ANSI Z1.9 (Acceptance Sampling for Variables)

Summary

ANSI Z1.9 is a standard sampling methodology that has been established for the acceptance or rejection of lots using measurements made on a sample of units taken from that lot. Based on a sample of *n* units taken from a batch or lot containing *N* items, the batch or lot is either accepted or rejected. The standard is based on a previous standard called Mil-Std-414, which was officially discontinued. It is equivalent to the ISO 3951 standard.

The full ANSI Z1.9 standard includes the specification of sample sizes and acceptance criteria. It also contains rules for switching between normal inspection, tightened inspection, and reduced inspection, based on the results of recent samples.

This procedure calculates required sample sizes to be used with the ANSI Z1.9 sampling methodology. It also plots operating characteristic curves to compare alternative sampling plans.

Full details of the standard may be found in the publication titled <u>ANSI/ASQ Z1.9-2008: Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming</u>.

Sample StatFolio: *ansiz19.sgp*

Data Input

The initial dialog box displayed when the procedure is selected is shown below:
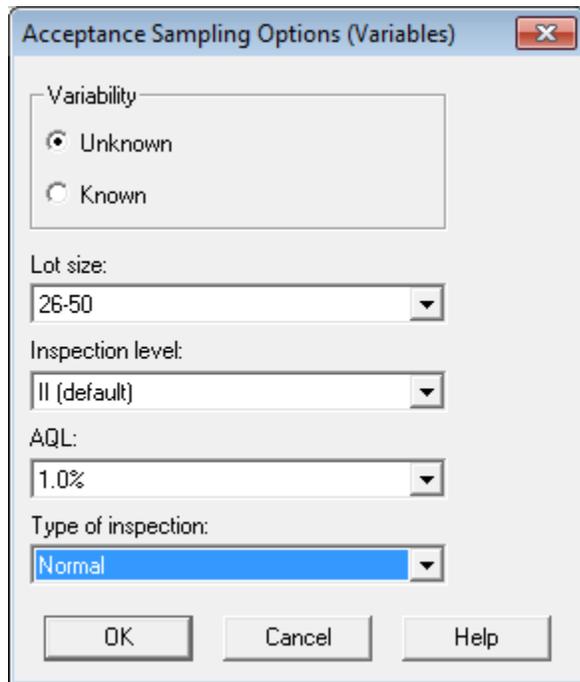
- **Variability:** whether the variability in the measurements amongst the units in the lot is known or will be estimated from the data.

- **Lot size:** the size of the lot or batch from which units will be randomly selected.

- **Inspection level**: the inspection level to be used. The standard describes five inspection levels. There are 3 general inspection levels, labeled I, II, and III. The default inspection level is II. Inspection level I may be used when less discrimination is needed. Inspection level III may be used when more discrimination is needed. There are also 2 special inspection levels: S3 and S4. They are designed for situations when small sample sizes must be used and large sampling risks must be tolerated.

- **AQL:** the *Average Quality Limit*, which is defined as the largest acceptable value for the percent of nonconforming units (units not meeting the specifications).

- **Type of inspection**: *normal*, *tightened*, or *reduced*. When beginning a sampling scheme, normal inspection is used. Tightened inspection is implemented when recent inspection results have been poor. Reduced inspection is implemented when recent inspection has been very good. The ANSI Z1.9 standard includes rules for switching between the three types of inspection.

The second dialog box displayed indicates the desired action and other information:
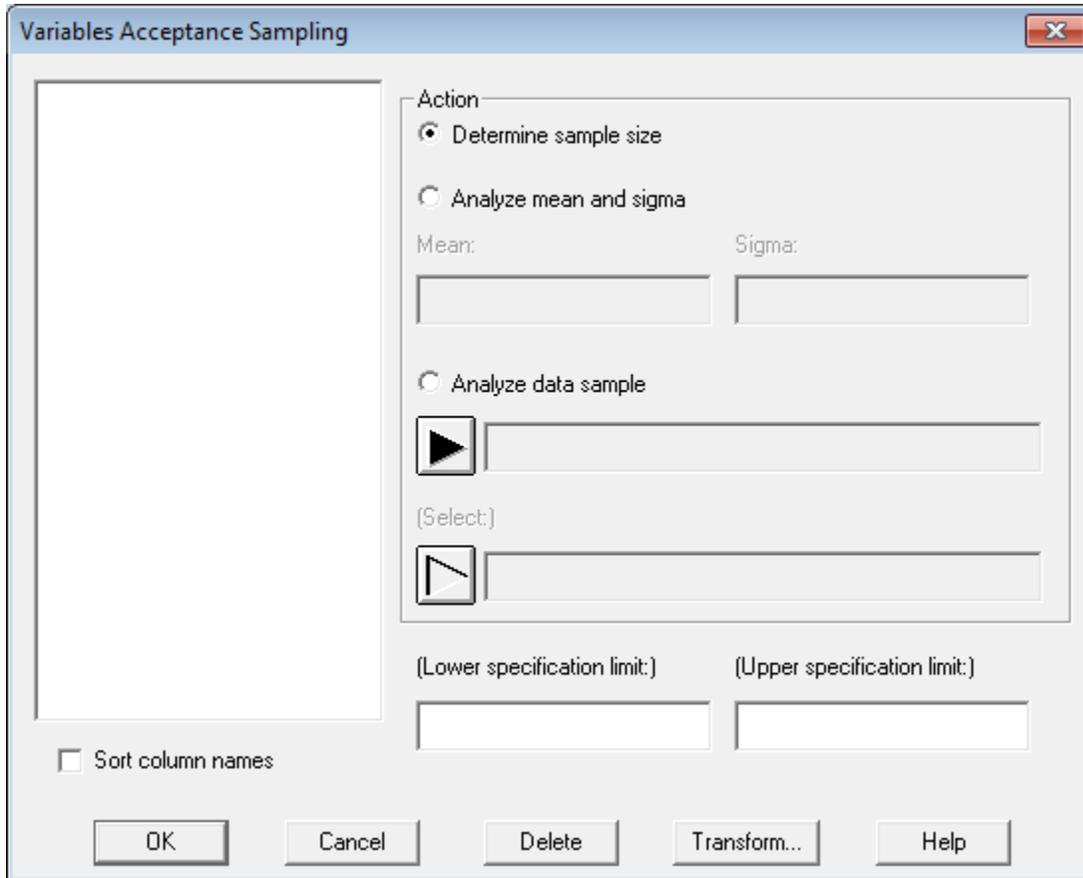
- **Action:** There are 3 choices:

  o *Determine sample size*: displays the required sample size *n* prior to the collection of any data.

  o *Analyze mean and sigma*: determines whether to accept or reject the lot based on the values of the mean and standard deviation of *n* units sampled from the lot.

  o *Analyze data sample*: determines whether to accept or reject the lot based on a column of measurements made on *n* items sampled from the lot.

- **Lower and upper specification limits:** the specification limits upon which acceptance or rejection of the lot is to be based. In order to accept or reject the lot, at least one specification limit must be entered.

Each action is illustrated below.

Action 1: Determine Sample Size

Prior to the collection of data from the lot, the required sample size may be determined. The example in the previous section indicates a lot size between 26 and 50, inspection level 2, normal inspection, based on an unknown standard deviation. Given this information, the following is displayed by the program:

ANSI Z1.9/ISO 3951/MIL-STD-414
Variability: Unknown
Lot size: 26-50
Inspection level: II (default)

AQL: 1.0%
Type of inspection: Normal

Sampling plan: (code D)

Sample size	n=5
Maximum allowable percent nonconforming	M=3.330%

The sampling plan is generated by:

> *Step 1: Assignment of sample size code letter*
>
> Based on the lot size and inspection level, a sample size code letter is assigned. The code may be any of the following: B, C, D, E, F, G, H, I, J, K, L, M, N, or P.
>
> *Step 2: Determination of sample size and maximum allowable estimated percent nonconforming*
>
> Based on the assigned sample size code letter, the type of inspection, and the AQL, the required sample size *n* is determined, together with the maximum allowable estimated percent of nonconforming units *M*.

For the example, the assigned code letter is "D". This requires taking a sample of $n = 5$ units from the lot and accepting the lot if the estimated percent of nonconforming units is no greater than $M = 3.33\%$.

Action 2: Analyze Mean and Sigma

After the sample of *n* units is collected, the mean and standard deviation of the measurements made on those units may be entered as illustrated below:
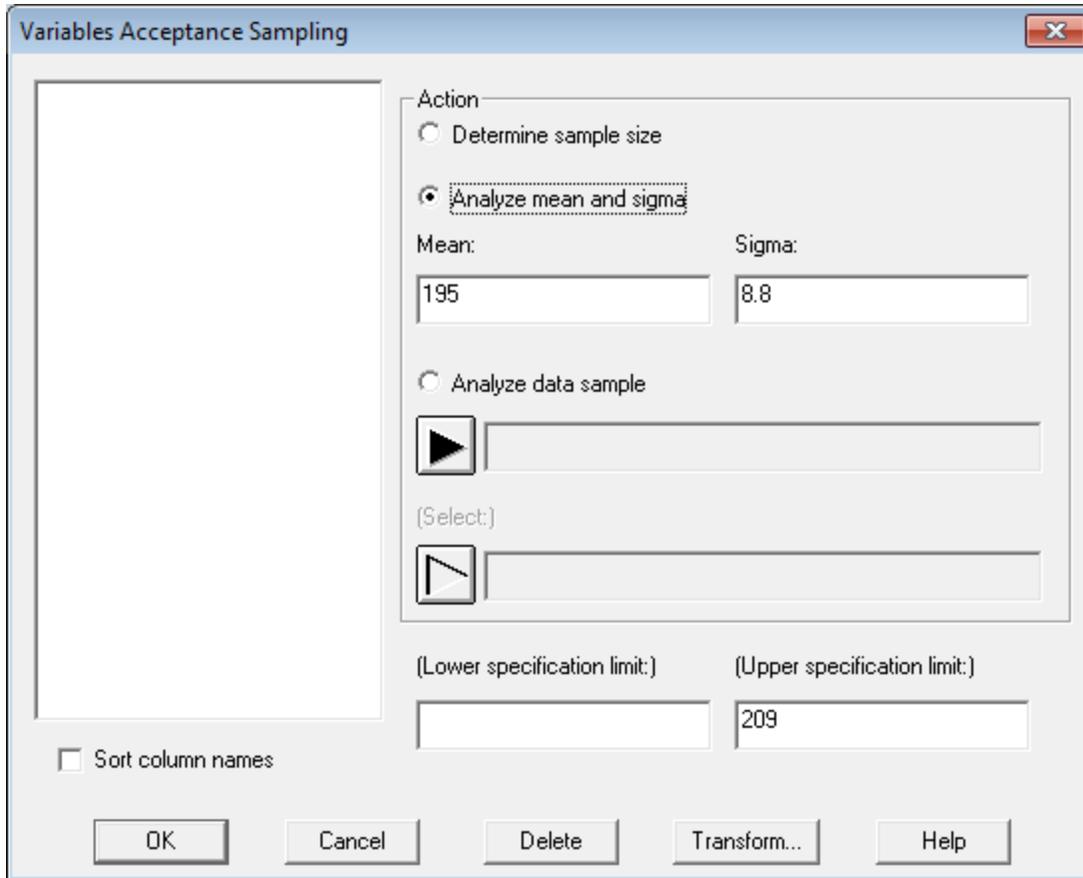
- **Sample mean**: the sample mean

$$\bar{x} = \frac{\sum\limits_{i=1}^{n} x_i}{n} \qquad (1)$$

- **Sample standard deviation**: the sample standard deviation

$$s = \sqrt{\frac{\sum\limits_{i=1}^{n} (x_i - \bar{x})^2}{n-1}} \qquad (2)$$

Note: If the variability is known, the known value of σ should be entered instead of the sample estimate.

- **Lower specification limit** (if any): the minimum allowable value *L* of the characteristic being measured.

- **Upper specification limit** (if any): the maximum allowable value *U* of the characteristic being measured.

At least one specification limit must be entered in order to estimate the percent of nonconforming units.

When the *OK* button is pressed, an analysis window is displayed containing the following *Analysis Summary*:

ANSI Z1.9/ISO 3951/MIL-STD-414

Variability: Unknown
Lot size: 26-50
Inspection level: II (default)

AQL: 1.0%
Type of inspection: Normal

Sampling plan: (code D)

Sample size	n=5
Maximum allowable percent nonconforming	M=3.330%

Sample results

		Quality index	*Est. lot percent nonconforming*
Sample mean	195.0		
Sample std. deviation	8.8		
USL	209.0	1.59	2.172%

Since the estimated lot percent defective is not larger than 3.330%, the lot is accepted.

To estimate the percentage of nonconforming units in the lot, up to two quality indices are first calculated from:

$$Q_L = \frac{\bar{x} - L}{s} \tag{3}$$

and

$$Q_U = \frac{U - \bar{x}}{s} \tag{4}$$

The estimated lot percent nonconforming is then calculated from the quality indices using a formula involving the *F* distribution. If the sum of the estimated percent nonconforming for the two quality indices is greater than *M*, the lot is rejected.

The output above indicates that if a sample of *n* = 5 units is randomly sampled from the lot and yields a sample mean $\bar{x}$ = 195 and a sample standard deviation *s* = 8.8, the estimated percent of nonconforming units in the lot equals 2.172%. Since this is not greater than 3.33%, the lot is accepted.

Action 3: Analyze Data Sample

After the sample of *n* units is collected, the individual measurements may be entered instead of the sample mean and standard deviation. Suppose the sample is as follows:

The second dialog box would then be completed as shown below:

When the OK button is pressed, the program will calculate the sample mean and sample standard deviation and display the following:

ANSI Z1.9/ISO 3951/MIL-STD-414

Variability: Unknown
Lot size: 26-50
Inspection level: II (default)

AQL: 1.0%
Type of inspection: Normal

Sampling plan: (code D)

| Sample size	n=5
Maximum allowable percent nonconforming	M=3.330%

Sample results
Data variable: Measurements

		Quality index	Est. lot percent nonconforming
Sample mean	195.0		
Sample std. deviation	8.80341		
USL	209.0	1.59	2.182%

Since the estimated lot percent defective is not larger than 3.330%, the lot is accepted.

Except for some slight differences due to rounding, the output is the same as when the sample mean and standard deviation were input directly.

Operating Characteristic Curve

This pane displays the OC Curve, which shows the probability of accepting lots with various levels of nonconforming units.

Operating Characteristic (OC) Curve
Lot size: 26-50; Inspection level: II (default); AQL: 1.0%; Type of inspection: Normal; Variability: Unknown
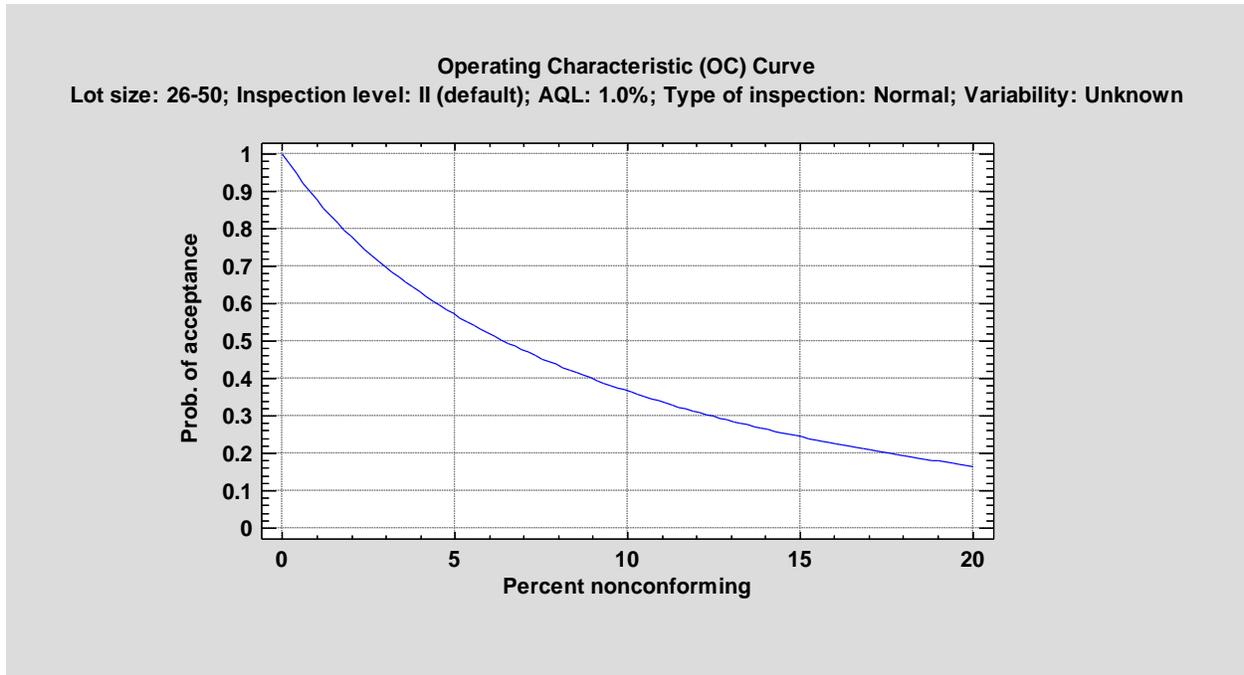
For example, if the lot contains 5% nonconforming units, then the probability of accepting the lot is approximately 0.57 or 57%. This OC curve may be compared to that of other sampling plans.