WINSPC C/S Statistics Reference

Introduction

The WINSPC C/S equation editor is used (internally to the product) to construct control charts, and references many pre-defined statistics. Some of the meanings of these statistics are not clear from their names. The purpose of this paper is to document all of the statistics defined in a standard installation of WINSPC C/S.

Please note that many of the summary statistics have two forms: one form assumes that the data is normally distributed, the other form does not.

There are two types of statistics in WINSPC C/S: subgroup statistics and summary statistics. A subgroup statistic is any statistic that takes on a new value for each subgroup. A summary statistic is a singular valued statistic (i.e., it has a single value for any given result set). All of the summary statistics are marked as such, and all unmarked statistics are subgroup statistics.

Alphabetical Listing of Statistics

Avg *(summary)*

This is the average of all of the individuals. This calculation ignores chart type and subgroup size.

$$Avg = \frac{M_1}{M_0}$$

Bar

Bar instructs the program to find the average value of the previously named statistic. Bar must follow a valid subgroup (i.e., non-summary) statistic name. Examples of valid usage are:

Self.R.Bar, Self.Mean.Bar, Self.S.Bar

Examples of invalid usage are:

Self.Bar, Self.Cpk.Bar, Self.R.Bar.Bar

Bar converts a subgroup statistic into a summary statistic.

c4(*subgroup size*)
d2(*subgroup size*)
d3(*subgroup size*)
e(*subgroup size*)

These are fundamental chart constants. All constants that define the spread of the control limits on the standard control charts are derived from these values.

CL *(obsolete)*
LCL *(obsolete)*
UCL *(obsolete)*

These statistics are present for historical reasons, and should never be used. See PriUCL, PriCL, PriLCL, SecUCL, SecCL, and SecLCL.

CMinus

$$C^{-}{}_{i} = -\max\{0, T - Mean - \frac{\sigma}{2} + C^{-}{}_{i-1}\}$$

CPlus

$$C^{+}{}_{i} = \max\{0, Mean - T - \frac{\sigma}{2} + C^{+}{}_{i-1}\}$$

Cm *(summary)*

For data assumed to be normal:

$$C_m = \frac{USL - LSL}{8 \cdot \frac{N_\sigma}{3} \cdot \sigma}$$

For data not assumed to be normal:

$$C_m = \frac{USL - LSL}{PercFromNumSigma(4) - PercFromNumSigma(-4)}$$

Cp *(summary)*

For data assumed to be normal:

$$C_p = \frac{USL - LSL}{2 \cdot N_\sigma \cdot \sigma}$$

For data not assumed to be normal:

$$C_p = \frac{USL - LSL}{PercFromNumSigma(3) - PercFromNumSigma(-3)}$$

Cpk *(summary)*

$$C_{pk} = \min\{C_{pl}, C_{pu}\}$$

Cpkm *(summary)*

For data assumed to be normal:

$$C_{pkm} = \frac{C_{pk}}{\sqrt{1 + \left(\frac{\mu - T}{\sigma}\right)^2}}$$

For data not assumed to be normal and PercFromNumSigma(0) >= Target:

$$C_{pkm} = \frac{C_{pk}}{\sqrt{1+\left(\frac{PercFromNumSigma(0)-T}{PercFromNumSigma(0)-PercFromNumSigma(-1)}\right)^2}}$$

For data not assumed to be normal and PercFromNumSigma(0) < Target:

$$C_{pkm} = \frac{C_{pk}}{\sqrt{1+\left(\frac{T-PercFromNumSigma(0)}{PercFromNumSigma(1)-PercFromNumSigma(0)}\right)^2}}$$

Cpl *(summary)*

For data assumed to be normal:

$$C_{pl} = \frac{\mu - LSL}{N_\sigma \sigma}$$

For data not assumed to be normal:

$$C_{pl} = \frac{PercFromNumSigma(0)-LSL}{PercFromNumSigma(0)-PercFromNumSigma(-3)}$$

Cpm *(summary)*

For data assumed to be normal:

$$C_{pm} = \frac{C_p}{\sqrt{1+\left(\frac{\mu - T}{\sigma}\right)^2}}$$

For data not assumed to be normal and PercFromNumSigma(0) >= Target:

$$C_{pm} = \frac{C_p}{\sqrt{1+\left(\frac{PercFromNumSigma(0)-T}{PercFromNumSigma(0)-PercFromNumSigma(-1)}\right)^2}}$$

For data not assumed to be normal and PercFromNumSigma(0) < Target:

$$C_{pm} = \frac{C_p}{\sqrt{1+\left(\frac{T-PercFromNumSigma(0)}{PercFromNumSigma(1)-PercFromNumSigma(0)}\right)^2}}$$

Cpu *(summary)*

For data assumed to be normal:

$$C_{pu} = \frac{USL - \mu}{N_{\sigma}\sigma}$$

For data not assumed to be normal:

$$C_{pu} = \frac{USL - PercFromNumSigma(0)}{PercFromNumSigma(3) - PercFromNumSigma(0)}$$

Cr *(summary)*

$$C_r = \frac{100}{C_p}$$

CuSum

$$CuSum_i = CuSum_{i-1} + Mean - T$$

Diff

$$Diff = Product.Mean - Product.\mu$$

Note: The Diff and the Diff-bar statistics are identical. However, Diff is for variables of subgroup size one, and Diff-bar for subgroup size greater than one. This was done to maintain consistent nomenclature with the technical literature.

Diff-bar

$$Diff - bar = Product.Mean - Product.\mu$$

Note: The Diff and the Diff-bar statistics are identical. However, Diff is for variables of subgroup size one, and Diff-bar for subgroup size greater than one. This was done to maintain consistent nomenclature with the technical literature.

Diff-barR

$$Diff - barR = Product.R$$

DiffMR

This is the moving range of the Diff statistic. It depends on the values of the Diff statistic as well as the SubRangeSize statistic.

DistMedian *(summary)*

This is the median value a Pearson system probability distribution fitted by the method of moments to the individuals. Said another way,

$$DistMedian = Perc(0.5)$$

EWMA

$$EWMA_i = \lambda \cdot Mean + (1 - \lambda) \cdot EWMA_{i-1}$$

EWMS

$$EWMS_i = \lambda \cdot (Mean - Avg)^2 + (1 - \lambda) \cdot EWMS_{i-1}$$

EWMV

$$EWMV_i = \lambda \cdot (Mean - EWMA_i)^2 + (1-\lambda) \cdot EWMV_{i-1}$$

EWRMS

$$EWRMS_i = \sqrt{\lambda \cdot (Mean - Avg)^2 + (1-\lambda) \cdot EWRMS_{i-1}{}^2}$$

EstSampleMu

This is the estimate of the process mean based on a control chart assuming a subgroup size of 1.

EstSampleSigma

This is the estimate of the process variability based on a control chart assuming a subgroup size of 1.

GeneralizedParams *(summary)*

This is the "Assume Data Is Normal" setting of the variable (found in Variable Setup). It is 0 if "Assume Data Is Normal" is checked, and 1 if "Assume Data Is Normal" is not checked.

IndW (W)

This is the W statistic for individuals. The W statistic is the moving range of the Z statistic. It depends on the values of the Z statistic as well as the SubRangeSize statistic.

IndWStar (W*)

This is the W* statistic for individuals. The W* statistic is the moving range of the Z* statistic. It depends on the values of the Z* statistic as well as the SubRangeSize statistic.

InvChiSqCumDist *(summary)*

This is the value of the inverse, Chi-squared, cumulative distribution function. Said another way,

$$InvChiSqCumDist(n, y) = z$$

such that,

$$\int_{-\infty}^{z} p_n(x)dx = y$$

where,

$$p_n(x) = \frac{x^{(n/2)-1} \cdot e^{-x^2/2}}{2^{n/2} \cdot \Gamma(n/2)}$$ (x > 0) (the standard Chi-Squared distribution)

and,

$$\Gamma(x) = \int_{0}^{\infty} t^{x-1} \cdot e^{-t} dt$$ (the standard Gamma function)

IsNA

The value of this statistic is one if any of the individuals in a subgroup has the value of N/A, and zero otherwise.

Kurtosis (β_2) *(summary)*

$$\beta_2 = \frac{M_4 \cdot M_0 - 4 \cdot M_3 \cdot M_1 + 6 \cdot M_2 \cdot M_1^{\,2} / M_0 - 3 \cdot M_1^{\,4} / M_0^{\,2}}{(M_2 - M_1^{\,2} / M_0)^2}$$

LCL *(obsolete)*

See CL and PriCL for more information.

LRL

This is the value of the lower reasonable limit of the variable.

LSL

This is the value of the lower specification limit (or engineering limit) of the variable.

Lambda (λ) *(summary)*

The exponential weighting factor used by all of the exponentially weighted charts as set in Variable Setup.

LastSubGrpForRecalc

This is the subgroup number of the last subgroup to be included in a control limit calculation. The value of this statistic depends on whether or not control limits are to be calculated on every subgroup (e.g., p chart), and whether or not the control chart is a custom chart type. Generally speaking, the value of this statistic is the distance past the last calculation restart marker.

LotSize *(summary)*

This is the "Lot Size" setting of the attribute (found in Attribute Setup). This statistic only has meaning for fixed lot size attributes.

MR

This is the moving range of the Mean statistic. It depends on the values of the Mean statistic as well as the SubRangeSize statistic.

Max

This is the largest value in the subgroup.

Mean

This is the average of all of the individuals in the subgroup. This calculation is sensitive to both subgroup size and N/A values.

Median

This is the median value of the individuals in the subgroup.

Min

This is the smallest value in the subgroup.

Moment0 (M_0) *(summary)*

$$M_0 = \sum x_i^{\,0}$$

Moment1 (M_1) *(summary)*

$$M_1 = \sum x_i^{\,1}$$

Moment2 (M_2) *(summary)*

$$M_2 = \sum x_i^{\,2}$$

Moment3 (M_3) *(summary)*

$$M_3 = \sum x_i^{\,3}$$

Moment4 (M_4) *(summary)*

$$M_4 = \sum x_i^{\,4}$$

Mu (σ) *(summary)*

This is the estimate of the process mean based on a control chart. This is X-bar for an individuals chart, X-bar-bar for an X-bar chart, median-bar for a median chart, and so on.

NumSigma (N_σ) *(summary)*

The spread of the control limits as set in Variable Setup or Attribute Setup or Short run setup. The default value is 3, that is, the control limits are 3 sigma above and below the center line of the chart.

Perc

This is the value of the inverse cumulative distribution function. Said another way,

$$Perc(y) = z$$

such that

$$\int_{-\infty}^{z} p(x)dx = y$$

where p(x) is a Pearson system probability distribution fitted by the method of moments to the individuals.

PercFromNumSigma

This is the value of the inverse cumulative distribution function with an equivalent area as the normal distribution function. Said another way,

$$PercFromNumSigma(y) = z$$

such that

$$\int_{-\infty}^{z} p(x)dx = \int_{-\infty}^{y\frac{\sigma}{S}} \frac{e^{-x^2/2}}{\sqrt{2\pi}} dx$$

and p(x) is a Pearson system probability distribution fitted by the method of moments to the individuals.

Pm *(summary)*

For data assumed to be normal:

$$P_m = \frac{USL - LSL}{8\frac{N_\sigma}{3}S}$$

For data not assumed to be normal:

$$P_m = \frac{USL - LSL}{PercFromNumSigma(4) - PercFromNumSigma(-4)}$$

Pp *(summary)*

For data assumed to be normal:

$$P_p = \frac{USL - LSL}{2 \cdot N_\sigma \cdot S}$$

For data not assumed to be normal:

$$P_p = \frac{USL - LSL}{PercFromNumSigma(3) - PercFromNumSigma(-3)}$$

Ppk *(summary)*

$$P_{pk} = \min\{P_{pl}, P_{pu}\}$$

Ppkm *(summary)*

For data assumed to be normal:

$$P_{pkm} = \frac{P_{pk}}{\sqrt{1 + \left(\frac{Avg - T}{S}\right)^2}}$$

For data not assumed to be normal and PercFromNumSigma(0) >= Target:

$$P_{pkm} = \frac{P_{pk}}{\sqrt{1 + \left(\frac{PercFromNumSigma(0) - T}{PercFromNumSigma(0) - PercFromNumSigma(-1)}\right)^2}}$$

For data not assumed to be normal and PercFromNumSigma(0) < Target:

$$P_{pkm} = \frac{P_{pk}}{\sqrt{1 + \left(\frac{T - PercFromNumSigma(0)}{PercFromNumSigma(1) - PercFromNumSigma(0)}\right)^2}}$$

Ppl *(summary)*

For data assumed to be normal:

$$P_{pl} = \frac{Avg - LSL}{N_\sigma S}$$

For data not assumed to be normal:

$$P_{pl} = \frac{PercFromNumSigma(0) - LSL}{PercFromNumSigma(0) - PercFromNumSigma(-3)}$$

Ppm *(summary)*

For data assumed to be normal:

$$P_{pm} = \frac{P_p}{\sqrt{1 + \left(\frac{Avg - T}{S}\right)^2}}$$

For data not assumed to be normal and PercFromNumSigma(0) >= Target:

$$P_{pm} = \frac{P_p}{\sqrt{1 + \left(\frac{PercFromNumSigma(0) - T}{PercFromNumSigma(0) - PercFromNumSigma(-1)}\right)^2}}$$

For data not assumed to be normal and PercFromNumSigma(0) < Target:

$$P_{pm} = \frac{P_p}{\sqrt{1 + \left(\frac{T - PercFromNumSigma(0)}{PercFromNumSigma(1) - PercFromNumSigma(0)}\right)^2}}$$

Ppu *(summary)*

For data assumed to be normal:

$$P_{pu} = \frac{USL - Avg}{N_\sigma S}$$

For data not assumed to be normal:

$$P_{pu} = \frac{USL - PercFromNumSigma(0)}{PercFromNumSigma(3) - PercFromNumSigma(0)}$$

Pr *(summary)*

$$P_r = \frac{100}{P_p}$$

PriCL
PriUCL
PriLCL
SecCL
SecUCL
SecLCL

These six statistics are the complete set of control limits. They represent the upper, center, and lower limits on the primary and secondary charts. The "primary" chart is the upper chart (visually), and the "secondary" chart is the lower chart (visually). For example, the X-bar chart is the primary chart and the R chart is the secondary chart of an X-bar & R chart pair.

Product

Product is an indirection construct used with short run characteristics. Short run characteristics are created by normalizing and interleaving data from several variables. Many of the charts associated with short runs require the values of different statistics for the individual variables that make up the short run. For example,

$$Z^* = \frac{Product.Mean - Product.\mu}{Product.MR.Bar}$$

Or, Z* for a particular subgroup is the average of the individuals in the subgroup of the variable that contributed the individuals to the subgroup, minus the process mean of that variable, divided by the average moving range value of that variable.

For 'Product' to have any meaning, 'Self' must refer to a short run characteristic.

PZMin *(summary)*

$$PZ_{\min} = \min\{PZ_u, PZ_l\}$$

PZl *(summary)*

For data assumed to be normal:

$$PZ_l = \frac{Avg - LSL}{S}$$

For data not assumed to be normal:

$$PZ_l = \frac{PercFromNumSigma(0) - LSL}{PercFromNumSigma(0) - PercFromNumSigma(-1)}$$

PZu *(summary)*

For data assumed to be normal:

$$PZ_u = \frac{USL - Avg}{S}$$

For data not assumed to be normal:

$$PZ_u = \frac{USL - PercFromNumSigma(0)}{PercFromNumSigma(1) - PercFromNumSigma(0)}$$

R

This is the difference between the largest and smallest individuals in a subgroup.

RestartRelativeSG

Some statistics in WINSPC C/S are recursive, that is, the value of such statistics is a function of the value of itself for the previous subgroup (e.g., EWMA, EWMV). One of the new features that was added to WINSPC C/S v2.0 was the ability to restart such recursive statistics. This is accomplished through the use of a new button on the data collection form. When this button is pressed, a marker is placed in the database to note the subgroup of the action. The value of RestartRelativeSG is this same subgroup number.

S

This is the standard deviation of the individuals in a subgroup.

SSquared (S^2 or variance)

This is the square of the standard deviation of the individuals in a subgroup.

Sigma *(summary)*

This is the estimate of the process variability based on a control chart. This is R-bar / d2 for an R chart, S-bar / c4 for an S chart, and so on.

SigmaType *(summary)*

This is the Mean & Standard Deviation type setting as it appears in the Variable Setup, Attribute Setup, and Short Run Setup dialogs. It is 0 for 'Est. based on process variables', 1 for 'Est. based on data', and 2 for 'Constant'.

Skew ($\sqrt{\beta_1}$) *(summary)*

$$\sqrt{\beta_1} = \frac{M_3 \cdot M_0 - 3 \cdot M_2 \cdot M_1 + 2 \cdot M_1{}^3 / M_0}{\sqrt{M_0 \cdot (M_2 - M_1{}^2 / M_0)^3}}$$

SpecType *(summary)*

This is the specification type setting as it appears in the Variable Setup dialog. It is 0 for bilateral spec limits, 1 for unilateral upper specified spec limits, and 2 for unilateral lower specified spec limits.

StationSubgroupNumber

This is the station-relative subgroup number assigned to each subgroup as it is collected. These numbers reflect the collection order of the data on each station.

StdDev (S) *(summary)*

$$S = \sqrt{\frac{M_2 - \frac{M_1{}^2}{M_0}}{M_0 - 1}}$$

StdProdS

$$StdProdS = \frac{Product.S}{Product.\sigma}$$

SubgroupSize *(summary)*

The subgroup size of the variable as set in Variable Setup.

SubrangeSize *(summary)*

The subrange size of the variable as set in Variable Setup. This statistic only has meaning for variables of subgroup size one.

SystemSubgroupNumber

This is the subgroup number assigned to each subgroup as it is collected. These numbers reflect the collection order of the data system-wide.

Target (T)

This is the target (or nominal) value of the variable.

UCL *(obsolete)*

See CL and PriCL for more information.

URL

This is the value of the upper reasonable limit of the variable.

USL

This is the value of the upper specification limit (or engineering limit) of the variable.

ValidCount

This is the number of non-N/A individuals in each subgroup.

W

$$W = \frac{Product.R}{Product.\sigma}$$

WStar (W*)

$$W^* = \frac{Product.R}{Product.R.Bar}$$

Z

$$Z = \frac{Product.Mean - Product.\mu}{Product.\sigma}$$

Z-bar

$$Z - bar = \frac{(Product.Mean - Product.\mu) \cdot \sqrt{Product.SubGroupSize}}{Product.\sigma}$$

ZMin *(summary)*

$$Z_{\min} = \min\{Z_l, Z_u\}$$

ZStar (Z*)

$$Z^* = \frac{Product.Mean - Product.\mu}{Product.MR.Bar}$$

ZStar-bar

$$Z^* - bar = \frac{Product.Mean - Product.\mu}{Product.R.Bar}$$

Zl *(summary)*

For data assumed to be normal:

$$Z_l = \frac{\mu - LSL}{\sigma}$$

For data not assumed to be normal:

$$Z_l = \frac{PercFromNumSigma(0) - LSL}{PercFromNumSigma(0) - PercFromNumSigma(-1)}$$

Zu *(summary)*

For data assumed to be normal:

$$Z_u = \frac{USL - \mu}{\sigma}$$

For data not assumed to be normal:

$$Z_u = \frac{USL - PercFromNumSigma(0)}{PercFromNumSigma(1) - PercFromNumSigma(0)}$$

