Process Behavior Charts as Report Cards

The first of six uses

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The simple process behavior chart can be used in may different ways. Since report card data are common in all types of businesses the report card chart is often the first chart that people create. Some of the pros and cons of report card charts are covered here.

Report card data are data that have been created to track various aspects of a business or operation. They may be measures of activity (commonly expressed in dollars or volumes). Or they may be measures of satisfaction, of quality, of inactivity (such as wait times), or measures of performance compared to a standard or budget. In each case they attempt to summarize some aspect of an operation over the past time period in a single number. Thus, the essence of every report card number is to aggregate and summarize so as to provide the big picture.

As an example of a report card chart I will use an example from my mentor, Professor David S. Chambers, who was working with a medium-sized hosiery mill. This mill employed about 1500 workers and a reputation as a quality mill based on careful 100 percent inspection that graded the output of the plant into First, Irregulars, Seconds, and Rags.

In spite of this reputation the mill faced a real problem. Since workers were paid by the piece, each worker had to process a certain number of pieces per week in order to earn the minimum wage. If a worker's output did not exceed the minimum wage amount the company had to make up the difference. With a pending increase in the minimum wage, the managers realized that it would be nearly impossible to operate with the current equipment and technology without making substantial "make-up" payments each week. Some way had to be found to increase income in spite of a soft market and stiff competition.

The obvious solution was to change the mix of Firsts, Irregulars, Seconds, and Rags. By making more Firsts, and less of the other grades, revenues could be increased without increasing the costs. Operators would also benefit since a penalty system for bad work was in effect (each worker was docked two good pieces for each bad piece found at final inspection).

After consultation with David Chambers, the president decided to send about 20 of his supervisors to an SPC class at the university. After this course David sat down with the supervisors and helped them plan how to use SPC in the plant. Due to the nature of the work, and the enthusiasm of the supervisor, they decided to begin with the thirty loopers in the looping department.

The looping operation closed the toe of a knitted hose. It was a tedious operation, requiring the operator to thread the toe of the stocking onto a comb-like device called the looper dial. Exactly one thread from each side of the stocking had to go into each gap between the teeth of the

looper dial. A missed gap would create a hole in the finished stocking, and placing two threads from the same side in one gap would create a pucker. After the stocking was threaded onto the dial, the end was trimmed. If it was trimmed too long, the seam would be bulky which would result in a downgraded stocking. If it was trimmed too short, the stocking would fall off the dial and the operator would have to start all over again. Since they were paid by the piece, the loopers considered this to be "bad form." After being trimmed, the toe of the stocking was stitched by the looping machine, and the finished stocking was placed in the looper's production box.

To collect some data an inspector was brought into the looping department from the boxing room. This inspector would inspect four consecutively looped stockings from each operator four times each day. In this manner, sixteen pieces were obtained from each operator during the course of each day. The inspector was given a different randomized order for visiting the operators each day in order to prevent them from "loading" the output box. The inspector recorded the type and number of defects found, by operator, and the records were kept on a historical basis during the months of June and July.

During June and July no conscious effort was made to improve the process. The objective was merely to measure the quality of the looping work. Individual records were combined into a departmental record for each day of the two-month period. The departmental average amount of defective work was 4.8 percent for those two months. David Chambers created the *p*-chart for the department shown in Figure 1. (The limits shown were based on the average number of pieces examined each day.)

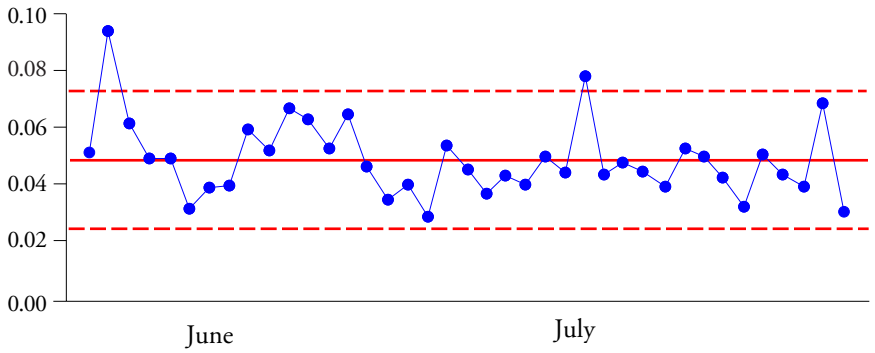

Figure 1: *p*-Chart for Looping Department during June and July

The *p*-chart in Figure 1 shows a fair degree of predictability with only two points outside the limits. The first point outside the limits was expected since there had never before been an inspector located in the department. The presence of a person taking work from a machine, and inspecting it on the spot, was very upsetting to the loopers. When the inspector showed up on the second day the loopers were in such an uproar that it was necessary for the supervisor to tell them that the company was cooperating with Professor Chambers in gathering some "real" data for class use and that their jobs were not threatened. This explanation seemed to reassure them.

The second out-of-limits point had a different cause. It was the custom in the hosiery industry to shut down for a week-long holiday around the Fourth of July. The second point outside the limits occurred on the Monday following this mid-summer holiday.

The chart in Figure 1 was explained to the Vice President for Manufacturing in the following manner. The conditions in the looping department were described as being relatively predictable. Assuming that no changes were made, about 5 percent defective product would be produced weekly.

Upon hearing this the Vice President swore that the company could not continue to operate with 5 percent defective products in looping—the company would be closed within six months under these conditions!

Of course, he had not previously known what the defect level was in the looping department, nor in any other particular department. The only record ever kept had been at the final pairing and boxing operation. No one had ever known just how bad things really were in the various departments even though the company had been in operation for 65 years.

Since the Vice President was dissatisfied with 5 percent defectives in the looping operation, he was asked what a "good" level would be. After reflection, he replied that a good operation would produce "no more than 2 percent defectives." Of course, statements of this sort tend to become targets or goals, and this proved to be no exception. However, since goals do not provide the means to improve the system they can easily lead to the distortion of both the data and the system itself. Fortunately, in this case, they already had an action plan for process improvement.

The consensus was that the optimum method of improvement was to work individually with each operator who needed help. Accordingly, the previously-collected data were used to create and maintain an ***np***-chart for each worker, starting with the June-July period. (Since these data were considered to be personnel records, a secretary in the personnel department actually kept these *personal* process behavior charts.) Rather than computing limits for each worker separately, the departmental average of $p = 0.048$ was used with the daily number examined of $\mathbf{n} = 16$ to obtain a central line of 0.8 and an upper limit of 3.4 for use with these ***np***-charts. These charts readily showed which loopers could be classified as good, average, or poor workers.

These charts were reviewed with the department supervisor, who then worked with each operator as part of the improvement effort. Beginning in August, the supervisor sat down with the operators, one at a time, and showed them their personal chart. The operators were told that if their work was average they should have no more than three defective pieces out of sixteen. Four or more defectives was worse than average, and zero defectives was better than average. (Although employees were only shown their own charts, everyone seemed to know how everyone else was doing within 10 minutes of their reviews—the news traveled at the speed of sound!) Along with these charts a follow-up effort was made to study work habits and correct deficiencies. The effect of this program was almost immediate. Some of the case histories follow.

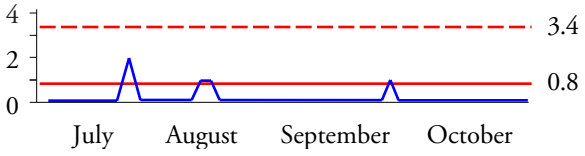

Figure 2: *np*-Chart for Operator 75

Operator 75 was an excellent operator. As the supervisor watched her he noticed that she

was using a different technique for loading the looper dial than they were teaching in the training room. When the supervisor got Operator 75 to teach her technique to others, everyone benefited.

Operator 22 was much worse than average in July. After observing her at work, the supervisor referred her to the personnel department for a possible eye examination. Upon examination, the doctor found that she was blind in the left eye, and only had 6/20 vision in the right eye. The vision in her right eye was correctable to 20/20, and with new glasses, her work immediately improved. After all, she could do the job blind!

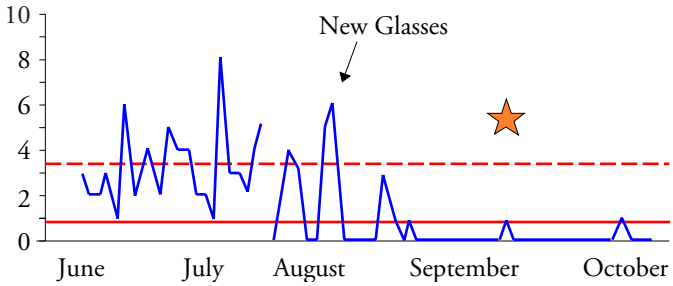

Figure 3: *np*-Chart for Operator 22

New glasses helped Operator 22 increase her pay by over 15 percent. At the same time, she increased her quality sufficiently to become a "Gold Star" looper. (The basic requirement to become a "Gold Star" looper was to produce no more than three mendable defectives per month. Being a "Gold Star" looper was a considerable honor, and those who lost this rating worked hard to regain it the next month.)

This experience also caused the company to reconsider its lack of policy regarding eye exams. It finally mandated periodic vision examinations for all operators. The initial group of examinations revealed additional operators who had real difficulties in seeing well enough to do their work.

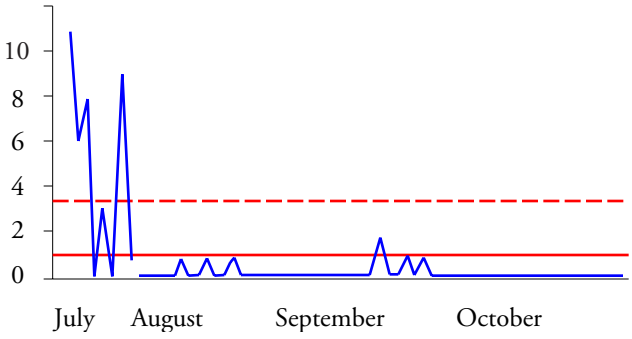

Figure 4: *np*-Chart for Operator 27

Operator 27 seemed to be the least capable operator during the analysis period. When the supervisor discussed her chart with her, and explained the quality improvement program, her response was: "Why, I've been here for five years, and this is the first time anybody has told me they were interested in good quality. I can do a much better job, if it makes any difference." Her

record in August, and thereafter, attests to the accuracy of her statement.

The record of Operator 106 deteriorated between June and July. She had been moved from the training room to the production line in June. Beginning in July she was pressured to improve her production in order to minimize the make-up pay. In response to this pressure she had increased production and she had also increased her proportion of defective stockings!

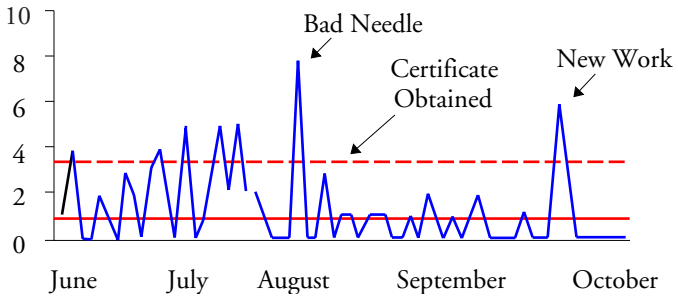

Figure 5: *np*-Chart for Operator 106

As the supervisor searched for an explanation for her poor performance, he found that her personnel record noted an impairment in her right arm. This impairment made it difficult for her to load the stockings on the looping machine, thus slowing her down. By obtaining a "Handicapped Worker's Certificate" from the U. S. Dept. of Labor the supervisor could exempt her from the minimum wage. This removed the pressure to produce more, and allowed her to produce a higher percentage of good pieces. Following this exemption her only bad day occurred when she had to adjust to a new type of knitting.

In spite of these successes, it was the case of Operator 73 that ended resistance to SPC in the plant. Operator 73 was in her early sixties and had been looping for ten years. During June and July her production had either been up or down, very bad or very good, with nothing in between. The supervisor worked with her during August and noted some improvement. In September she decided that new glasses might help, but the chart shows no evidence of improvement.

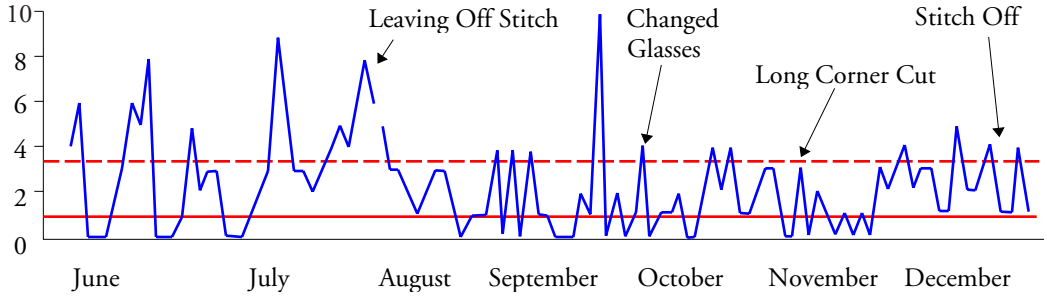

Figure 6: *np*-Chart for Operator 73

By October it was apparent that she had improved as much as possible. When compared to other operators during the same time period, her work was indeed poor. Although the supervisor did not think that she could do any other job at the plant, he was reluctant to

terminate a ten-year employee. So he decided to give her more time.

She did no better. During November she contributed 20 percent of the defectives for the whole department! By that time every looper knew that everyone except Operator 73 had improved. The other loopers began to resent the effort they had made when nothing seemed to be done about the poor work of Operator 73.

As the loopers continued to ask questions, the supervisor finally advised the personnel department that something had to be done. "Old 73" was disrupting progress, and requiring more and more of his time. So the managers reluctantly agreed to retire her at the end of December.

At the company Christmas party it turned out that "Old 73" won the first prize—an expensive electric range—in a "random" drawing. Near the end of the year, she was informed that the company could no longer use her, and that arrangements for a suitable pension had been made. When told of this "Old 73" was neither surprised, nor dismayed. She said, in fact, that she had known for 10 years that she could not loop well, and could not learn how. She was ten years ahead of management! She left with a good attitude, realizing that the supervisor had done everything possible to help her improve her performance.

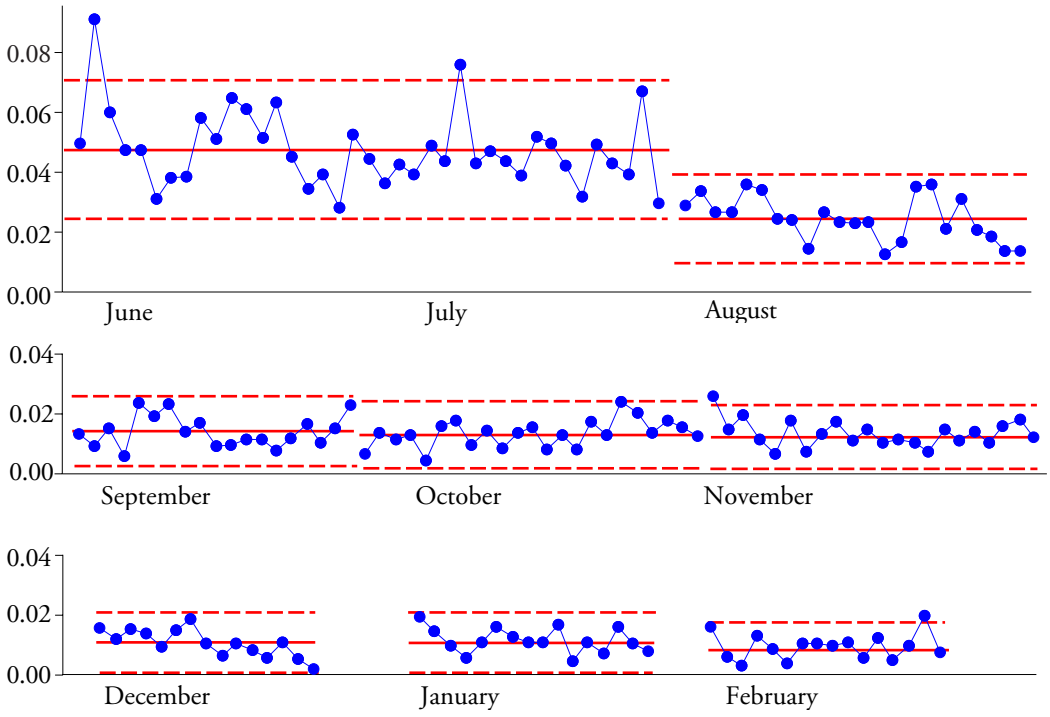

Figure 7: Report Cart *p*-Chart for Looping Department

The report card *p*-chart in Figure 7 shows how the looping operation improved. In the first month, the percentage of defective pieces dropped from 4.8 percent to 2.4 percent. In the following months, it rarely rose above 2 percent. By February, it was down to an average of 0.8 percent. Thus, in seven months, they reduced the number of defective pieces produced by 83 percent and increased the yield of the looping department.

While the report-card chart shows the improvements in the looping department, it was the individual charts that allowed the supervisor to help the workers do their jobs better. The report card data allow us to see the big picture, but it is only as those report card data are disaggregated to the level of operations and kept closer to real time that they become useful in finding the problems so that improvements can be made.

The more highly aggregated the number, the less specific it will become regarding particular portions of your operations. Likewise, as a number is used to summarize longer time periods it will become less timely with respect to the operation being tracked. Report card numbers may provide the big picture, but as data are aggregated into a report card measure their noise will also be aggregated at the same time. Consequently, all report card measures will be full of noise. This will make them appear to be more predictable than their individual components will be. As a result it will always be harder to detect a signal with report card data than with the components of the report card measure. This is why we generally find that improvement only becomes possible as the report card data get broken down into local data that are kept in real time.

So putting your report card data on a process behavior chart is only the first step in using the charts for continual improvement. While report card charts can be useful in telling the story, they are rarely specific enough to facilitate process improvement.