DataNet Quality Systems Knowledgebase

How do I use the Sensitivity Analysis tab in the Variable Analyzer?

The Sensitivity Analysis tab offers additional information which aids in the interpretation of control charts. This information concerns how sensitive a control chart is in detecting process shifts using the 1pt beyond control limits test.
This tab consists of three areas: the Options Bar, the Chart Performance Table, and the Chart Display.
The values in the Chart Performance Table and Chart Display area are calculated using the values in the Calculation Settings panel of the Variable Analyzer. Consequently, users can experiment to see which Calculation Settings panel values produce the best Chart Performance Table and Chart Display values.

The Options Bar – a bar of options that affect the Chart Performance Table and the Chart Display. The options are divided into three categories: Chart Type, Comparison Curves, and Shift Direction.
Chart Type – sets the chart type for the Chart Performance Table and Chart Display. By default, the X-bar & R chart is selected.

Comparison Curves – sets which additional curves are displayed in the Chart Display for comparison to the main curve. (The main curve can either be the heavy blue line or the heavy red line, depending on whether Positive or Negative is selected as the Shift Direction.) The main curve is calculated using the Calculation Settings panel's Subgroup Size value. Comparison curves are calculated using other subgroup sizes. Three options are available: None – results in no additional curves being displayed. This option is selected by default and is the only option that can be selected when the Chart Type is set to X & MR. Standard – results in six to seven additional curves being displayed, each based on one of the following subgroup sizes: 2, 3, 4, 5, 10, 15, and 20. These subgroup sizes are generally regarded as standard. If the Subgroup Size value in the Calculation Settings panel is one of these seven sizes, that size is reflected in the main curve and, therefore, selecting this option will result in six additional curves being plotted. If the Subgroup Size value is not one of these seven sizes, selecting this option will result in seven additional curves plotted. Relative – results in three to six additional curves being displayed. If the Subgroup Size value in the Calculation Settings panel is 2, selecting this option results in three curves being added: one for a subgroup size of 3, one for a subgroup size of 4, and one for a subgroup size of 5. If the Subgroup Size value is 3, four curves will be added: one for a subgroup size of 2 and one each for subgroup sizes of 4, 5, and 6. If the Subgroup Size value is 4, five curves will be added: one for a subgroup size of 2, one for a subgroup size of 3 and one each for subgroup sizes of 5, 6, and 7. If the Subgroup Size value is 5 or more, six curves will be added, three incrementing from the subgroup size value and three decrementing from the subgroup size value.

Shift Direction – sets the direction of process shift to be displayed in the Chart Display. The three possible directions are: Positive – results in the display of heavy blue curves. These curves represent a shift of the process mean toward the upper control limit. (The b-risk and ARL values in the Chart Performance Table are Positive shift values.) Negative – results in the display of heavy red curves. These curves represent a shift of the process mean toward the lower control limit. (Unlike Positive curves, there are no values from Negative curves represented in the Chart Performance Table.) Both – results in the display of both the Positive heavy blue curve and the Negative heavy red curve.

The Chart Performance Table – contains the following values:

a-risk Example In the above screen capture, the a-risk value is 0.00148. This indicates there is a 0.148% chance of a 1pt beyond control limits violation not signifying a process mean shift.

a-risk – the probability of a 1pt beyond control limits violation appearing on a control chart when the process mean has not actually shifted. (Typically, 1pt beyond control limits violations are understood to signify that the process mean has shifted.) The lower this probability, the more confident a quality engineer can be that a 1pt beyond control limits violation signifies a process shift and, therefore, the more confident he or she can be that attempts to correct a process shift are justified. (Note: Of the values in the Chart Performance Table, the a-risk value is the only value not visually represented in the Chart Display.)

ARL(0) Example In the above screen capture, the ARL(0) value is 673.7. This value indicates that, even if the process remains in-control, a 1pt beyond control limits violation can be expected every 673.7 subgroups.

ARL(0) – short for average run length, ARL is the interval between 1pt beyond control limits violations that can be expected. The subscripted parenthetical number which follows ARL designates the number of standard deviations of shift present. An ARL(0) value, then, indicates the ARL that can be expected in the process when the process mean has not shifted; when the process is in-control, in other words. When a 1pt beyond control limits violation appears on a control chart, an analyst can examine the interval between that violation and the previous 1pt beyond control limits violation. If that interval matches or exceeds the process' ARL(0) value: the process can probably be classified as still in-control; the violation can probably be attributed to typical process variation; and a search for an assignable cause can probably be considered unwarranted.

b-risk (0.2s) Example In the above screen capture, the b-risk (0.2s) value is .99792. This means that there is over a 99.8% chance of the first subgroup collected after a mean shifts by 0.2s being within the control limits. This probability is high compared to the other b-risk values because those other values are calculated for larger process shifts and the larger the shift the less likely the first subgroup following it will be in-control.

b-risk (0.2s) – the probability that a 0.2s shift in the mean of a process will not result in the first subgroup collected following the shift violating the 1pt beyond control limits test. To illustrate, say something happens to an in-control process at 8:00 AM that shifts its mean up or down by 0.2s. The chance that the first subgroup collected after 8:00 AM will not violate the 1pt beyond control limits test is what is meant by b-risk (0.2s).

b-risk (0.5s) – same as b-risk (0.2s) above but for a process shift of 0.5s.

b-risk (1s) – same as b-risk (0.2s) above but for a process shift of 1s.

ARL (1) Example In the above screen capture, the ARL (1) value is 8.4. This indicates that, if a 1pt beyond control limits violation occurs within 8.4 subgroups of the previous 1pt beyond control limits violation, one can probably conclude that the process mean has shifted by 1s and that a search for an assignable cause is warranted.

ARL(1) – same as ARL(0) except it indicates the ARL that can be expected if the process mean shifts by 1s.

The Chart Display

O.C. – O.C. stands for operating characteristic. There are different types of O.C. charts. The type of O.C. chart in this Chart Display area defines a control chart's b-risk (see definition above) for different sizes of process mean shifts. The Chart Type selection in the Options Bar determines which chart statistic is analyzed for b-risk values in an O.C. chart; the X-bar statistic for instance is analyzed in the top O.C. chart and the R statistic is analyzed in the bottom O.C. chart when the Chart Type is X-bar & R. To use this type of O.C. chart:

O.C. (X) Example Say the standard deviation value of 1s is selected from the x-axis. The point on the heavy blue curve that corresponds to this value has a y-axis beta risk value of just under 0.9. This means that there is just under a 90% probability that a process mean shift of 1s toward the upper control limit will not result in the first subgroup collected following the shift having a value that exceeds the upper control limit.

1. Locate a process mean shift size on the x-axis. (The unit for this size is standard deviations.)
2. Locate the point on a curve on that corresponds to this value. If desired, mouse over this point to see the subgroup size on which the curve is based.
3. Read the y-axis value that corresponds to this point.

ARL – a chart of the average run length (see definition above) for different sizes of process mean shifts. The procedure for using this chart is the same as the procedure for using the O.C. given above.

ARL (X-bar) Example Again, say the standard deviation value of 1s is selected from the x-axis. The point on the heavy blue curve that corresponds to this value has a y-axis value of between 8 and 9 subgroups, meaning that an analyst can safely conclude 1s process shift has taken place if a 1pt beyond control limits violation occurred within 8-9 subgroups of the previous 1pt beyond control limits violation.

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