

# Moving to a fourth generation: SPC that lets you do your work

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## Abstract:

This paper reviews the ways in which process control technology has moved historically from earliest techniques to the use of new technologies, and introduces the “fourth generation” of statistical process control (SPC) in a new monitoring product that changes the way SPC is done.

## Background

With several generations of SPC technology under our belts, it may be time to rethink how we apply SPC in the 21<sup>st</sup> century. Basic techniques have been practiced since the 1930s. Some companies will soon be able to say “we’ve been practicing SPC for a hundred years!” Since the time that Walter Shewhart first proposed the techniques, these have been widely deployed.

Over the years, there have been improvements in how SPC is used. Some of this improvement can be attributed to changes in technology. When personal computers and software arrived, the tedium of manual calculations was reduced. When databases came into the picture, it became easier to organize and find data gathered for SPC. When the Internet arrived, it became easier to share and publish SPC information.

Despite the improvements, our current approach to SPC is ripe for an overhaul. A combination of technology improvements, organizational changes, and a more systems-based mindset among companies has set the stage for the next leap forward.

Before thinking about that leap, it is instructive to consider how the use of SPC has evolved. While none of this may be new information, it is important to view the sometimes small changes that have moved SPC forward and to understand the “big picture” of statistical process control.

## 1<sup>st</sup> Generation SPC

When control charts were introduced, humans did all the work; they did it all manually, using pencil and paper. The process began by identifying an important quality metric. Next, a set of data was gathered from production, using a sampling plan. For example, three pieces were measured every 30 minutes with the values dutifully recorded on paper. When enough data had been gathered, a set of control limits was calculated, by hand, using pencil and paper. The limits were transferred onto graph paper and the data points were plotted. Out-of-control points were studied, assignable cause variation was removed, and limits may have been re-calculated. Eventually, a chart on graph paper was posted and samples began to be plotted directly on the chart. As new samples were plotted, operators were taught to look for out-of-control conditions and trends.

- **What humans had to know:** Basic math skills, basic understanding of variation, basic SPC knowledge, how to use a formula to calculate values, SPC chart interpretation.

- **What humans had to do:** Record data on paper; make calculations on paper, plot data on graph paper, interpret control charts for out-of-control conditions, and make process decisions based on interpretation of the chart.

**Challenges:** Pencil and paper data entry and calculations are tedious and error-prone. The chart and the data are available only locally and only by direct process workers. The quality of the chart interpretation varies based on the training and skills of the individuals involved. The history of control chart activity, which could also be described as the “previous learning” of a control chart, is not easily stored and reviewed—except by someone who likes file cabinets. The time-consuming nature of SPC charting puts a limit on the number of metrics that can be monitored.

## 2<sup>nd</sup> Generation SPC

In the early 1980s, personal computers and software became popular. When companies saw the benefits of using word processing and spreadsheet software, it was not long before they sought software to help in their SPC work. The early SPC programs all shared several traits. They allowed the user to enter, save, and retrieve data from quality metrics. They did the basic statistical calculations for the user. They displayed charts of this data automatically, reducing the need for graph paper and manual charting. These programs tended to store data in a proprietary way that was convenient and efficient for the program to manipulate.

- **What humans had to know:** Basic computer skills, basic understanding of variation, basic SPC knowledge, SPC chart interpretation. Also, it wasn’t a bad idea to know how to back up data files!
- **What humans had to do:** Record data in the computer; interpret control charts for out-of-control conditions, and make process decisions based on interpretation of the chart.

**Challenges:** The data gathered for SPC tends to be captive to the program where it has been entered. Since some SPC software is difficult to use, incorrect application of SPC may ensue. The software can do more than paper and pencil systems, leading to a proliferation of new analytical choices that might be made incorrectly. Data files are easily lost or deleted because backup systems are not yet widely deployed. The quality of the chart interpretation varies, based on the training and skills of the individuals involved and on how correctly the software and charts have been configured. Data and charts are still primarily used and available only locally – where the data originates. The time consuming nature of SPC charting puts a limit on the number of metrics that can be monitored.

### 3<sup>rd</sup> Generation SPC

In the 1990s, computers began to be tied together into local area network (LANs). Computers also started to become “easier to use” because of graphical user interfaces, mice, and more standardized looking and acting software. Database programs became more widespread and started to be used as consistent storage of data for different kinds of applications. These trends had an impact on the new versions of SPC software released at the time. They were developed with graphical interfaces and they tended to store data in a database rather than as proprietary files. Additionally, this data could now be shared across the network, allowing users on multiple computers to gain access.

- **What humans had to know:** Basic computer skills, understanding a computer network, basic understanding of variation, basic SPC knowledge, SPC chart interpretation, graphical user interfaces and basic database technology.
- **What humans had to do:** Record data in the computer; interpret control charts for out-of-control conditions, and make process decisions based on interpretation of the chart.

**Challenges:** The number of choices available to the user in the software is increasing in this third generation. This can lead to problems of misapplication of SPC and general confusion among software users. The quality of the chart interpretation varies, based on the training and skills of the individuals involved and on how correctly the software and charts have been configured. More metrics can now be tracked, but there is still a human bandwidth issue.

### Summarizing the first three generations of SPC

	Human must know...	Human must do...	Problems...
<b>1<sup>st</sup> generation SPC</b>	Basic math, computations, chart plotting, SPC, chart interpretation.	Plot charts by hand. Interpret chart. Act on interpretation.	Error prone. Data and charts are only local. Reviewing, storing history of charts is difficult. Number of metrics limited.
<b>2<sup>nd</sup> generation SPC</b>	Computer skills, data entry skills, SPC, chart interpretation.	Computer data entry. Interpret chart. Act on interpretation.	Data captive to program. Data is easily lost. Data and charts are only local. More analytic choices – misapplication. Number of metrics limited
<b>3<sup>rd</sup> generation SPC</b>	GUI skills, basic database knowledge, LAN knowledge, data entry skills, SPC, chart interpretation.	Computer data entry. Interpret chart. Act on interpretation.	More and more analytic choices; confusion. More metrics possible, still human intensive for interpretation.

You might notice that what the human does has not changed. The tools may be different and the calculations are more accurate, but the basic workflow has not changed. First-generation computer systems often mimic, almost to a fault, the manual systems they are designed to replace. Rather than rethink the problem, it is easier to re-use the original thinking and create a computer solution that does the same thing.

Here is a question: How many quality metrics could a third-generation SPC user keep track of, compared to an SPC user trained by Walter Shewhart himself? This is obviously rhetorical and today’s SPC user probably *can* track more metrics – but it is not a huge difference. Today’s SPC systems still require significant human interaction, and the number of metrics we can track is not nearly as large as the number we *might like to track* given enough resources.

Now, before you get all “Luddite” on me, let me say this: the goal is not to take jobs away from people. The goal is to free people who are doing mundane, repetitive work so they can concentrate on more value-added work focused on keeping the customer happy and loyal to whatever product or service is provided.

## 4<sup>th</sup> Generation SPC

You won't find a definition for fourth-generation SPC on the NIST website. If you Google long enough, it will show up somewhere. There is nothing official about this; the name is just a way to think about and discuss how SPC might make the next leap forward.

Let's start by describing some things in today's computing environment. A key fact is that **data is flowing into databases**. This is happening on an unprecedented scale. The data is flowing from many different sources. It comes from ERP systems such as SAP. It comes from plant automation systems like those available from Rockwell Automation. It comes from LIMS systems such as Labworks. It also comes from various systems developed in-house. The data might be collected by automated systems or it might come from users typing into enterprise or web-based applications; the source is not important, but that fact that all this data lands in a relational database is quite useful. Much of this data ends up in Microsoft SQL Server, Oracle, IBM, or MySQL databases.

Data in relational database is accessible. This accessibility can be configured to be local, plant wide, intranet wide, or even worldwide via the Internet. There are many database query tools available and many applications are capable of asking these databases for data. This data can be used for reporting, analysis, decision making, and yes...even for SPC.

Another factor in today's computing environment is that people are connected and have a variety of ways to communicate instantly. Email, text messaging, social networking, and the Internet in general have greatly enhanced communication among employees. This is creating new opportunities for quality improvement across barriers that were previously insurmountable.

Any self-respecting fourth generation SPC system will take these factors into account. Rather than mimic the paper-based systems of the past, 4GL-SPC should leverage today's technology to expand SPC benefits by an order of magnitude.

### Features of 4<sup>th</sup> Generation SPC

In a fourth-generation SPC system, the analysis is separated from the data collection and data entry. Today, to know if a point is out-of-control on an X-bar chart, a common approach is to start by either entering the data or importing the data into an application that can make X-bar charts, and then displaying the chart and looking at it to see if a point is out-of-control. Imagine that this data originated from a weight sensor in the plant and was stored in a database. Why not leave the data in the database and just think about it with SPC software?

We pay attention to metrics because we want to know as soon as possible when a quality issue begins to develop. In today's SPC paradigm, we check a chart at some regular interval – say hourly, daily, or weekly. Often, the chart will show no signal. In other words, everything is all right. That is great news, but you have just used a few minutes of valuable time for no reason. Imagine that the system could just tap you on the shoulder and say “Hey...you might want to check on the chart for weight.” It would do this only when a significant signal is detected. Now, rather than being able to track, say, 10 charts, you can potentially be kept aware of hundreds or thousands of charts. The main feature here is that the task of

interpreting charts for out-of-control conditions has been delegated to the computer. In previous generation SPC systems, this has always been a job for the human.

A fourth generation SPC system should also communicate with you. It should do this even when you are not near the computer or actively running a specific program. After all, the computer knows when new data arrives in the database. It can also know how you want to analyze the data. So when it discovers something important, it should be able to tell you about it. Most people carry cell phones and use e-mail, so these are logical channels for the fourth generation SPC system to use.

Much of the technology needed to create fourth generation SPC exists. Clever integrators are already starting to deploy these systems. Is it time to rethink your approach to SPC?

### **Summary**

We have been applying SPC using a similar approach for a long time. This approach is limiting the number of quality metrics that can be tracked effectively because it is human resource intense. It's time for a new and innovative approach to SPC--a fourth-generation approach. This approach should expand by an order of magnitude the number of quality metrics we can track. It should do this without a significant increase in costs and it should leverage today's database and instant communications technology. Fourth-generation SPC should create an accelerating virtuous cycle of improving quality and reducing costs.

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