

TECHNOTES

by  **Texwipe®**
An ITW Company

Each of us has expectations of the products we purchase, often measured in terms of performance satisfaction. We typically assess this performance, in terms of quality and consistency of the product. But what do these words really mean?

CONSISTENCY AS A MEASURE OF WIPER QUALITY

Quality is commonly defined as meeting or exceeding stated performance targets while consistency is, “the agreement or harmony of parts or features to one another or a whole.”¹ Therefore, consistency is an integral parameter that allows the expected quality to be achieved.

Typical SPC Chart

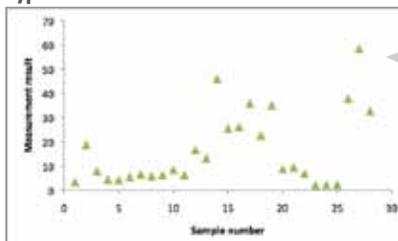


Figure 1

SPC Chart with Several Wipers for Comparison

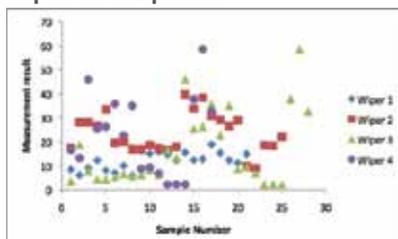


Figure 2

SPC Data Summarized as Average and Standard Deviation Values

	Wiper 1	Wiper 2	Wiper 3	Wiper 4
Average	12.17	23.28	16.38	22.41
St. Dev.	3.71	8.62	15.18	16.73

Table 1

Determining Cleanroom Wiper Consistency

Wipers are used to control contamination in cleanroom environments in a variety of industries, from building the next-generation microchip to manufacturing the newest vaccine. Each of these settings may have different applications for a cleanroom wiper, but measuring the wiper quality should always be the same, i.e. consistent.

We demonstrate here three methods of evaluating wiper consistency using a common sample data set.

Statistical Process Control (SPC)

Statistical process control (SPC) is the application of statistical methods to the monitoring and control of a manufacturing process to ensure that it operates at its full potential to produce conforming product. Wiper manufacturers should employ SPC programs to control the physical, chemical and contamination characteristics for each wiper lot that is manufactured.

Typically SPC data are plotted by sample number (as shown in Figure 1). However, if multiple lot or wipers are to be compared, determining the best quality wiper can quickly become confusing and uninformative (as shown in Figure 2).

The downside: With all these data points, it is often difficult to determine which wiper has the highest quality.

Data Averages and Standard Deviations

A commonly used method to compare cleanroom wiper quality is through data averages and standard deviations which assumes normal distribution. (Note: The same data set as represented in Figure 2 is compiled in Table 1.) Such a method reduces a very large set of available data that has been produced over time to two numbers that are inadequately represent the data set.

The downside: Each data set is summarized by just two data points, and, as a result, much information is lost.

Consistency as a Measure of Wiper Quality

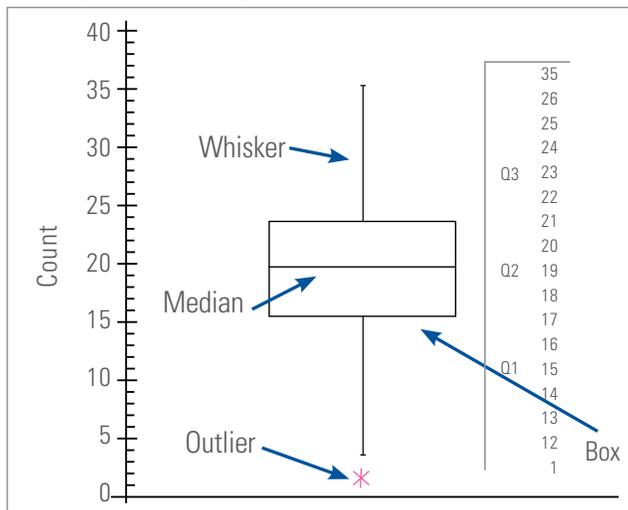
Consistency Charts

Incomplete data summaries as represented by typical or average values to misrepresent the true quality of a cleanroom wiper. A quicker, easier and more statistically unbiased method to evaluate many large sets of data is a Consistency Chart. These may also be referred to as "Box and Whisker Charts."

The components of a Consistency Chart are:

- **Line** – represents the median or middle value of a ranked data set. (Extreme values do not affect the median value as much as an average could be affected.)
- **Box** – represents the range of values in which fifty percent of the data lie. If the median line is nearer to one end of the box, the data are skewed toward that end. A smaller box indicates that the values are more similar.
- **Whisker** – the line at each end of the box, expresses a range of values in which twenty-five percent of the data set lie. A short whisker indicates that values within the whisker range are similar to each other.
- **Outlier** – indicates points that are significantly different than the rest of the dataset

Anatomy of a Consistency Chart



Consistency Charts are constructed through the following steps.

1. The data set values are ranked from highest to lowest.
2. The ranked data are divided into quartiles.
 - a. The median value (Q2) is the middle value of the entire data set, which, in general, is the most likely value in the data set.
 - b. The first quartile value (Q1) is determined by locating the median of the lower half of the data set.
 - c. The third quartile value (Q3) is found by determining the median value of the upper half of the data set.
3. The box is constructed.
 - a. Use the Q1 and Q3 values as the lower and upper bounds of the box.
4. The whisker ends are defined.
 - a. The difference of the box ends, $Q3 - Q1$, defines the Intra-Quartile Range (IQR).
 - b. The lower whisker is determined by $Q1 - 1.5 * IQR$. If the last value of the data is greater than the value determined by $Q1 - 1.5 * IQR$, the whisker is shortened to that value.
 - c. The upper whisker is determined by $Q3 + 1.5 * IQR$. If the last value of the data is less than the value determined by $Q3 + 1.5 * IQR$, the whisker is shortened to that value.
5. The outliers are determined.
 - a. Any values beyond the whiskers are considered outliers (values that are markedly smaller or larger than other values) and are indicated with an asterisk.

Consistency as a Measure of Wiper Quality

Figure 3 shows a simple mock data set (right hand side). Shown below are calculations that determine the median value, the values of the box ends, the values for the upper and lower whiskers, and the indication of an outlier data point.

- The median or middle value is 19.
- The box end values are 15 and 23, Q1 and Q3, respectively.
- $IQR = Q3 - Q1 = 23 - 15 = 8$
- Lower whisker = $Q1 - 1.5 * IQR = 15 - 1.5 * 8 = 15 - 12 = 3$. The lower whisker is located below the value "12" at "3."
- Upper whisker = $Q3 + 1.5 * IQR = 23 + 1.5 * 8 = 23 + 12 = 35$. The upper whisker is located at the value "35."
- Since the value "1" is beyond the lower whisker, it is marked with an asterisk (*) as an outlier.

Illustration of a Consistency Chart to Represent a Data Set

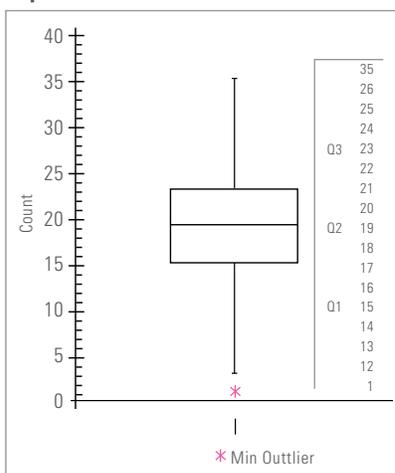


Figure 3

Interpreting Consistency Charts

Figure 4 shows a comparison of the data sets for four wipers. The data were obtained by the method described in IEST-RP-CC004.3, Section 6, biaxial shake, >0.5 μ m LPC (liquid particle counting) analysis of wipers.

Observations

Looking at the chart, the following observations can be made:

- Wiper 1 has the smallest box and the shortest whiskers.
- Wiper 2 and Wiper 4 have similar medians.
- Wiper 3 has the lowest median.
- Wiper 3 has an outlier value as shown by the asterisk above the whisker and the longest whisker.
- The median for Wiper 3 is nearer to the lower end of the box indicating many values are similar and low, that is, fifty percent of the data values are between 2 and 8; however, the other fifty percent of the values range between 8 and 58.
- Wiper 4 has the largest box and the largest range in the data.

Biaxial Shake, >0.5 μ m LPC, Wiper Comparison

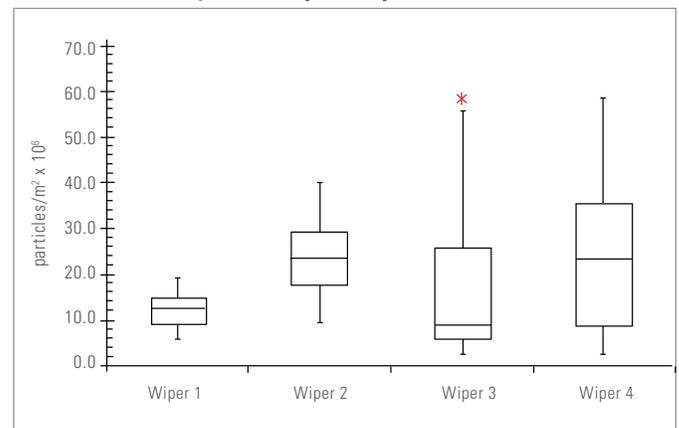


Figure 4

Consistency as a Measure of Wiper Quality

The true measure of the quality of a cleanroom wiper lies in its consistency as manufactured over an extended period of time (i.e. months, years) using a given, unaltered process.

References

1. *Webster's New Collegiate Dictionary*. 1977. 8th ed. Springfield, MA: Merriam-Webster.
2. "Evaluating Wiping Materials Used in Cleanroom and Other Controlled Environments," IEST-RP-CC004.3, Institute for Environmental Sciences and Technology, Rolling Meadows, IL, 2004; www.iest.org.

Summarizing these observations, Wiper 1 and Wiper 3 are the better products of the four. In comparing Wiper 1 and Wiper 3, the following observation can be made:

- The data set for Wiper 1, or the whole box and whisker diagram, lies within the box for Wiper 3.
- Of the test results for Wiper 3, twenty-five percent are lower than those for Wiper 1.
- More than twenty-five percent of the test results for Wiper 3 are higher than those for Wiper 1.

This presents us with a far better way to fairly evaluate the quality of cleanroom wipers than simply comparing the average value and/or the standard deviation which are necessarily incomplete representations of the data set. A minimum of three data points are necessary to define the construction of a Consistency Chart. However, when evaluating cleanroom wipers in practice, one should ensure that the Consistency Charts being compared have more than fifteen data points each as well as comparable numbers of data points for the analysis to be most meaningful. The true measure of the quality of a cleanroom wiper lies in its consistency as manufactured over an extended period of time (i.e. months, years) using a given, unaltered process.

What truly matters in a critical cleaning operation is that each wiper from a bag, each bag within in a lot and each lot of a given wiper product is delivered to the end user with the highest assurance of the expected quality. Consistency Charts offer the most unbiased representation of the consistency of cleanroom wipers from within a bag or lot, over an extended period of time.

Conclusions

Selecting the best cleanroom wiper for a particular application requires the most unbiased scientific assessment of the available data for any given wiper. Texwipe specializes in developing best practices within our manufacturing operation in order to minimize variability in our processes. This translates into reduced variability in our wiper products.

The Consistency Chart comparison of the four wipers shown here allows for a quick determination that Wiper 1 is a better performing cleanroom wiper because it is more consistent in its quality measures. A user has greater assurance that Wiper 1 will perform as expected with a higher degree of confidence when compared to the other wipers shown in the data set, due to its greater consistency.

The quality of a cleanroom wiper should therefore be evaluated not merely through a typical or average value, but more importantly through a statistically valid assessment of how consistently that typical value is attained in practice over a period of time.

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