# Statistical Process Control can pay dividends

*by Jim McConchie*

Statistical Process Control involves sampling the production from the process, comparing the data to a standard (ie drawing or specification), determining the causes of any problems, and taking corrective actions.

The most important point to understand is that no two things can ever be made exactly alike, just as no two things are identical in nature. The key to success in manufacturing is to understand the causes of these variations and to have a method of displaying them.

In the past this involved employing quality control inspectors to measure the variations and record them against date and time. The sample was usually of three to five products and the dimension under scrutiny was recorded onto data sheets, then averaged and the difference between the smallest and largest reading was calculated.

The average was plotted against time to give an X/bar chart and the range also against time on a separate chart to give the R chart. These charts showed if any trends were developing, caused by tool wear or variations in the process.

Upper and lower control limits were also calculated for the collected data and compared to the upper and lower specification limits to determine if the process was in control or not. The standard deviation was calculated and used in capability studies and a histogram plotted showing the normal distribution of the process.

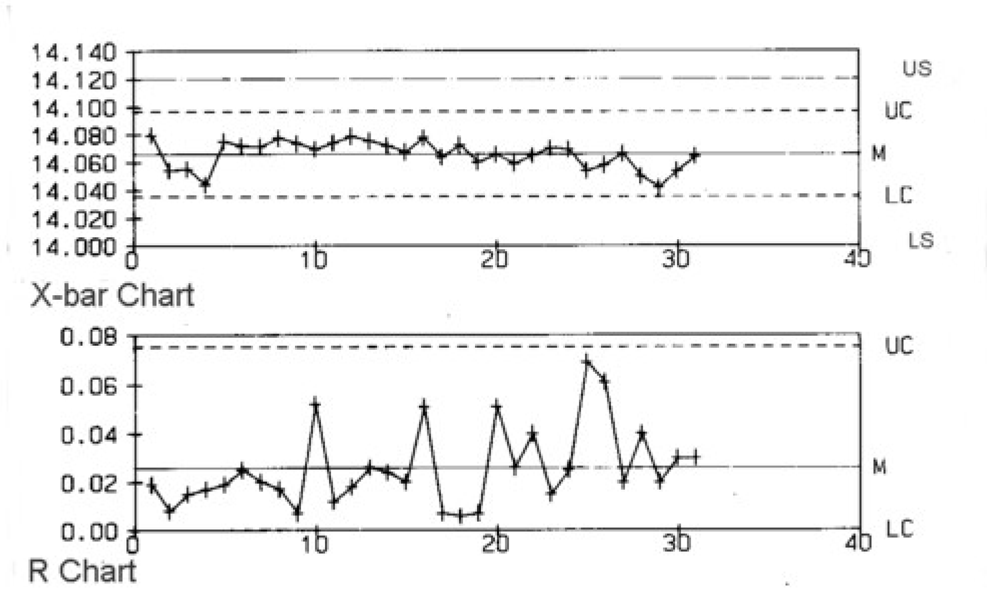
All this was very time-consuming and required very thorough training to be able to perform the calculations, accurately plot and understand the results, then make the necessary corrections.

With the introduction of computerisation this mundane data collection, calculation and plotting is all done in seconds as the data is entered into the computer, either automatically or manually from a data sheet.

Whether the data is collected via computers or by the manual process, the basic concepts and control charts are still the same. The following charts are examples of the type of charts which are used to display the results:

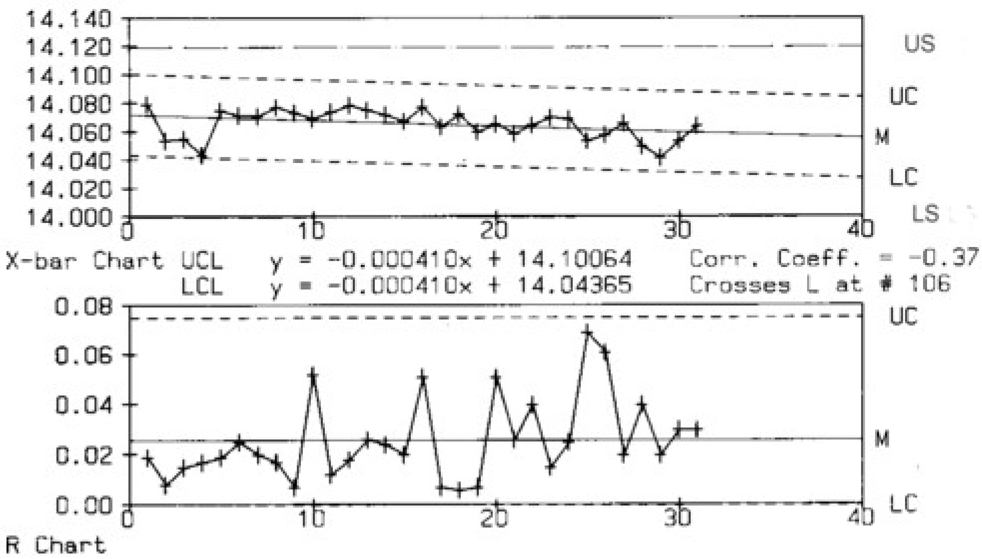
**Control Chart:**

The normal control chart is X/bar and R, which is the average of the sample and the difference between the biggest and smallest reading of the sample - plotted against the number of samples. The alternative control chart is X and MR, which is each reading and the difference between successive pairs of measurements -plotted against the number of samples.



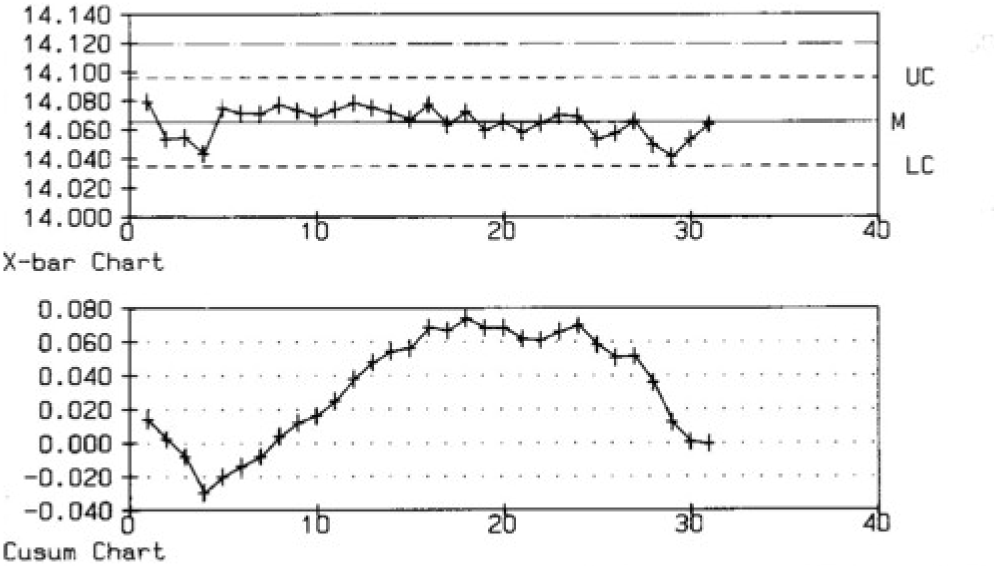

**Trend Chart:**

This is a control chart which is corrected to show the trend and shows the effect of tool wear. By calculating the mean and control limits as a slope it is possible to determine the initial settings and length of run that will give the maximum period between machine settings.



**CuSum Chart:**

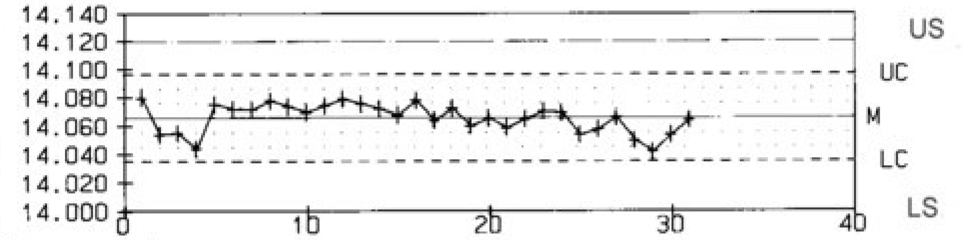
This chart is very sensitive to sudden shifts in the process. The chart shows the cumulative sum of the variation of each subgroup average from the grand average.




If control charts show that the collected data is running between the upper and lower control limits, then the process is deemed to be in control. If not in control the other charts are used to determine what is going wrong and the process is corrected.

**Run Sum Chart:**

Provides extensive analysis of runs and trends in the process.




X-bar Chart

| | | | | |
|---|---|---|---|---|
| In Control | 31 | 100.00% | 7 in a Row on One Side | 6 |
| Out of Control | 0 | 0.00% | 7 in a Row Inc. or Dec. | 0 |
| Above Mean | 18 | 58.06% | 2 of 3 Above +2SD | 0 |
| On Mean | 0 | 0.00% | 2 of 3 Below -2SD | 0 |
| Below Mean | 13 | 41.94% | 4 of 5 Above +1SD | 0 |
| Zone A | 2 | 6.45% | 4 of 5 Below -1SD | 0 |
| Zone B | 9 | 29.03% | Longest Run | 12 |
| Zone C | 20 | 64.52% | Highest Run Sum Above Mean | 3 |
| Quadrants 1&4,2&3 | 22 | 8 | Lowest Run Sum Below Mean | -4 |
| Number of Runs | 12 | | Run Sums Exceeding 4 | 0 |

**Process capability study**

Process capability studies are performed to determine the inherent reproducibility of parts created in a process and hence can show whether or not the process can meet specifications. In addition, the study can also provide estimates of the percentage of defective parts that can be expected.

Ideally the process should be in control as determined by the above methods of data evaluation. The process should not be altered during the period of time that the data is collected. This data is then used to evaluate the process capability.

The practical usages of such a study are numerous, and include the following:

• Evaluating new equipment purchases.

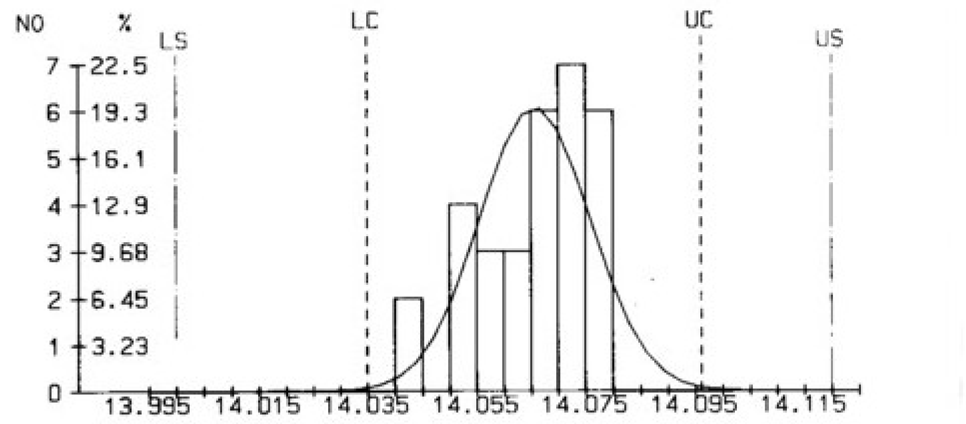
• Predicting whether design tolerances can be met.

• Selecting the appropriate machine for the job.

• Setting specifications.

• Costing out contracts accurately.

The histogram is the basis for all capability studies:




| | | | | | |
|---|---|---|---|---|---|
| #Samples | 31 | In Spec Act. | 100.0000% | Cpk | 1.78 |
| Chi-2 ACCEPTED | 1.97 | Below Spec Act. | 0.0000% | Cp | 1.96 |
| Skewness | 0.65 | Above Spec Act. | 0.0000% | PC 6 | 51.0% |
| Kurtosis | -0.44 | Ind. SD ( RMS) | 0.0102 | PC 8 | 68.0% |

The histogram can be drawn for individual readings X or the average of the subgroups X/bar The normality (chi-square, skewness, kurtosis), and capability indices (Cp, Cpk, PC, PP) and predictions of product out-of-specification shown under the graph can all be calculated from the collected data with a scientific calculator or automatically in computerised data collection.

The data is normally shown as vertical columns, grouped to represent the number of readings for that particular size. A curve is then drawn to encompass the bars and show the normal or abnormal distribution of the data as a visual aid to show how the process is shaping up. Only a quick glance is needed to get a good idea of how the production is going.

CP - is a capability index defined by the formula

CP = Tolerance

6 sigma

Sigma = the standard deviation of the collected data.

The CP may range from zero to infinity, with the larger value indicating a more capable process. If the CP is greater than 1.33 the process is capable, between 1.00 and 1.33 it is capable but should be monitored, and less than 1.00 the process is not capable.

CPK - is an index combining CP and the difference between the process mean and the specification mean. If the CPK and CP are equal, the process is centred on the specification mean. If less than one, the process is not capable. Conversely if the CPK is greater than one the process is capable.

CPK = the lesser of:

(Upper Specification - Statistical Mean)

3 sigma

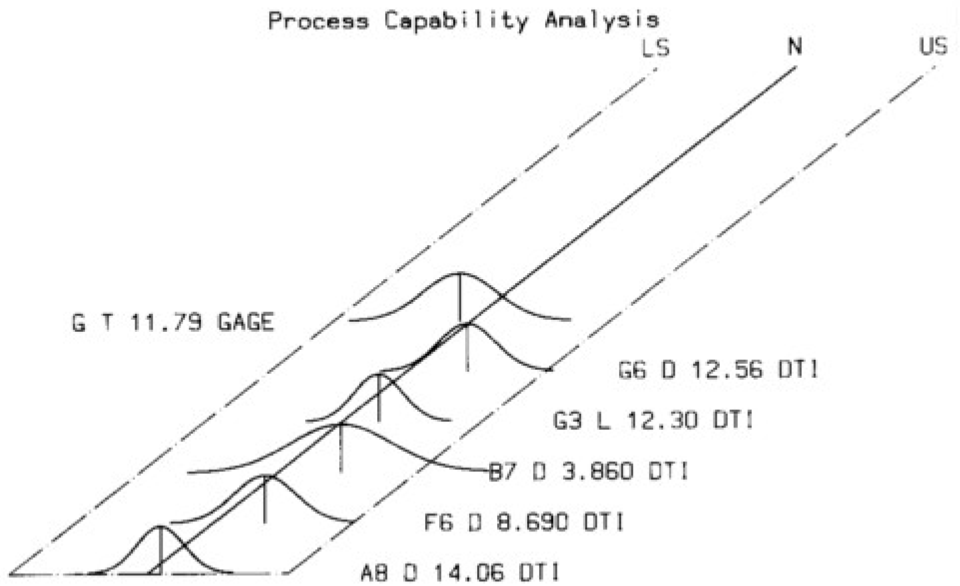
or

(Statistical Mean - Lower Specification

3 sigma

Multiple Capability Charts are a very useful tool to show at a glance how the total process is going. This requires that the individual histograms are rescaled so that there is a common mean, with upper and lower specification limits on common lines:

For manually collected data this is tedious, but with computerised data it's a breeze.

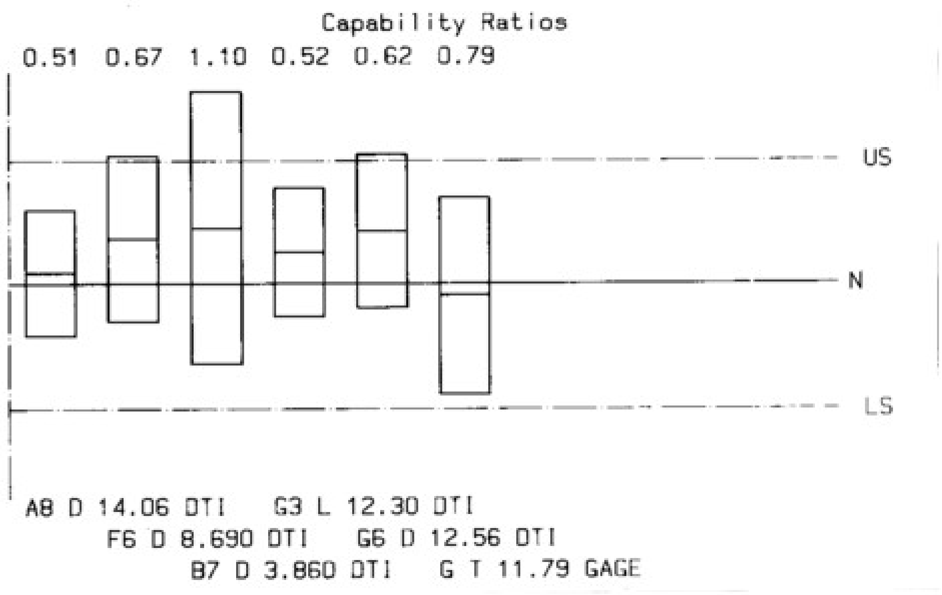



Although the above analysis has been made easier and many times faster by computerisation, the results are only an aid to improving or maintaining the process. The operators who actually look after the process need to have some training in how to understand the results and what to do to achieve the best production from the process. It is up to them to make quality products the first time, and by understanding what is happening when a problem occurs scrap is kept down to a very low level.

Other charts used to show the process capability is:

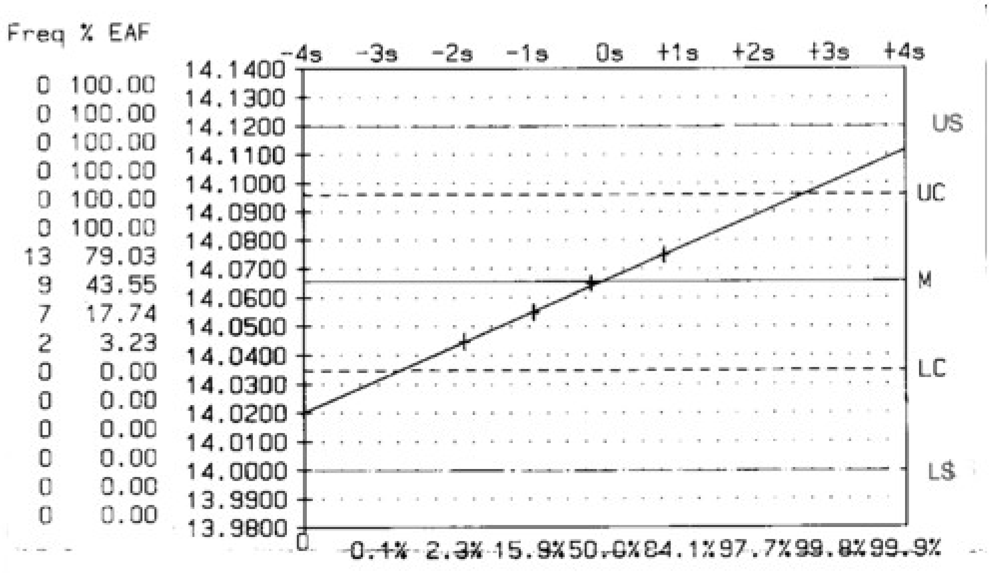
**Capability Ratio:**

This is the inverse of the CP




**Capabililty Analysis Chart:**

This is a short term study that helps predict the potential for achieving long term process capability.




The method of measurement must be reliable and the measuring instrument must have an accuracy of at least 10 times that of the tolerance to ensure that the data collected is in fact a representation of the process and not variation caused by measuring method.

Information on SPC and quality related courses may be obtained from local Technical Institutes or the New Zealand Organisation for Quality Assurance.

In house training of SPC techniques for all the staff will pay dividends and can be supplied by CIM-SYS Technology (NZ) Ltd.

**Abbreviations**

US = Upper specification limit.

LS = Lower specification limit.

UC = Upper control limit.

LC = Lower control limit.

M = Statistical Mean.