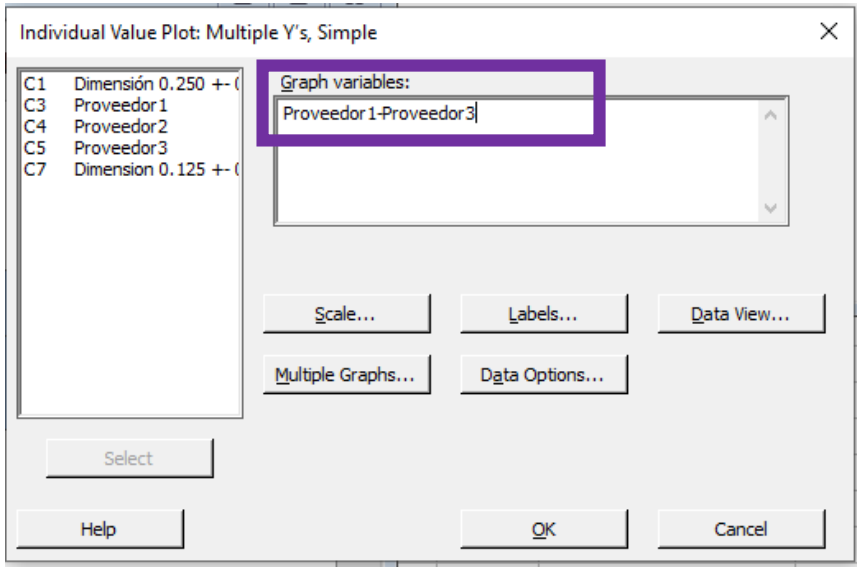
- The 25% of the data has a value of 9 or less.
- The 50% of the data has a value of 10 or less.

Creating Graphs – Individual Value Plot

A graph similar to boxplots is the Individual Value Plot. To create it, select ”Graph > Individual Value Plots > Multiple Y’s” and add the data from C3 to C5 (“Proveedor 1” to “Proveedor 3”) and select OK.

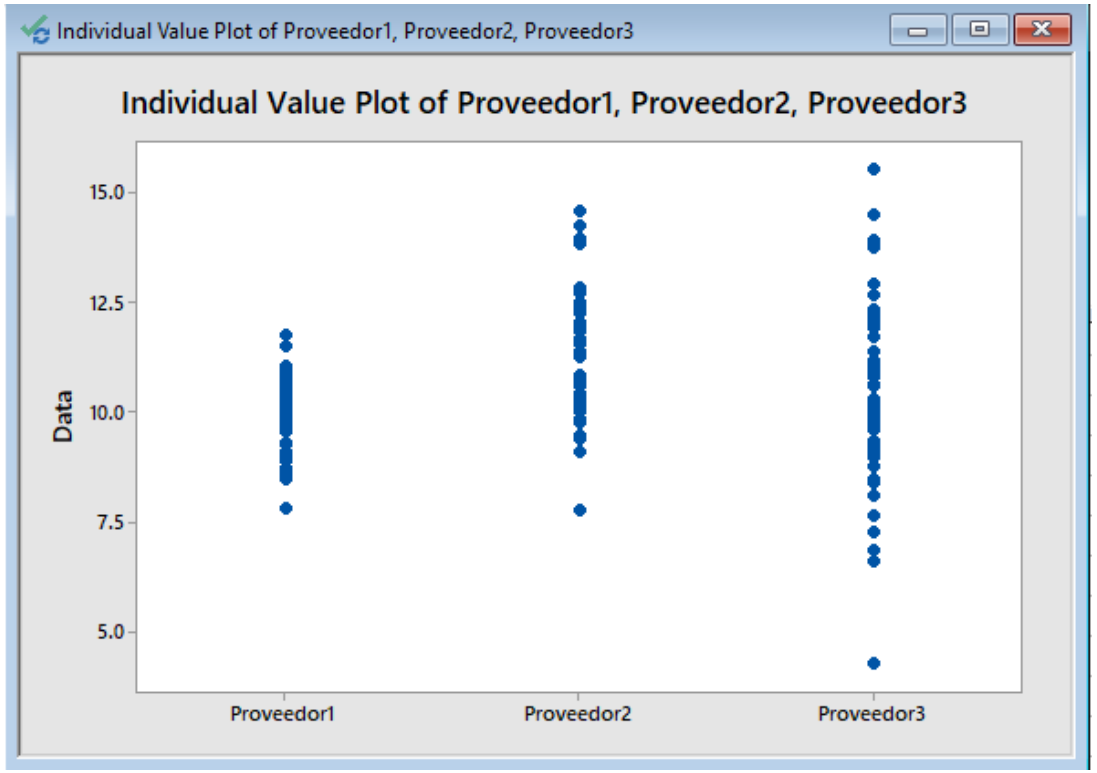


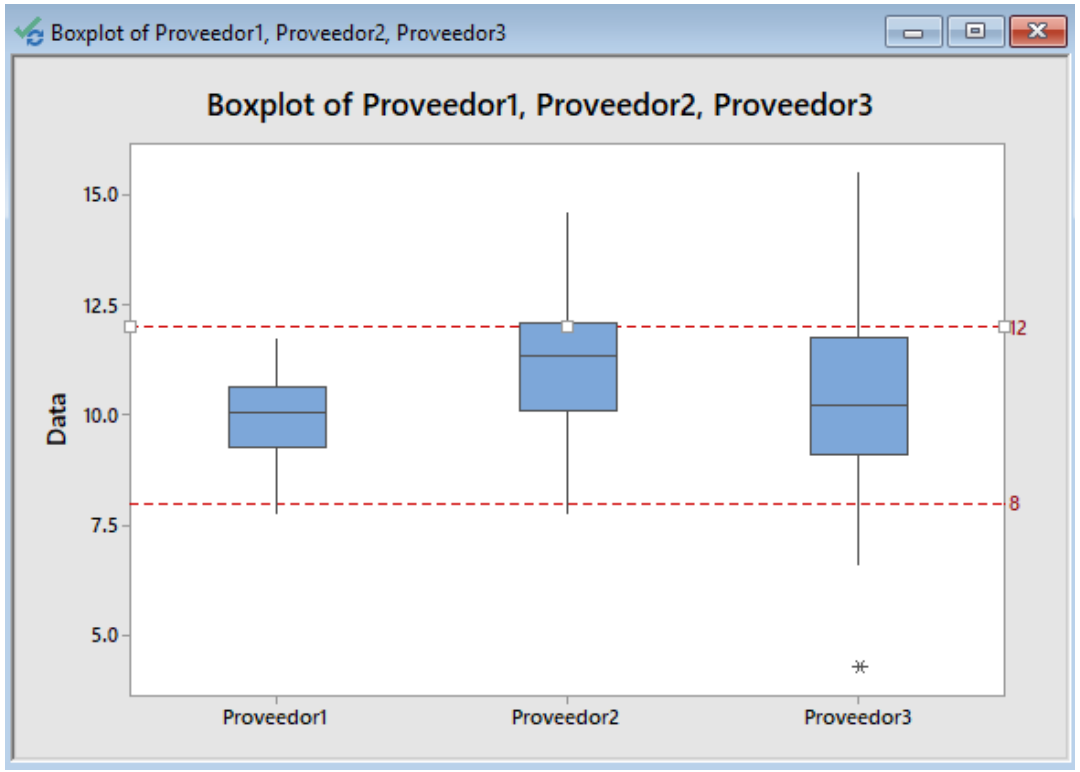




Creating Graphs – Individual Value Plot

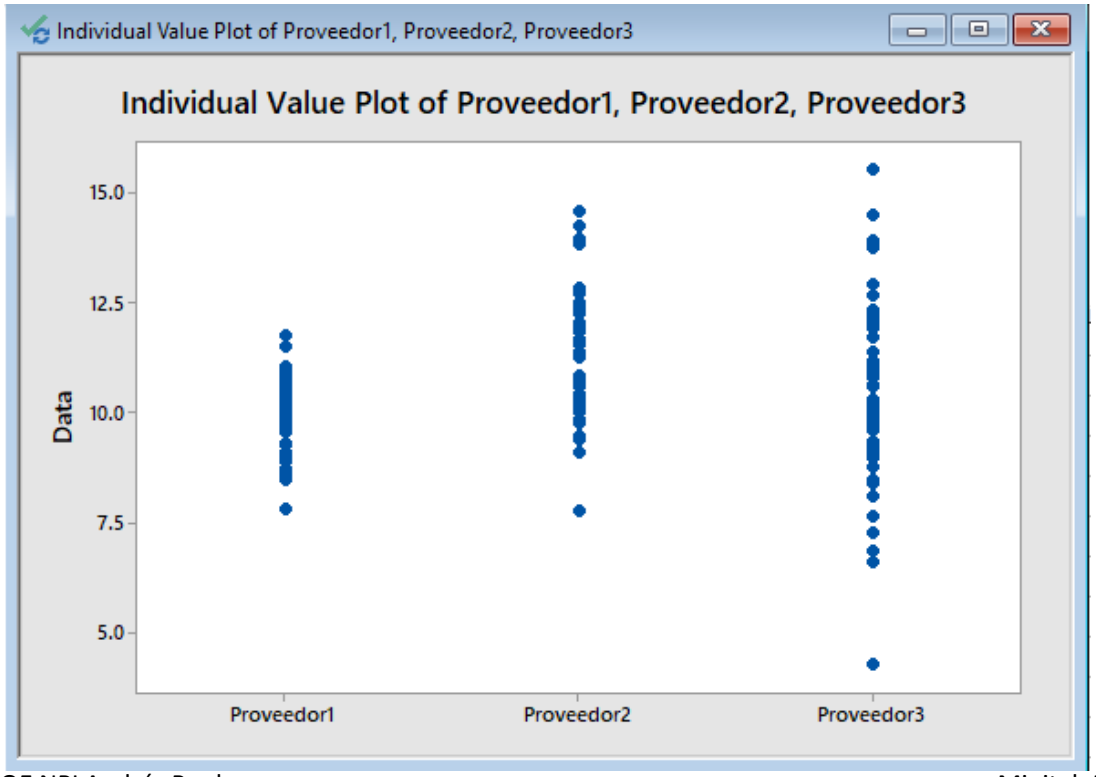
Observe the rendered graph. It is different to a boxplot, with the difference that each value is shown individually as a dot, instead of being grouped in a quartile (box).

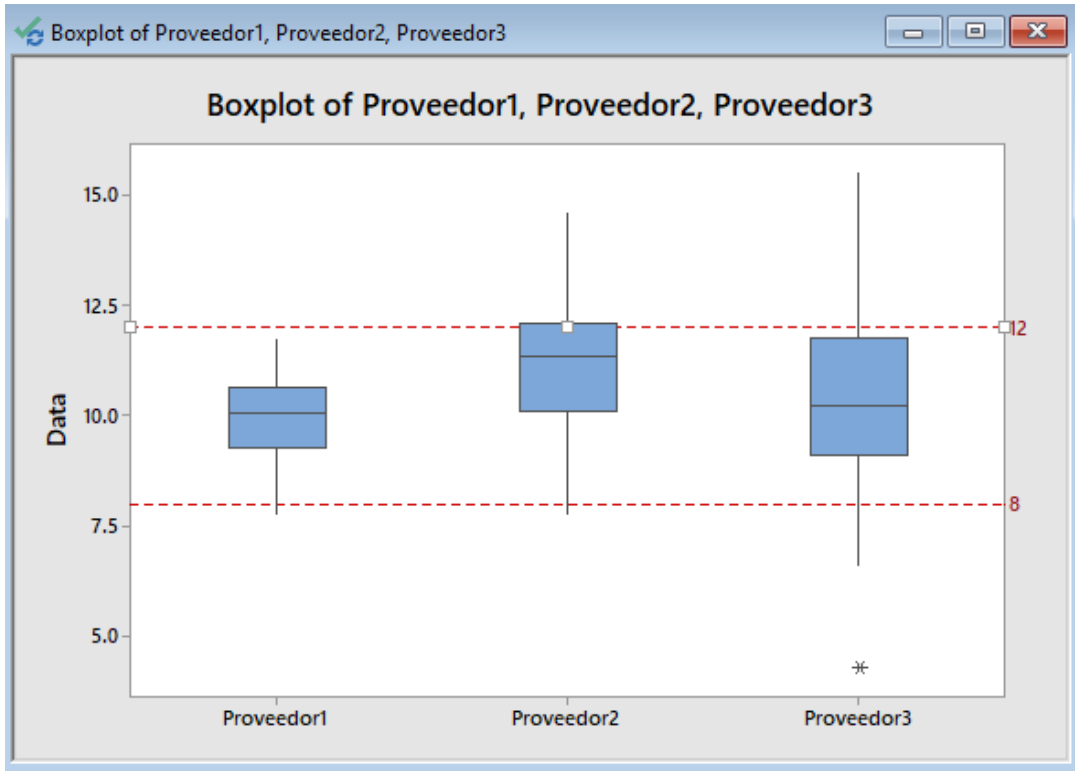




Creating Graphs – Individual Value Plot

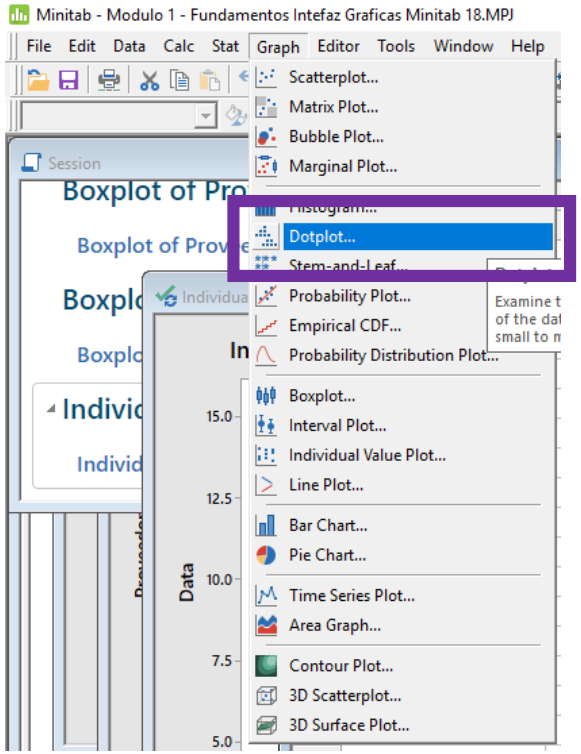
This graph can be modified the same way as the prior ones. You can change the title, add reference lines or choose a different color. It is not as common as the boxplot graph, though, since the latter is visually more simple and easier to interpret.

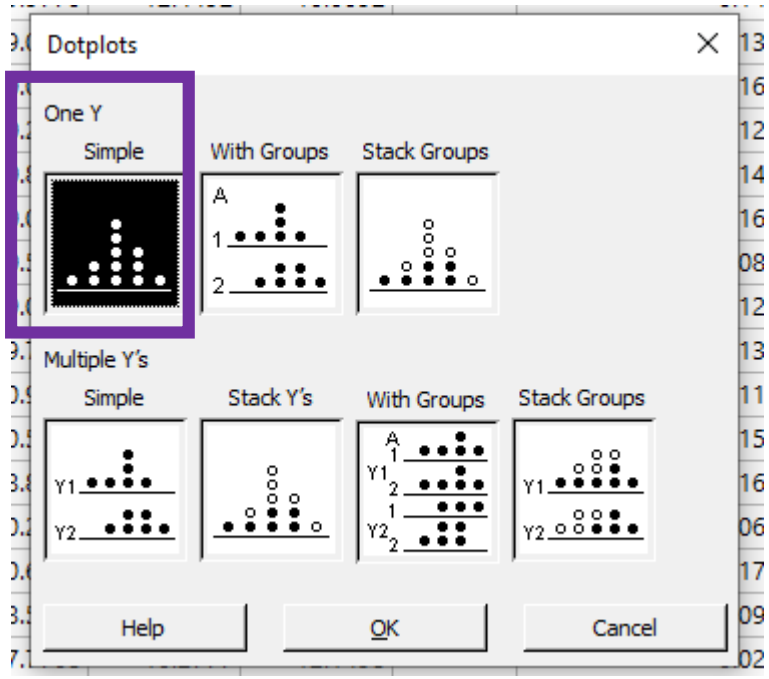


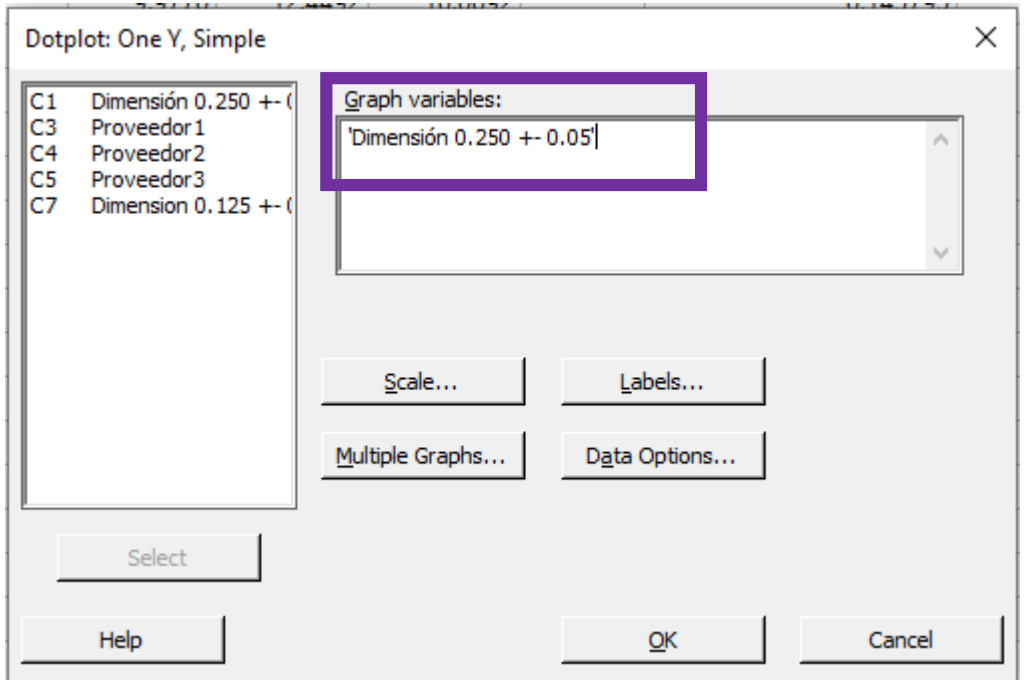


Creating Graphs – Dot Plot

Similarly as with the boxplot and individual value plot graphs, there is also the dot plot graph, which is simply a histogram where the values are represented individually. To create it, just select “Graph > Dot Plot > Simple”, select the column C1 “Dimensión 0.250” and press OK.

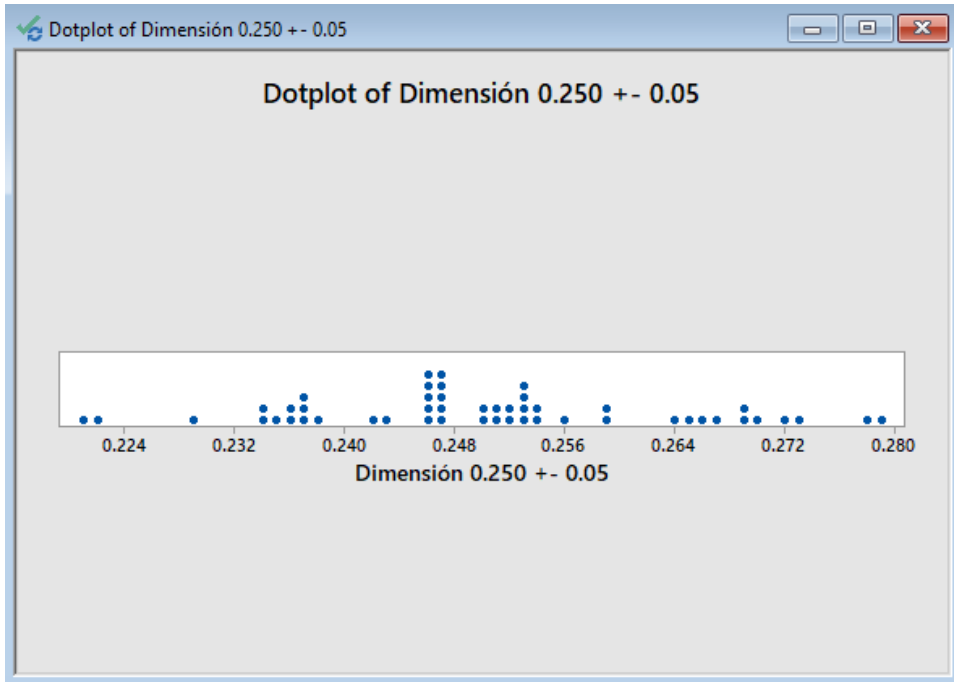


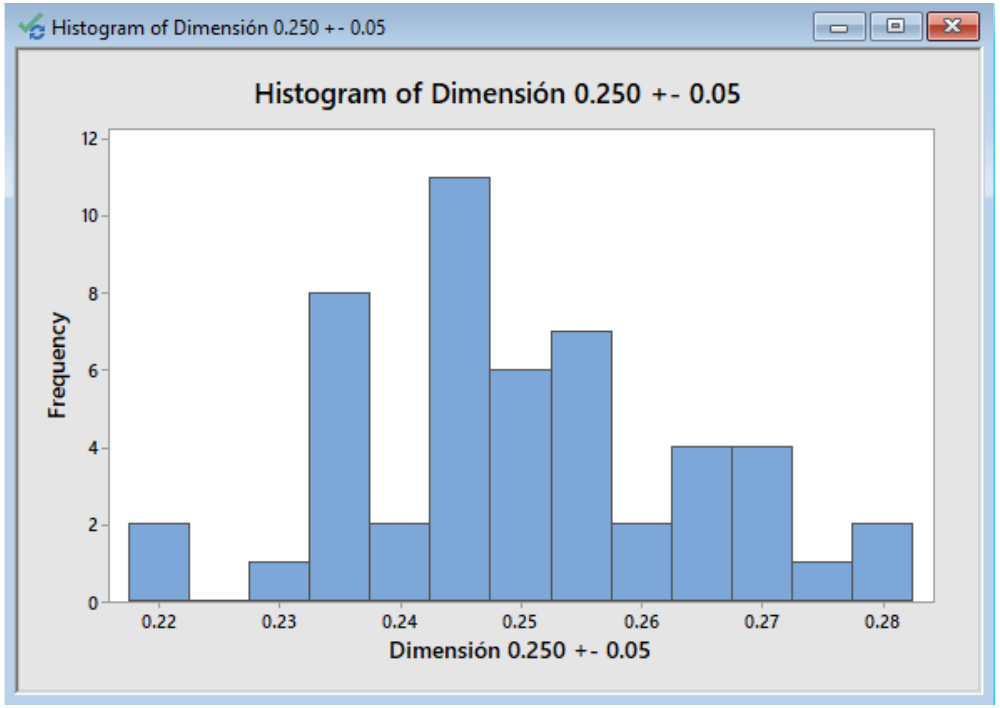




Creating Graphs – Dot Plot

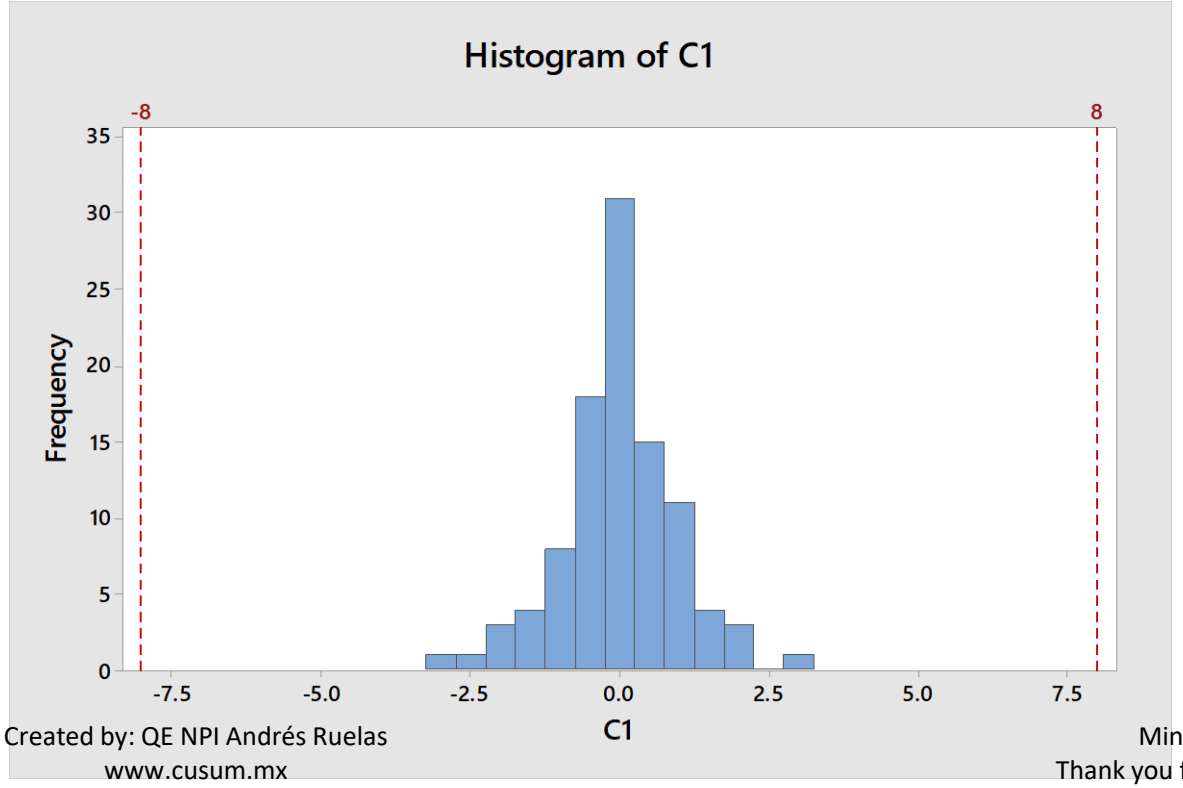
Next, the following graph is rendered. The data is grouped individually, depending on the range. You can observe this graph is similar to the histogram, with the difference that the height of the bars is instead represented by stacked dots.

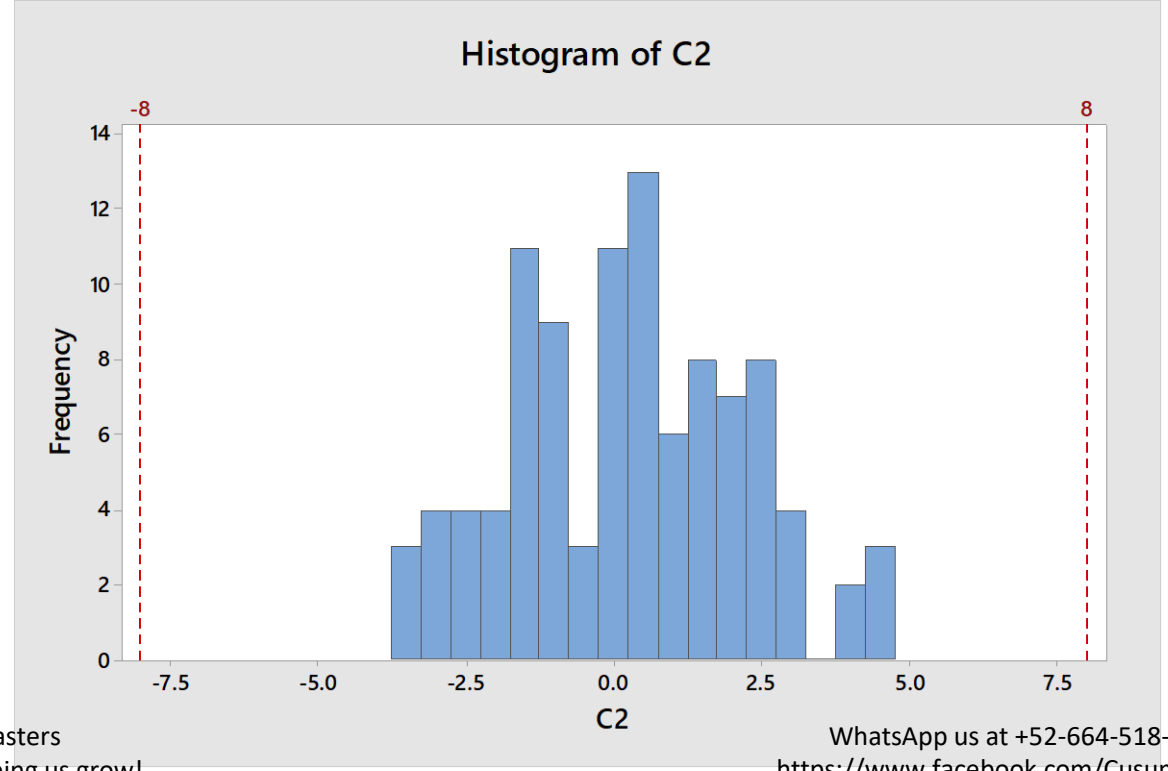




Basic Data Analysis

So far, we have went over the Minitab interface, and created the most common graphs: histograms, boxplots, individual value plots and dot plots. These graphs will allow you to analyze your data visually, but to truly understand statistical analyses, some essential knowledge is needed. Observe the next two graphs:



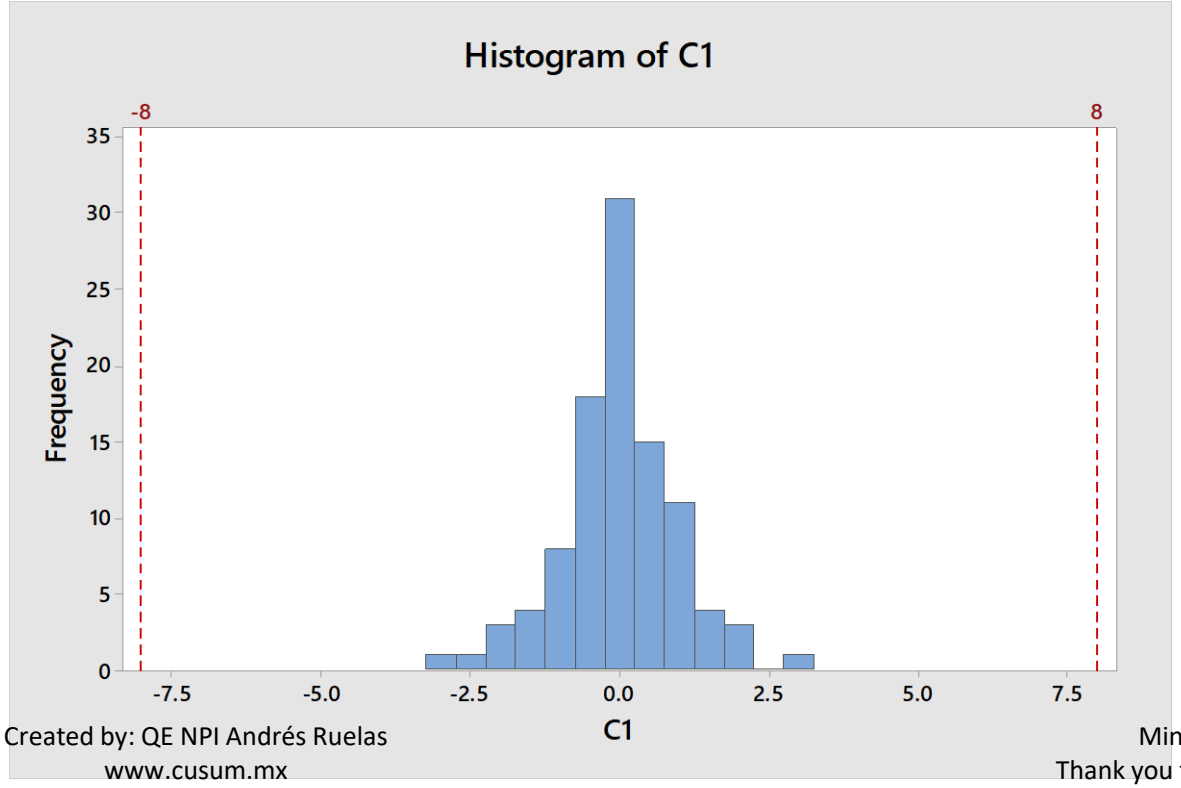


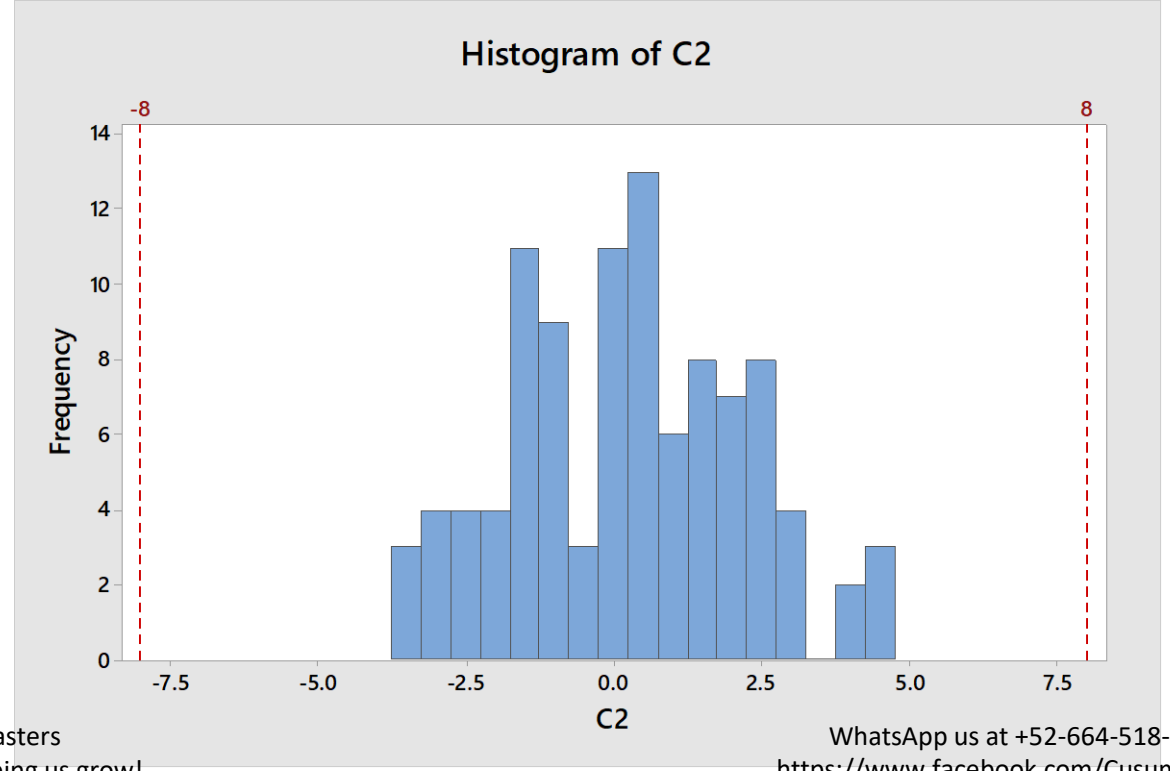
Basic Data Analysis

The basic elements needed to analyze data are the following:

- The median: The average of all data.
- The standard deviation: Hoy disperse is the data.

Both graphs (histograms) have the same median (average), but a different deviation.



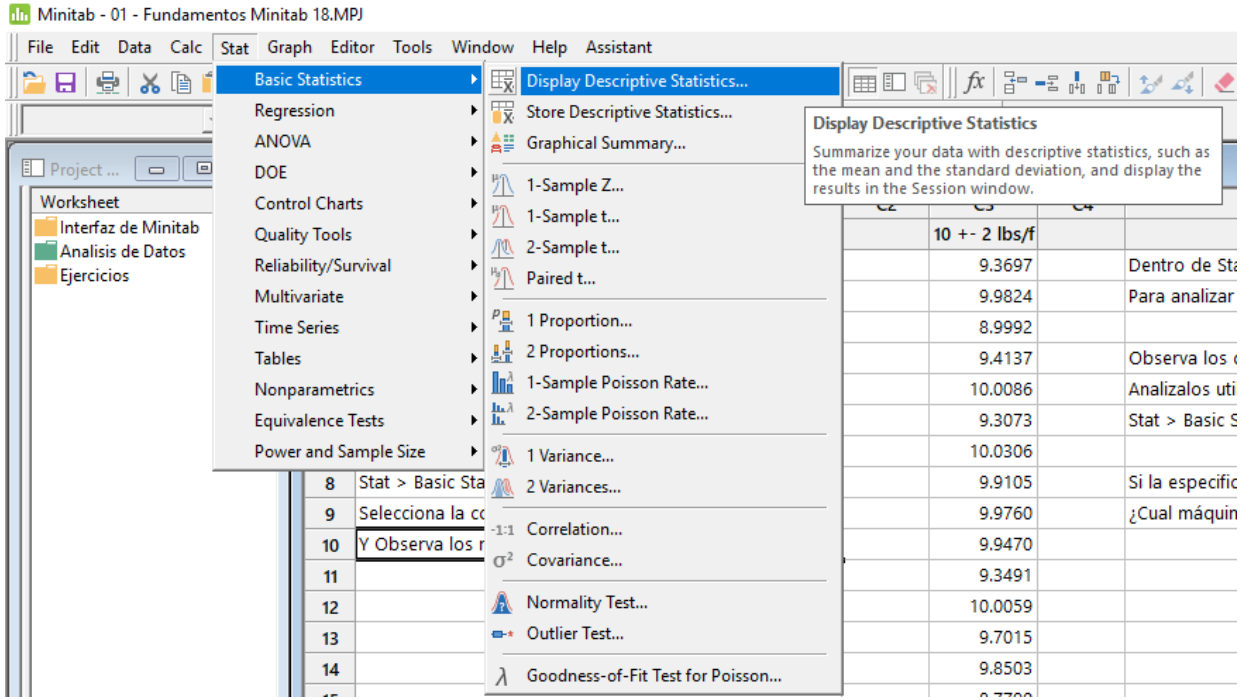


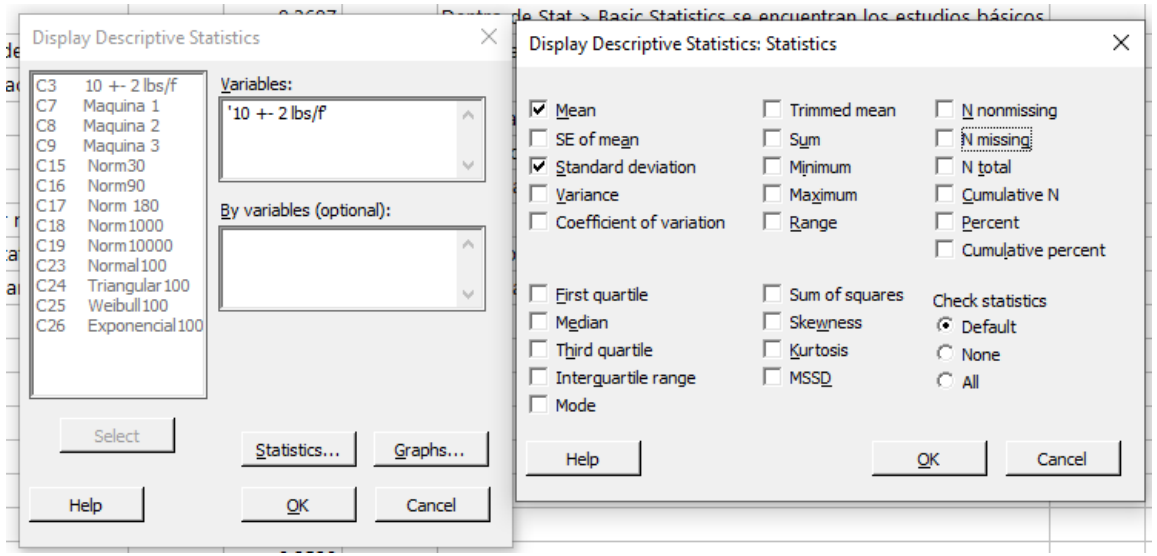
The Importance of the Deviation

The standard deviations is key to assess if a process complies or not with a specification. It allows you to know the amplitude of your process.

You can calculate the median and standard deviation as follows:

Stat > Basic Statistics > Display Descriptive Statistics





The Importance of the Deviation

By clicking OK, the session window will display the requested information about the process.

Descriptive Statistics: 10 +- 2 lbs/f

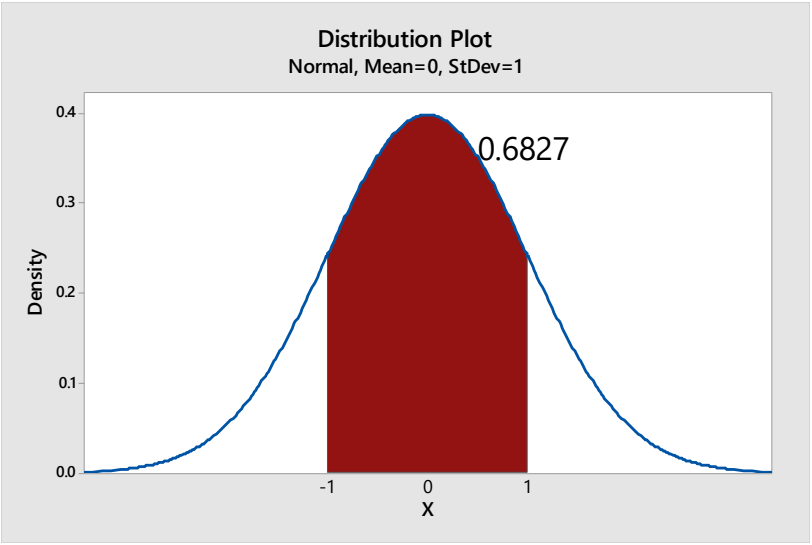
Statistics

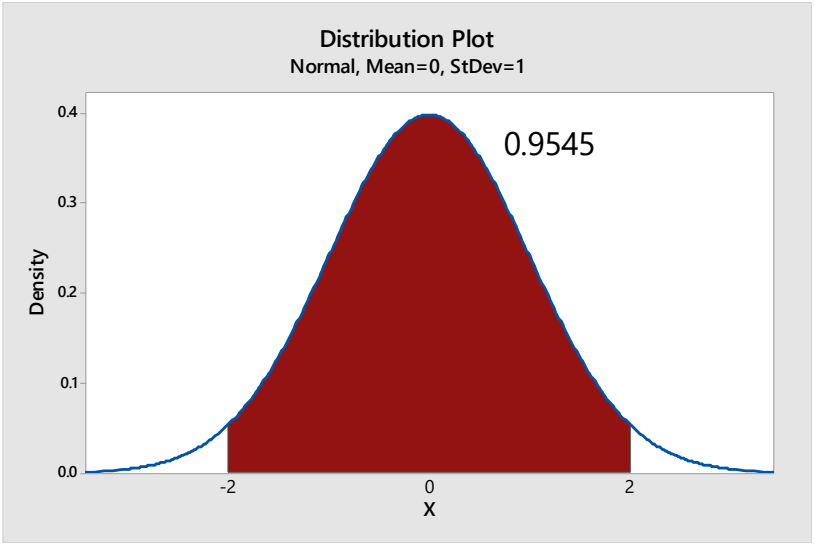
Variable	Mean	StDev
10 +- 2 lbs/f	9.7209	0.4688

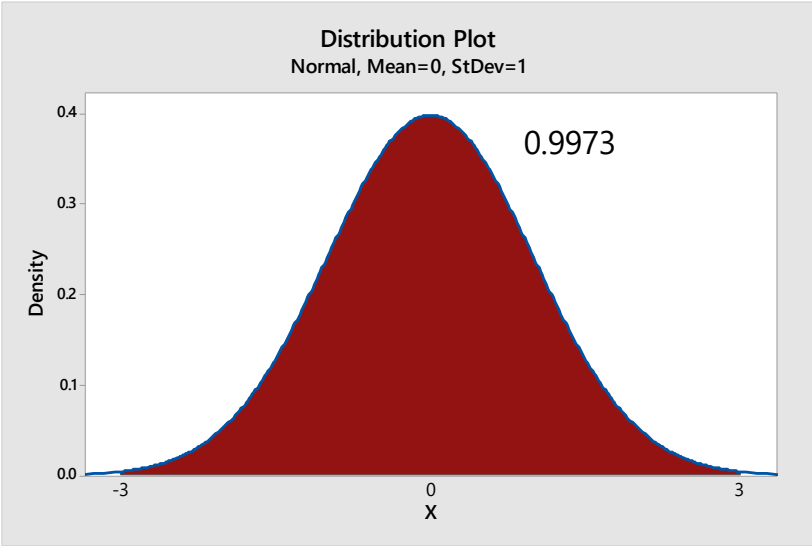
The Importance of the Deviation

The standard deviation is used to know the breadth of data that follows a normal distribution. Commonly, it is said that the median +- 3 σ (standard deviations) groups almost all of the data.

Median +- 1 deviation = 68.27% of the data	Median +- 2 deviations = 95.45% of the data	Median +- 3 deviations = 99.73% of the data

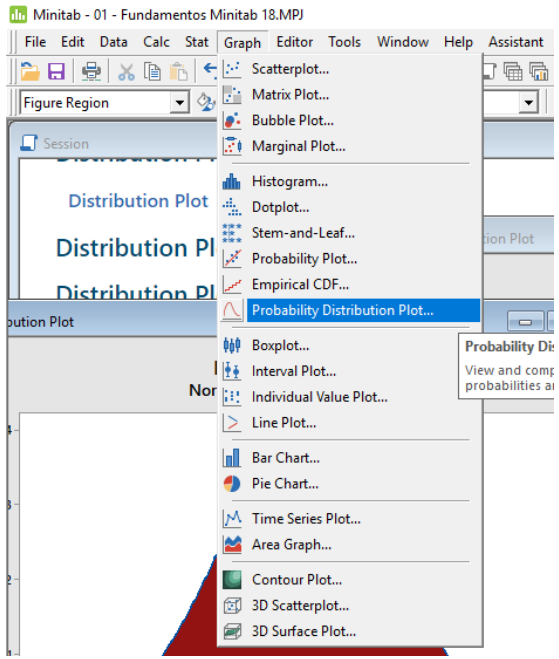


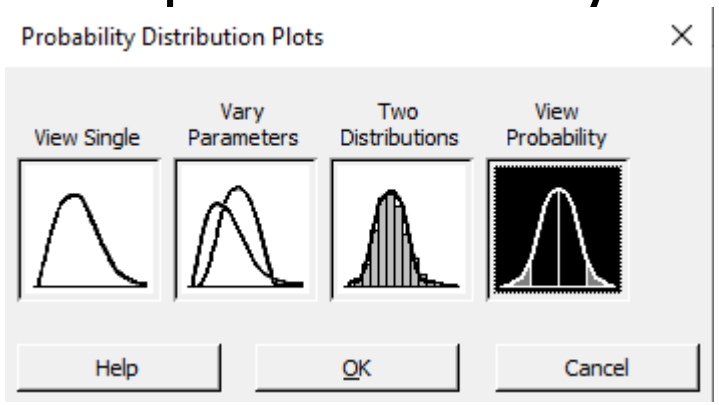


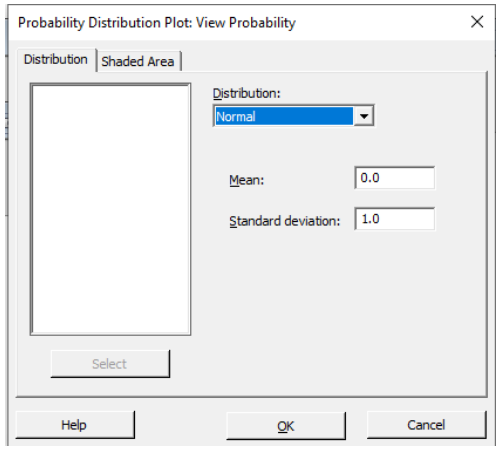


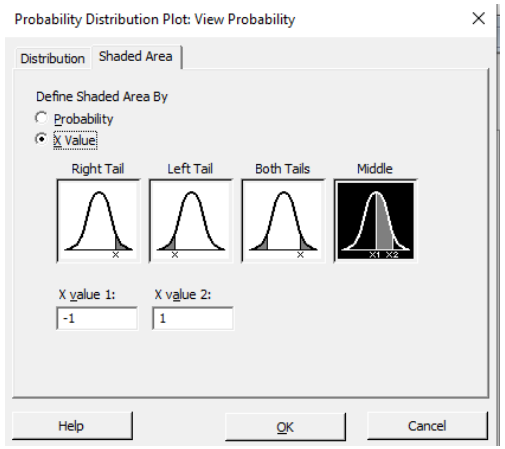
Probability Distribution Plots

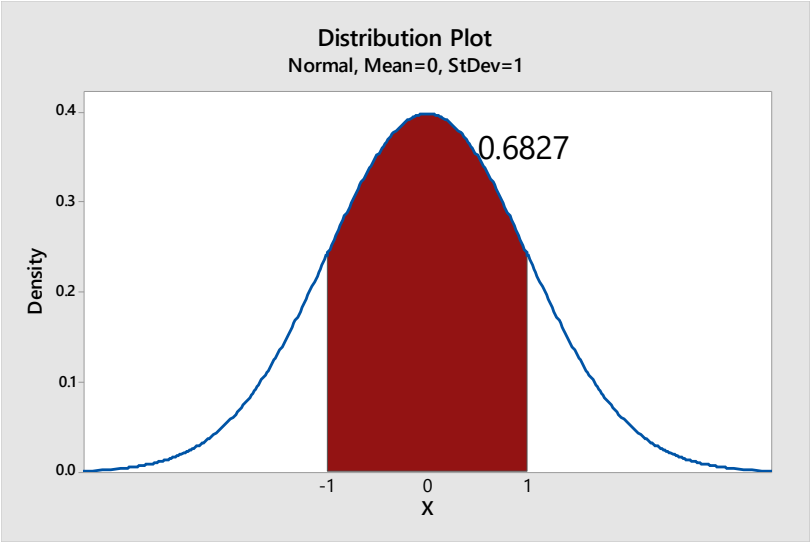
To create the previously shown graphs, do as follows:
Graph > Probability Distribution Plot > View Probability > Input the value for the median and the deviation > Input the value you want to highlight (Shaded Area).







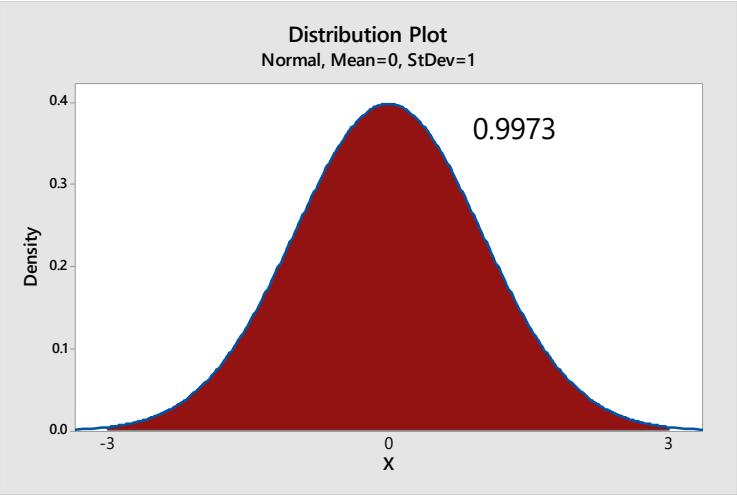


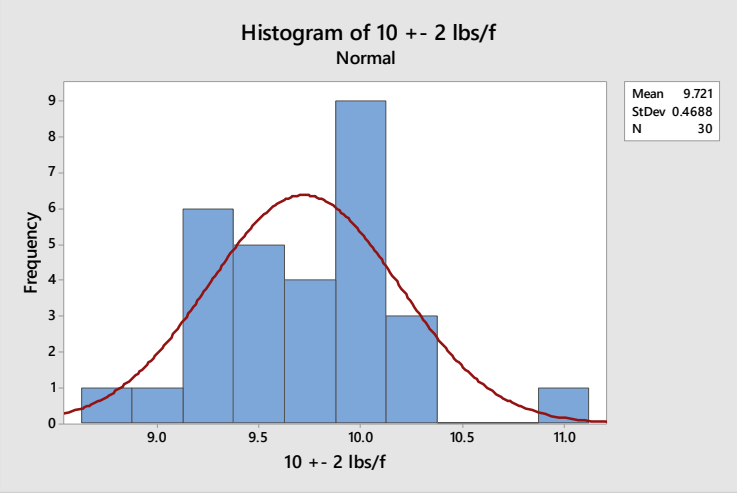


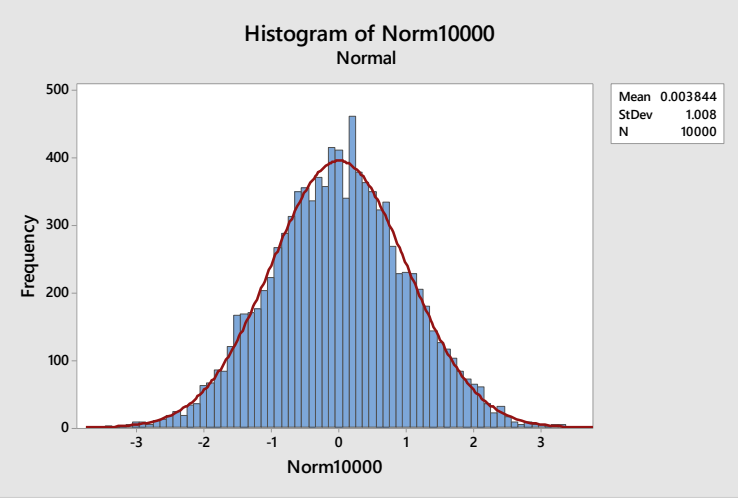
Normal / Gauss Distribution

It is frequently mentioned that the data must be normal. This means that, when we graph such data, it must follow the shape of the Gauss bell. Observe how there's symmetry in the following bells.

Examples

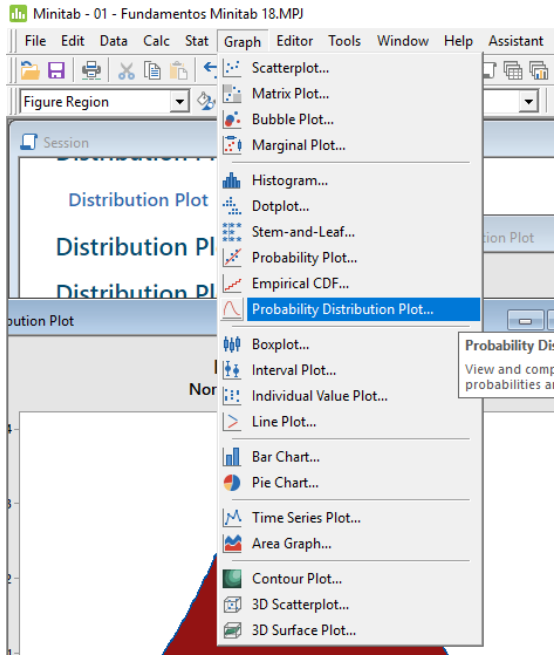


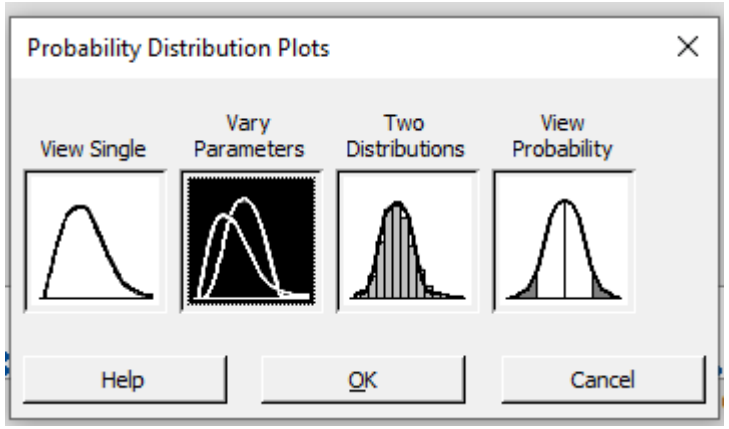


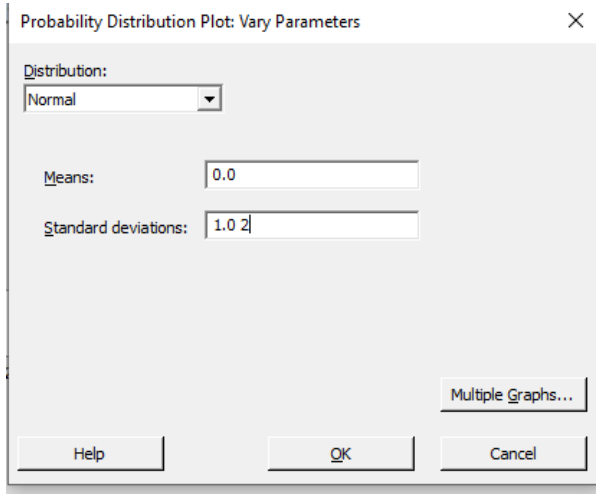


Normal / Gauss Distribution

Normal data follows the shape of a bell, regardless the value of the standard deviation, or the median. To demonstrate this, select: Graph > Probability Distribution Plot > Vary Parameters > Select Normal > Valor Media = 0, Standard deviation = 1, 2

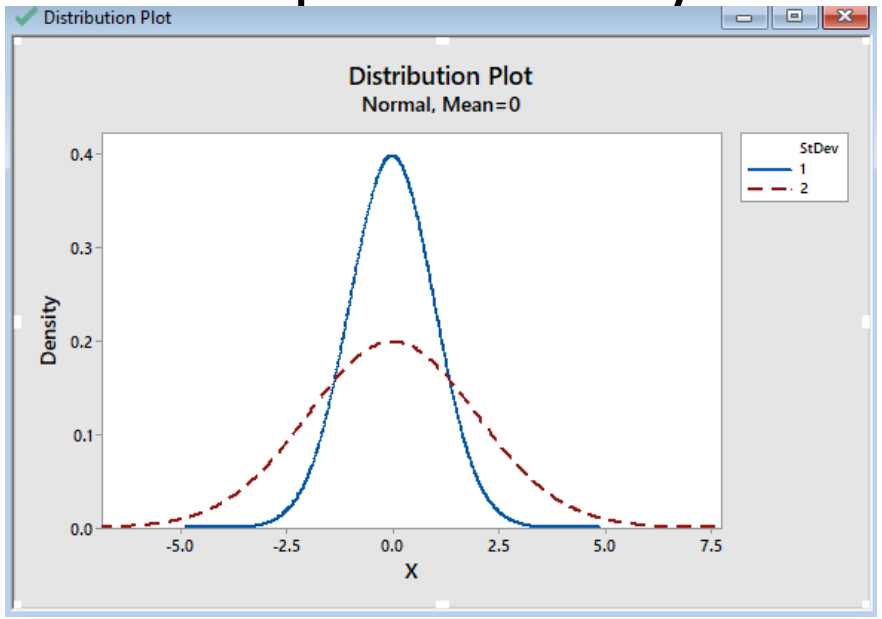






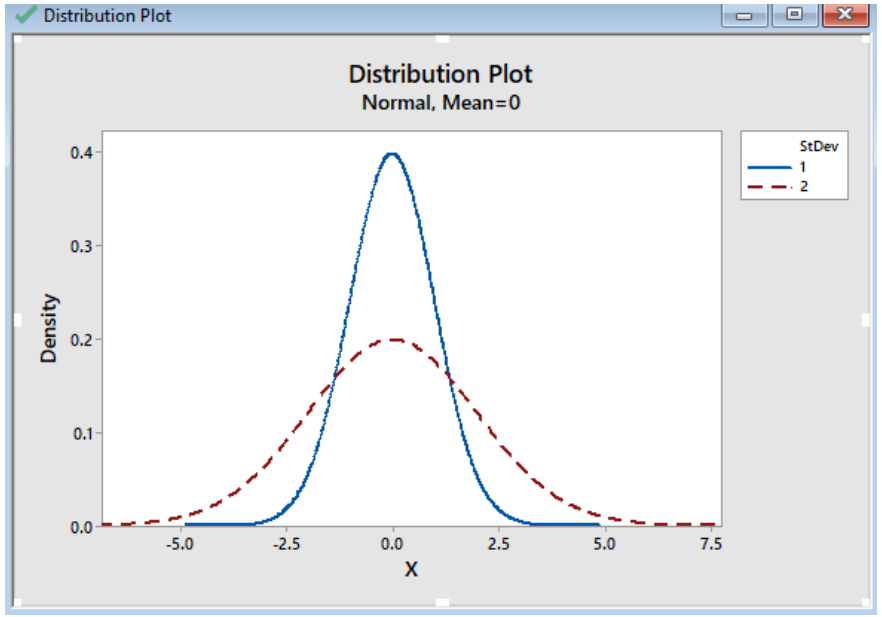
Normal / Gauss Distribution

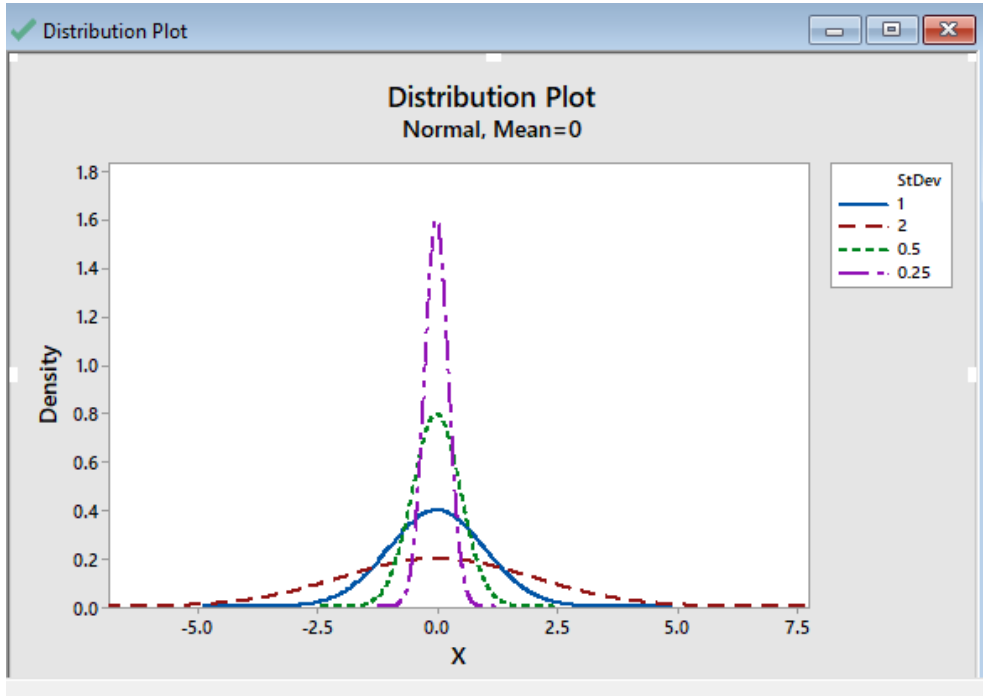
By selecting OK, the following graph will be created. Notice how the blue curve is slimmer than the red curve. This means that the red curve (standard deviation of 2) is more disperse than the blue on (standard deviation of 1). In conclusion, standard deviation is a value that tells us how disperse is the data. Your data will be less disperse when most of the values are similar (e.g. 1.1, 1.2, 1.1) and will be more disperse when your values are very different (e.g. 1, 5, 25).



Normal / Gauss Distribution

We have created additional normal distribution graphs, so you can observe how, as the standard deviation is smaller, the data is more grouped together (the median being 0).





Module 1. Minitab basics

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