SHEWHART CHARTS & PRE-CONTROL: RIVALS OR TEAMMATES?

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ABSTRACT

The past few years have seen a debate between advocates of classical Shewhart control charts and advocates of Pre-Control. Pre-Controllers argue for their method as a replacement for costly and time-consuming X-bar and R charts. They seem to promise the world, and suggest Pre-Control is a method by which we can leapfrog over the Asian competition.

Charters find these arguments redolent with an odor usually found near docks and piers. They respond with great vigor and detailed statistical analyses of the insensitivity of Pre-Control. Replacement of control charts with this tool, they argue, will destroy all the progress we have made in understanding our processes. Instead of target-driven, stability-oriented approaches, we will return to the Dark Ages of tolerances. Instead of new heights, we will plummet to new depths in the competitive arena.

This paper examines the claims made by each side from the practitioner's perspective. Sources for further reading and study are suggested. The published supplier quality requirements of Chrysler, Ford and General Motors are examined regarding acceptance of each of these methods. The place of both tools in variation reduction and continual improvement is considered. Finally, as opposed to a rejection of classical control charts or a rejection of Pre-Control, an approach is presented which suggests the use of both tools in the manufacturing environment. "Does it work?", "Can I use it?" and "When should I use it?" are discussed for each tool. It is suggested that control charts are overused. Pre-Control is not a replacement for control charts. It is instead another tool with its own proper fields of application.

TEXT

The validity of Pre-Control versus Control Charts has been the topic of debate in recent years. While not as well-known as the so-called "Taguchi Wars," it is fair to say that plenty of heat and confusion has been generated.

Pre-Controllers:

"When Shewhart developed his theory, the concept of statistically analyzing the variation of a process in order to improve its quality was unheard of. His work was truly pioneering. He intended his book as a prospectus of the future in quality control. The preface states, "This book constitutes a record of progress and an indication of the direction in which future developments may be expected to take place". Unfortunately, as is often the case in such matters, Shewhart's prospectus has become orthodoxy for many of today's quality control practitioners."

"The control chart is yesteryear's technology....Quality professionals should give up their attachment to this horse-and-buggy relic in favor of precontrol, which is simpler, more versatile, and statistically more powerful."

"The control chart was recalled from exile and received a coronation. Its reign continues. It has been a tyrannical reign, with several original equipment manufacturers (OEM) customers, especially Ford, demanding use of the control chart as a passport to doing business with them. They force control charts down the throats of unknowing or unwilling suppliers, and bludgeon into submission those knowledgeable suppliers who dare to point out that the control chart emperor wears no clothes! And, as often happens, the royal court is filled with camp followers, hangers-on, and charlatans who exploit the desperation of companies to gain a foothold on the SPC bandwagon by offering courses, tutorials, consultations, and ubiquitous computer software programs, all dealing with the power and glory of control charts. Yet quality progress, as measured by C_p and C_{pk}, has barely inched forward in the majority of American companies, despite the widespread use of control charts."

Charters:

"We feel that this paper has no place in a newsletter whose mission statement is to foster `effective use of statistical methods for quality and productivity.' This paper represents a tool that is outmoded and long since abandoned in favor of the more appropriate technology of control charts."

"Perhaps it is appropriate to mention here the perversions of the control chart technique which attempt to establish `control limits' based upon specification limits. These perversions include PreControl.... Specification limits are the voice of the customer, and control limits are the voice of the process. Those who confuse these two voices will get nowhere."

The issues raised in the control chart/Pre-Control debate are confusing for the non-statistician practitioner. Both methods, it is claimed, work better and are statistically more powerful. Statisticians argue α and β risks, false alarm rates, etc. While important, these portions of the debate are not helpful for the non-statistician.

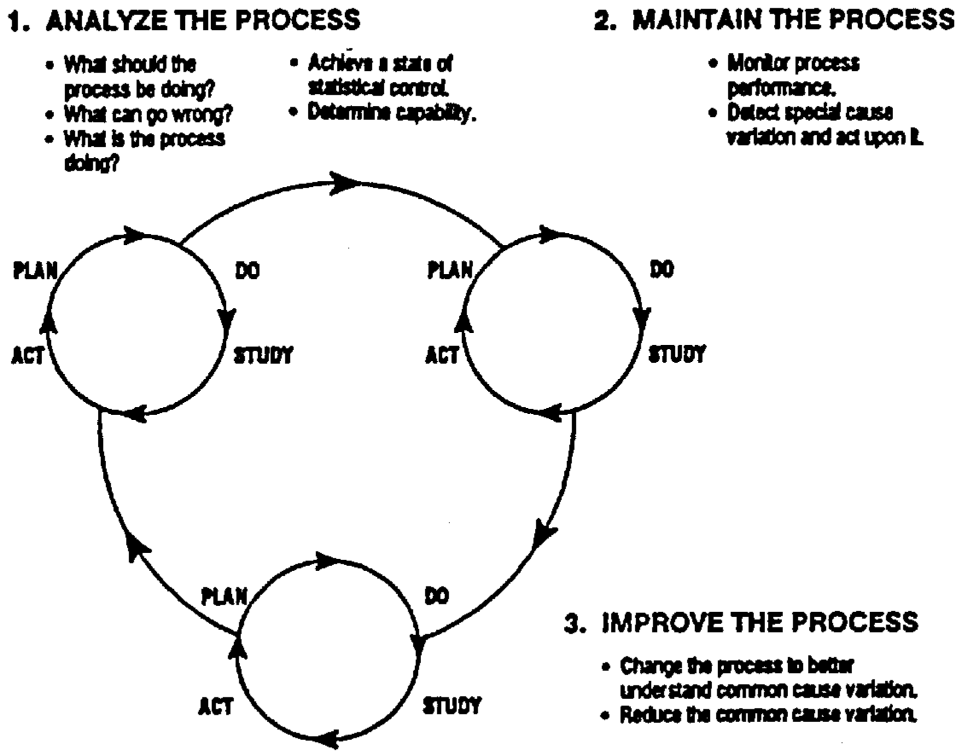
Several points should be reviewed to reach a proper understanding of these tools and their roles today. First, Dr. Walter A. Shewhart developed the control chart in the 1920s. The consultant team from Rath and Strong developed Pre-Control in the 1950s. Both techniques were developed to aid in the economic production of parts **within specification**. It was a different world than today's, when process improvement meant getting most of one's production to print.

Second, Pre-Control was developed as an alternative to control charts for short run manufacturing. That is, where the time necessary to collect the subgroups and establish control limits was longer than the operation time. Forty years later, the application of SPC to short run manufacturing continues to evolve.

Third, there exists a significant difference in philosophy between the proponents of these tools. Charters support a target oriented, loss function approach. They believe that to be competitive in the world market, an approach which continually strives to reduce variation towards zero is required. This effort should be independent of specifications and tolerances. The goal is reduced cost and satisfied customers leading to increased market share. Pre-Controllers do not agree. As Peter Shainin put it, "The idea that reduction in variation without limit constitutes improvement is a gross oversimplification. Reduction in variation is improvement only when the width of the process distribution is greater than the tolerance. If the customer wants the distribution narrower than the tolerance, the tolerance is incorrectly set." Pre-Controllers argue that endless variation reduction efforts are non-value added, and therefore increase cost instead of reducing it.

Fourth, processes and part characteristics can be separated into two distinct groups, those without and those with statistical controls. The first group relies upon operator judgment, computer controls with internal feedback, or some other technique to maintain the part or process within specification. When operator judgment is used, attributes (rather than variables) gages are often used as well.

Fifth, the Process Improvement Cycle is an aid to understanding the requirements of the second group.



The Process Improvement Cycle

Every process to which statistical (SPC) techniques are applied is somewhere in this cycle. Those processes which are being evaluated for statistical control and capability, or which have received recent improvement efforts, are at Stage 1: Analysis. Processes which have demonstrated capability and are operating "in control" are at Stage 2: Monitoring. Finally, those processes which **were** stable, but to which improvement efforts are being applied are at Stage 3: Improve. While control charts have been applied to processes at all three stages, the needs (and therefore the tools which should be used) are different.

Stage 1 processes require an SPC tool which indicates whether or not a state of statistical control exists. Stage 2 processes represent the **majority** of our SPC applications today. Here a tool is needed which will signal a change in either the process location or spread. Stage 3 processes are undergoing improvement efforts, and after these efforts, will be at Stage 1 again. Tools used during Stage 3 are those which quantify the type and magnitude of the improvement efforts. An understanding of the different needs of the process stages can result in a better selection of statistical tools, and reduced cost.

The basic difference in philosophic orientation between Charters and Pre-Controllers has led to the colorful debate and lack of a middle ground. Practitioners want the methods they promote to be successful. They want to see product within specification, lower costs of inspection, and sufficient control to ensure that customers are satisfied. Three questions need to be answered regarding each method: Does it work? Can I use it? When should I use it?

DOES IT WORK?

Debate about statistical power aside, in practice both methods do work. That is, they both will achieve what they are designed to do. The control chart remains the most sensitive technique by which to discover if a process is acting in a state of statistical control prior to determining its oped to aid in the economic production of parts **within specification**. It was a different world than today's, when process improvement meant getting most of one's production to print.

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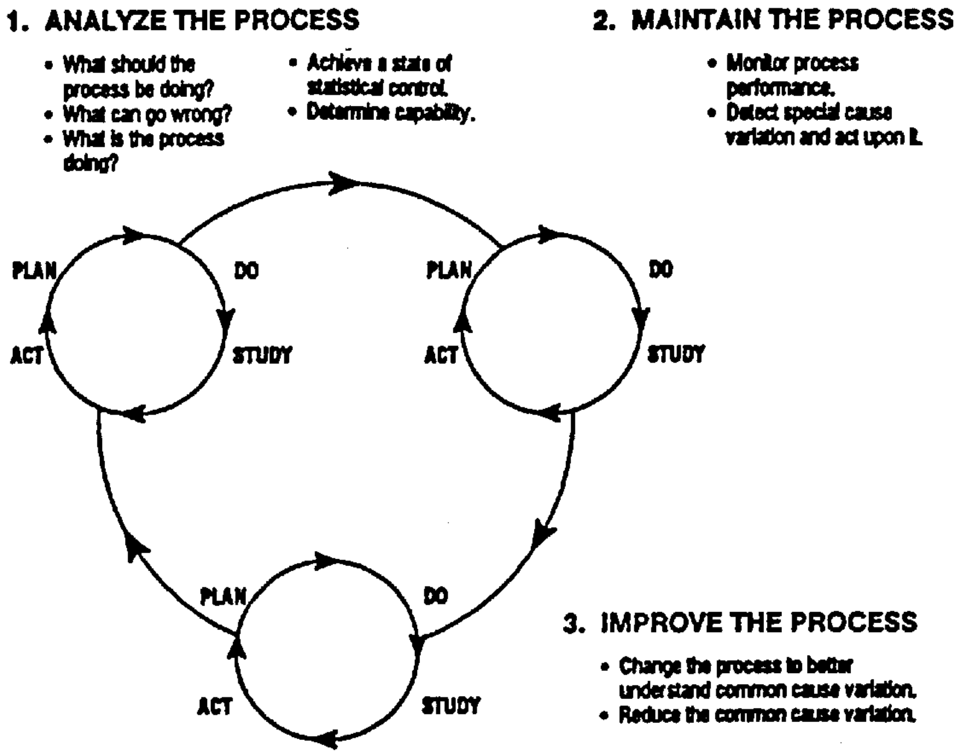

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Pre-Control, as originally conceived, is product (as opposed to process) oriented. Limits are based upon the specification, then "warning zones" are created between the nominal value and the specification limit. It gives operators a statistical tool to replace decisions based upon their experience. It qualifies a process and maintains its output within specification. Its strengths are its lack of mathematics and data recording (no physical record need be kept), the quickness with which a decision can be reached, the ease in which it may be taught, and that it allows the operator to be more intimately involved "hands on" with his process. Another strength is that it allows inspection by attributes gaging, which is quicker than using variables gaging. Its weaknesses are its dependence upon tolerances in an era which has more and more accepted the Loss Function as the proper paradigm for understanding "good" versus "bad", its dependence upon parts rather than the process, and its lack of a record for later analysis and review.

Modified Pre-Control

The paradigm of Pre-Control can be modified to **process** limits, instead of specification limits. This allows the strengths of the tool to be applied to a process which has first been qualified as in a state of statistical control. Further, the number of parts sampled can be increased to provide greater sensitivity. Gruska and Heaphy provide one such scheme. Rather than specification limits, use the +/- 3σ process values as the limits. Then move the warning limits to +/- 1.5sigma. For normally distributed processes, 87% of the process distribution will be in the central "green" zone, 13% in the warning zone and 0.3% in the stop zone. Using a sample size of 5, the decision rules become:

Step 1. Check 2 pieces.
- If both are in the green zone, continue to run.
- If 1 or both are in the stop zone, implement out-of-control reaction program, then return to Step 1.
- If 1 or both are in the warning zone, go to Step 2.

Step 2. Check 3 more pieces.
- If any are in the stop zone, implement out-of-control reaction program, then return to Step 1.
- If 3/5 are in the warning zone, implement out-of-control reaction program, then return to Step 1.
- If 3/5 are in the "green" zone, continue to run.

By modifying Pre-Control to the process limits, its greatest weakness is removed. Its strengths remain. Modified Pre-Control is another statistical tool for our consideration.

CAN I USE IT?

Customer satisfaction is an issue when using these techniques in the automotive market. Ford Motor Company, states in **Q-101** that there are "certain statistical methods that are counter-productive to the philosophy of continual improvement. These include pre-control ("stop-light" control)....**These methods are not acceptable evidence of continuous improvement.**" Neither Chrysler nor General Motors have a formal written position on Pre-Control. Chrysler's **SQA Manual** assumes that control charts will be used, while allowing the possibility of alternative methods. General Motors requires that SPC be used, but does not mandate any specific methods.

Pre-Control can be used by automotive suppliers, but it is usually not accepted as a valid SPC technique. The traditional North American automotive customers also believe that variables data is somehow superior to attributes data. This is a holdover from a decade ago when it was necessary to demand variables data so that a process could be **qualified**. Ford requires variables gaging for SPC. An attributes data approach can be applied to process, rather than specification, boundaries. Data need not only be in specification/out of specification, but can also be within or without the 6σ process. Suppliers who desire to use Pre-Control or Modified Pre-Control (with the three-zone gage approach) should be prepared to defend the practice to customer supplier quality representatives. There are situations where techniques such as Pre-Control are proper, and defensible. It is the role of the supplier to educate the customer in these situations.

WHEN SHOULD I USE IT?

For those part characteristics which rely upon operator judgment (no statistical controls are applied) using Pre-Control can reduce variation. Initiation of Pre-Control would represent an improvement in control of the process. It should be limited to those characteristics which do not require SPC. The division of the tolerance into three zones (instead of the more usual two) gives the operator greater insight into the part/process behavior without added cost. Pre-Control can allow the operator to do a better job without adding to his workload significantly.

For those part/process characteristics which have SPC applied, the location on the Process Improvement

Cycle should be determined. The control chart continues to be the tool of choice for process analysis (Stage 1). Of possible control charts, the sensitivity of the X-bar/R chart makes it the tool of first choice. Processes undergoing specific improvement efforts (Stage 3) may also use control charts. Other tools, such as analysis of variance and designed experiments, are currently in the limelight, but the comparative simplicity and graphical nature of the control chart assures it of continued use for understanding how improvement efforts have affected the part or process.

Relatively few SPC applications are on parts and processes at Stage 1 or Stage 3. Stage 2 processes account for the majority of our SPC efforts, and the control chart is not the only tool of choice in this situation. Parts or process, in a state of statistical control, traditionally are monitored to discover evidence of special cause(s) which affect the process location or spread. Where the process C_p/C_{pk} is higher than some critical value, such as 2.0, the need for quick reaction to special cause(s) is greatly reduced. Processes with a high C_p/C_{pk} should have different reaction plans to out-of-control conditions. They need only be monitored to indicate large shifts in the process average or spread. For these processes, Modified Pre-Control is a less expensive tool than control charts.

CONCLUSION

Pre-Control can be on the same team as control charts. The Process Improvement Cycle should be used to analyze at what Stage the control effort is. Based upon how much control is needed, the proper tool can be selected.

In the early 1980s, implementation of SPC was judged by control chart effusion, rather than effectiveness. In the 1990s, correct use of SPC is judged by more sophisticated standards. But the existence of a myriad of control charts is still considered evidence of proper and aggressive implementation of both SPC and the continual improvement philosophy. Removing a control chart is often viewed as a lack of commitment to quality.

Control charts should be used primarily as a tool for problem solving, not process monitoring. Once proper and adequate controls are developed for a process, it is should be periodically audited, and the control charts removed. The supplier must be prepared to educate his customers regarding the Process Improvement Cycle and its implications for statistical tools. Replacement of control charts with other monitoring methods, such as Modified Pre-Control, will allow more cost efficient operation of our businesses. In addition, those processes which are charted will be more visible, as they should be.

Continual improvement requires the reduction of variation across the entire business. It needs to be seen as a spiraling upward of the entire organization. Removal of unnecessary control charts will allow suppliers to focus on those processes which need the attention of that tool. Cost efficient application of statistical methods requires that Pre-Control, Modified Pre-Control and other methods be allowed on the roster. They really should be teammates, not rivals.

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