Misapplications of SPC…and the Consequences

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Statistical Process Control (SPC) is a method that enables manufacturers to prevent problems and to control their production processes. Unfortunately, it is rarely applied correctly, so manufacturers tend to be inefficient, reactive, and even unprofitable.

Upon investigating most warranty, safety, and product recall cases, we find that the problems would have been prevented had the plant collected and analyzed production data properly—with appropriate SPC charts. Instead, inspection equipment often focuses on whether parts are "within specification" or not. They don't realize that the large majority of failed parts are actually within specifications—so the game is not about meeting specifications—rather, it's about producing consistent products.

When applied properly, SPC identifies *changes* to a process. These can be changes that are still within specification—but are statistically different than where the process was previously running. By identifying the changes, personnel can identify what caused the change and potentially improve the process or prevent the production of inferior products.

Variation among products is one of the biggest problems for a manufacturer. If every product came off the line identically, they would all perform similarly in the marketplace. Unfortunately, products perform quite differently in the marketplace. For example, a refrigerator compressor may fail within the first few months of service or it may not fail for many decades.

SPC charts can quickly detect increases or decreases in variation, and variation is arguably the biggest problem manufacturers face. If variation *decreases* (as shown on an appropriate S chart), personnel can identify the causes and sustain the improvement. If variation *increases*, personnel can identify the issue long before parts are scrapped or customers complain.

The Consequences of Failure to *Prevent*

Many manufacturing leaders believe that their production personnel use SPC properly, but the evidence suggests otherwise. Warranty costs and product recalls persist and product liability suits are widespread. Over the past 30 years, plants and

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jobs have moved overseas, and the U.S. has lost over 30% of its manufacturing jobs (source: Bureau of Labor Statistics).

Warranty costs of large U.S. manufacturers typically average 2% of revenue. So, for every $1 Billion in revenue, a company spends a needless $20 Million in warranty expenses.

Recall costs (just for consumer products and excluding automotive recalls) are more than $700 Billion annually (according to the Consumer Product Safety Commission). It is difficult to estimate the total cost of vehicle recalls. There are over 76,000 vehicle recall records in NHTSA's database covering the years of 1966 – 2008. The largest 10 recalls included 55.5 million vehicles. If a dealer is paid $50 per repaired vehicle, then the 10 largest recalls cost nearly $2.8 Billion dollars. Of course, there are thousands of automotive recalls.

The manufacturing sector does not appear to be preventing problems via the use of proper SPC. With appropriate SPC in hand, problems would be prevented. Instead, excessive costs are borne by our manufacturers, and this has hindered their ability to compete in the global marketplace.

How has SPC been misapplied?

In our 20 years of working with companies in many industries, we have visited hundreds of plants, however, we have rarely seen SPC implemented effectively. As a result, the enormous benefits of SPC are seldom achieved. The common misunderstandings and misapplications of SPC programs and methods may be summarized into 3 broad categories:

1. *Fundamental Misunderstanding of the Purpose and Value of SPC*

2. *Problems with Chart Selection, Construction, and Interpretation*

3. *Lack of Supporting Methods for Successful SPC Implementation*

Specific issues in each category are discussed below.

<u>Fundamental Misunderstanding of the Purpose and Value of SPC</u>

- Some manufacturing personnel think that SPC charts indicate whether products will meet specifications. They do not. Instead, SPC charts tell us when the system has changed, so we can quickly identify the causes and potentially prevent an issue or make an improvement. The appropriate method to assess whether the products will meet specification is *Process Capability Analysis*.

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- Many professionals do not understand the difference between raw data (individual measurements) and averages (summarized data). Charts of averages can be very effective at detecting changes in a process, but averages *do not* identify whether parts meet specifications, because they posses much less variation than the raw data. However, the point of SPC is ***not*** to identify whether parts meet specifications. The purpose of SPC is to identify whether a significant change has occurred in the system (***before*** unacceptable product is made).

- Some manufacturing personnel do not understand the difference between control limits (the range over which we expect statistics to fall) and specification limits. One consequence is that people think that products are acceptable when in fact, the products may be nonconforming. Control limits represent the limits we expect ***statistics*** to fall between 99.7% of the time. Control limits are determined by process data. Specification limits represent the limits that individual part dimensions should be within, and the specifications are dictated by a designer.

- Some manufacturing personnel confuse "common cause" sources of variation with "special cause" sources of variation and make disastrous decisions as a result. Common cause sources of variation are the sources of variation that are natural and inherent to the process. Furthermore, when only they are present, the process is stable. Special cause sources of variation cause unexpected (statistically) changes. SPC easily distinguishes between the two types of variation (when applied properly).

- The charts are not usually interpreted correctly, so changes are not detected when they should have been, and vice versa. For example, the chart is actually indicating a process change, but the interpreter does not identify it. Good SPC software can prevent against this error. For example, many people do not know which pattern constitutes a trend. A "trend" is a pattern that would be highly improbable to occur if the process is stable. In order to determine whether there is a trend or not, the mechanics of probability must be applied. Other "out of control" signals also require probability computations in order to determine what patterns are and are not likely.

- Many operators believe that the SPC charts exist to monitor them personally—rather than the process. They are also fearful that if the chart identifies a change, they will be blamed. That is unfair to operators. Furthermore, if the chart identifies a change, the operator may be responsible for performing tasks which take away from normal production quotas. Finally, operators rarely have the ability to identify the causes of change since they are not responsible for supplier selection/quality, maintenance, etc.

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- Some managers think that SPC is expensive. Instead, it is the lack of SPC (and misuse) that results in damaging safety recalls, food and drug recalls, warranty costs, litigation costs, high scrap rates, angry customers, dependence on costly inspection equipment, problems in assembly, large variation in product performance (hence loss of customers), delays, and so on.

- Sometimes, plant employees want to use proper SPC, but management does not support the effort. Without the support of management, the application of SPC fails.

Problems with Chart Selection, Construction, Interpretation, and Reaction

- Many manufacturing professionals are only familiar with the control charts of the 1920's, the popular Xbar / R charts and X / MR charts. These charts were invented when production systems were far more primitive, but often, *these charts are inappropriate at managing and identifying changes that occur in modern day manufacturing systems*. There is a large variety of SPC charts available for contemporary production processes and special issues such as tool wear. There are also some efficient and effective charts for monitoring complex equipment with multiple cavities, spindles, filling heads, etc.

- Even when the Xbar chart is appropriate, inappropriate sample sizes are often used. If the sample size is too small, the process can change dramatically, but the SPC chart will not identify the change. Conversely, if the sample size is too large, the chart will constantly identify changes (or "out of control signals"), even though the products are fine from a practical perspective. For the charts to be effective, sample sizes must be specified so that the chart will detect process changes which have *practical* significance.

- A reliance on "R charts," is unwise. "R" stands for "Range," and many manufacturers rely on these charts to understand variation. The problem with ranges is that they discard most of the data and rely on the least representative data points. For example, if a sample of 10 measurements is taken, the range only uses two of the 10 values—and it ignores the other 8 measurements! The two it does use are the most subject to variation and error. Standard deviations should be used to assess variation—not ranges!

- ***How*** to physically sample for SPC is often done improperly. The proper sampling plan depends completely on the type of SPC chart being used. Some charts require "rational samples," and some require very different sampling plans. If the sample is collected improperly, the chart will indicate an extremely misleading picture.

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- Control limits can only be determined the process—not by management. Unfortunately, they are sometimes dictated—and completely irrelevant. Furthermore, when charts of individuals measurements are used, many professionals assume a Normal Distribution describes the data. Unfortunately, most manufacturing data is ***not*** bell-shaped. The erroneous assumption that data follows a Normal Distribution also leads to highly unreliable process capability estimates.

- When the chart does identify a change, personnel are supposed to determine the causes of the change. Instead, when the chart shows a change, operators or supervisors often try to make an adjustment—without knowing what to adjust or by how much to adjust. When the chart does identify a change, appropriate personnel should identify the cause of the change. Then, something has been learned—and random adjustments (which increase variation) can be avoided.

Lack of Supporting Methods for Successful SPC Implementation

- Much of the data used in SPC applications is poor measurement data. Many measurement systems do not have adequate discrimination (for example, the same 5 or 6 numbers are constantly recorded). Furthermore, many measurement systems are not repeatable (for example, the first time the part is measured, the value is X, but measure the part again, and the value will be Y—where Y might be quite different). With bad data (and it is rampant), SPC will fail. Measurement systems must be assessed and verified *before* implementing SPC.

- Plants often monitor characteristics that are not important and neglect to monitor inputs that are important. The reason is that they do not always understand which inputs and characteristics affect the product most and *should* be controlled. Efficient and effective methods such as Design of Experiments, ANOVA, and Regression may be used to which characteristics should be controlled and to specify the required degree of control.

Conclusion

When SPC is utilized properly, it enables manufacturers to prevent problems, control their production processes, and ultimately increase profits and customer satisfaction. It is our hope that manufacturers will commit to their own future by adopting proper SPC.

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