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## Step 1

Job Aid for Charting Generic *E. coli* Data – Statistical Process Control (SPC)**How to Calculate the Mean/Average (Steps 1-3)**

1. Open an Excel Spreadsheet. Start by labeling the columns, for example, Column A – cfu/cm<sup>2</sup>, Column B – Mean, Column C – UCL (2SD), and Column D – UCL (3SD). Always save the raw data.
2. Enter the *E. coli* data points in Column A (cfu/cm<sup>2</sup>). The lowest value that can be entered is 0.08, which is the minimum detectable level for Generic *E. coli*. Essentially, a value of 0.08 equals 0.
3. Click in an empty cell below and to the right of your data.
  - Type “=Av” and a pop-up function box appears.
  - Scroll down and double click Average.
  - Highlight all the data points in all the cells in column A by left clicking on the first data point and running down the column with your cursor to the end of the data points. The boxes that are highlighted will appear in the cell you selected “(A1:A13, for instance”.
  - You then add a closing parenthesis mark “)” to make it into a formula. In the example above it would appear as =AVERAGE(A1:A13) when you are done.
  - Click anywhere outside the cell when you are done and the calculated average (mean) of column A data points appears in the cell. Label the cell as “Mean”.

**How to Round Numbers (Step 4)**

4. To round the number to two decimals, click on the cell containing the number, right click and select “Format Cells...” from the pick list.
  - The “Number” tab appears as the default.
  - Under “Category” on the left side, select “Number”.
  - Rounding to two decimals is the default.
  - Click “OK” and the value will be rounded to two decimals in the cell.

**How to Calculate the Standard Deviation (SD) (Step 5)**

5. To calculate the Standard Deviation (SD) of the data in column A, click in a second empty cell below and to the right of your data.
  - Type “=St” in the box and a pop-up function box appears.
  - Double click STDEV.P and “=STDEV.P(“ appears in the cell.
  - Highlight all the data points in all the cells in column A by left clicking on the first data point and running down the column with your cursor to the end of the data points. The boxes that are highlighted will appear in the cell you selected “(A1:A13, for instance”.
  - You then add a closing parenthesis mark “)” to make it into a formula. In the example above it would appear as =STDEV.P(A1:A13) when you are done.
  - Click anywhere outside the cell when you are done and the standard deviation of column A data points appears in the cell; round the number to two decimals. Label the cell as “SD”.

**How to Calculate the Upper Control Limit (Step 6)**

6. While an establishment’s upper control limit is usually calculated by the establishment from the previous year’s data, an upper control limit can be calculated using the existing data. Upper control limits are calculated by adding the mean (average) plus either two Standard Deviations (SD) (for more rigorous control and a 95% confidence level that results above the upper control limit are not a random event) or three Standard Deviations (SD) (for less rigorous control and a 98.85% confidence level that results above the upper control limit are not a random event). Both methods are acceptable and the decision of how the upper control limit is calculated is up to the establishment. (Note: Lower statistical control limits (Mean + 2 SD) may be more likely to indicate that process control issues are present when they are not, while higher limits (Mean + 3 SD) may be more likely to miss potential process vulnerabilities.)
  - To do this in the Excel spreadsheet, click in an empty cell below and to the right of your data.
  - If calculating an upper control limit equal to the mean + 2 Standard Deviations, Type “=(2\*”, then highlight the cell with the Standard Deviation calculated previously in Step 5 above which will appear as a cell number (Ex. G25), then type “+”, and highlight the cell with the mean/average, which will appear as a cell number (Ex. G26).
  - Finally type a closing parenthesis mark “)”. In the example used the final formula appearing in the cell would appear as “=(2\*G25+G26)”.
  - To calculate an upper control limit equal to the mean + 3 Standard Deviations, substitute a 3 for the 2 in the formula. The final formula appearing in the cell would then appear as “=(3\*G25+G26” in the example above.
  - Click anywhere outside the cell when you are done and the Upper Control limit numerical value appears in the cell; round the number to two decimals. Label each corresponding cell as “2XSD” and “3XSD”, respectively.

### How to Construct a Process Control Chart (Steps 7-10)

7. To be able to construct the SPC chart, enter the mean (average) of your data from column A calculated in Steps 1-4 above in column B (labeled as Mean). Enter it into as many cells in Column B as you have data points in column A. (Ex. If there 13 data points in column A, enter the mean into the thirteen corresponding cells in column B). (Hint: The easiest way is to type it in the first box, then right click in the box and select "Copy". Highlight the cells below into which you want to enter the data, then right click and select "Paste".
  - Enter the numerical Upper Control Limit, calculated using either the mean + 2 or 3 Standard Deviations, in Step 7 above, into the cells in Column C corresponding to the data in columns A and B. If the establishment had calculated an Upper Control Limit from the previous year's data, you would enter that value in the cells in Column C.
8. To make a process control chart from the data, highlight all the data in columns A, B, and C, then click on the "Insert" tab, in the Toolbar section at the very top.
  - Click "Recommended Charts" and select **Line Chart**. The chart will appear in the spreadsheet.
9. To give additional detail to the chart, click on the chart, then click on the + sign (Chart Elements) to the upper right of the chart.
  - Place a check mark in the box next to the following: Axes, Axis Titles, Chart Title, Gridlines, Legend, and Trend line for Series A (the data in column A).
  - Click in box on the vertical axis that says, "Axis Title". Delete that name and type "**cfu/cm<sup>2</sup>**". These are the units in which generic *E. coli* is measured for sponging sampling. Then highlight the 2 and right click. Select "Font" from the list of choices. Check the box to the left of "**Superscript**" under Choices and click OK.
  - Click in the box on the horizontal axis that says, "Axis Title". Delete that name and type "**Sample Number**". Each value plotted on the graph corresponds to a value in Column A. Sample #1 = value in A:1. Sample #2 = value in A:2, ect.
  - If only every other sample number is displayed, extend the chart to make it longer by hovering your cursor over the middle dot on the end of the chart until a two way arrow (↔) appears, then left clicking on the dot and dragging it to make the chart longer.
  - Click on "**Chart Title**". Delete that name and type "**Generic *E. coli* (Name of the Establishment) (Date Range covered by the chart)**". Ex: Generic *E. coli* Open Beef 10/23-28/2017.
10. At the bottom of the chart you will see the titles of the lines that say, "**Series 1, Series 2, Series 3**, etc." These are titles in the Legend and identify what the line graphing those data points represents. Series 1 represents the data from Column A, Generic *E. coli* in cfu/cm<sup>2</sup>, Series 2 represents the mean/average of the data, which is listed in Column B, and Series 3 represents the Upper Control Limit, which is listed in Column C.
  - To change the names of the titles, click on the area where the series are listed.
  - A box around the listed series will appear. Right click in that box.
  - Click "Select Data" from the dropdown. The Select Data Source Box appears.
  - Click on Series 1 to highlight it. Click "Edit", which is immediately above where the Series are listed. An "Edit Series" box appears.
  - Type "Generic *E. coli*" in the Series Name box.
  - Click on Series 2 to highlight it.
  - Click "Edit", and type "Mean" in the Series Name box.
  - Click on Series 3 to highlight it.
  - Click "Edit", and type "Upper Control Limit = (whatever value represents the UCL)".
  - Click "OK". The graph is finished.

**Examples of data entered and process control charts (upper chart with UCL of mean + 2 SD and lower chart with UCL of mean + 3 SD are shown below.**