THE PRELIMINARY CONTROL CHART

E. LEWIS
Mossgas (Pty) Ltd South Africa

This paper gives a brief introduction to the use of the preliminary control chart, developed by the author to control processes prior to the implementation of statistical process control. There may be insufficient data available (perhaps in newly-commissioned plant), or low volume production, or operators and vendors unfamiliar with statistical techniques. In these and similar circumstances, the preliminary control chart's simplicity and versatility make it an invaluable tool.

Introduction

The preliminary control chart (PCC) has been developed for the sole purpose of applying preliminary controls to processes prior to the implementation of statistical process control (SPC); it is not a replacement for SPC.

It is a most useful control technique when applied to the commissioning of new plant, equipment and/or products where no historical data are available.

When applied to a low volume production industry, where SPC is a slow and difficult task to implement, the PCC bridges the gap that normally exists between the start of an SPC programme and obtaining enough data to calculate meaningful statistical process control limits.

The PCC allows the implementation of charts onto the workshop floor with an absolute minimum amount of preparation and training required. The chart is extremely easy to compile, plot and analyse and requires *no* statistical calculations until the launching of SPC charts. The preliminary control chart introduces the concept of process variation to the foremen and operators and helps to smooth the transition from inspection to statistical process control.

The simplicity of the preliminary control chart allows it to be instantly implemented by your vendors, preparing them for SPC, whilst simultaneously supplying a graphical illustration of their potential capabilities.

The preliminary control chart

The implementation of the preliminary control chart concept is achieved without the traditional capability study having been performed. The concept is a powerful combination of the pre-control[1] and run chart techniques which result in the plotting of individual values in sequence of manufacture, utilising the product or process specifications for control purposes, until process control limits can be calculated.

The product specifications are divided up into three colour zones, namely green, amber and red, and approximate to the same signals of a traffic robot: go, caution and stop. The proportions for the division are highlighted in Figure 1.

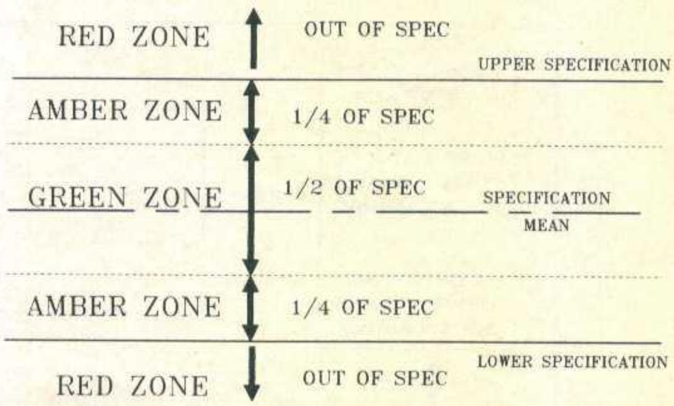

Figure 1. Preliminary control chart proportions

Prepare the chart by scaling the Y axis to accommodate the preliminary control chart proportions as in Figure 1 and draw in the specification mean, the upper and lower specification limits, and identify the colour zones on the chart. Refer to Figure 2.

The preliminary control concept

The colour signals

The GO signal

Before we can implement the chart, it is important first to achieve 'initial process set-up' by obtaining five consecutive points in the green zone (should be the first five items produced).

Any point thereafter falling in the green zone – that does not fail the pattern analysis as discussed in the next section – represents a 'go' signal.

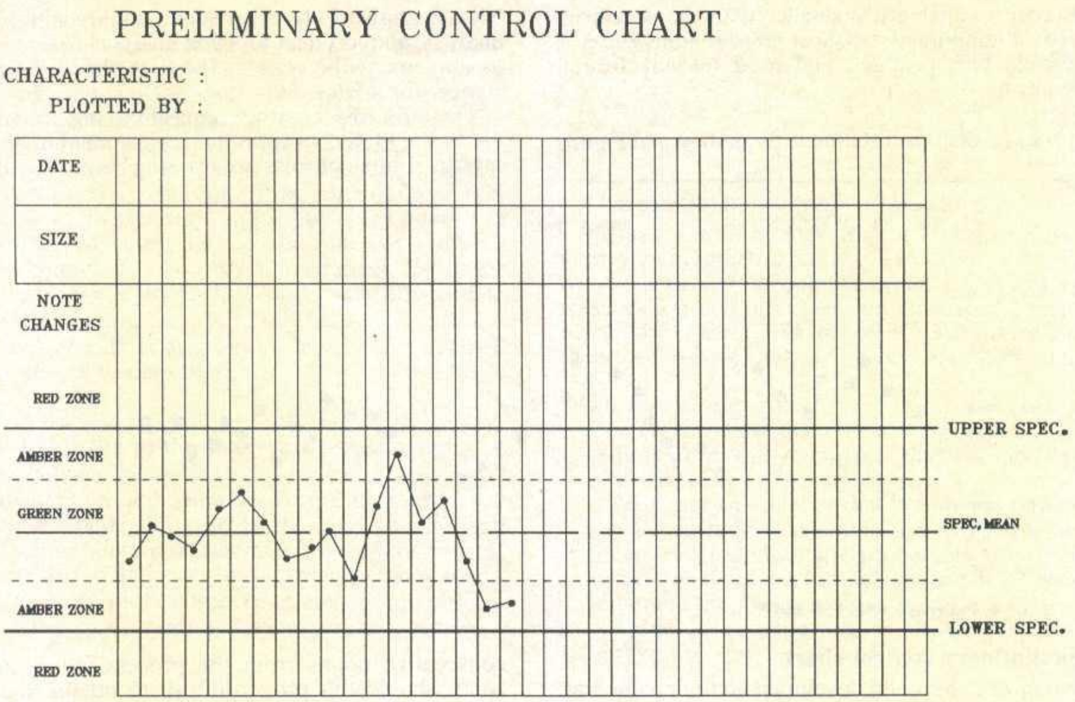

Figure 2. A preliminary control chart

The CAUTION signal
One point in any of the amber zones represents a caution signal – proceed with caution.

The ADJUST signal
Two successive points falling in the same amber zone (any side of the green zone as long as the points fall in the *same* amber zone) indicate that an adjustment is necessary to centre the process.

The STOP signal

a Two consecutive points falling in opposite amber zones signal that the process capability has probably increased and that the process should be stopped for investigation.

b Any one point falling in the red zone signals that the process is producing defectives and should be stopped immediately.

Figure 3 explains the signals graphically.

Pattern analysis
The primary characteristic of a natural process is that the plotted points fluctuate randomly and that they follow the laws of chance; in other words, they follow no particular pattern or recognisable system or order.

The characteristics of a natural process can be summarised as follows:

1 Most of the points are near the centre-line.
2 There become fewer points approaching the control limits.
3 Almost no points exceed the control limits.

When analysing the preliminary chart for unnatural patterns, the following three tests are applied:

Test 1
Eight or more consecutive points falling on any one side of the specification mean are an indication that the process has shifted and requires adjusting.

Test 2
Seven or more consecutive points steadily increasing or decreasing indicate a gradual process shift and that the process should be investigated and adjusted if necessary.

Test 3
15 consecutive points falling in the green zone indicate

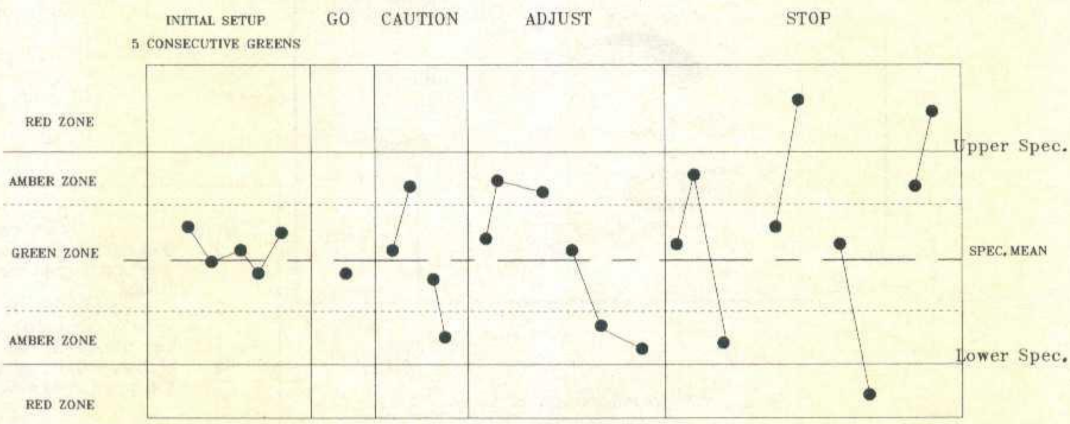

Figure 3. Colour signals

that the process capability is smaller than the specifications and that temporary statistical process limits (+/− 3 sigma) should be calculated and used for any future process control.

Graphically we can demonstrate the tests as shown in Figure 4 (below).

'classification of characteristics', 'failure mode and effects analysis' and 'product function analysis' before commencing to implement the charts. These methods, however, are a subject for a later discussion.

The most important prerequisite to obtain before making use of the PCC concept is the achievement of 'initial process set-up'. Initial process set-up is achieved by the first five

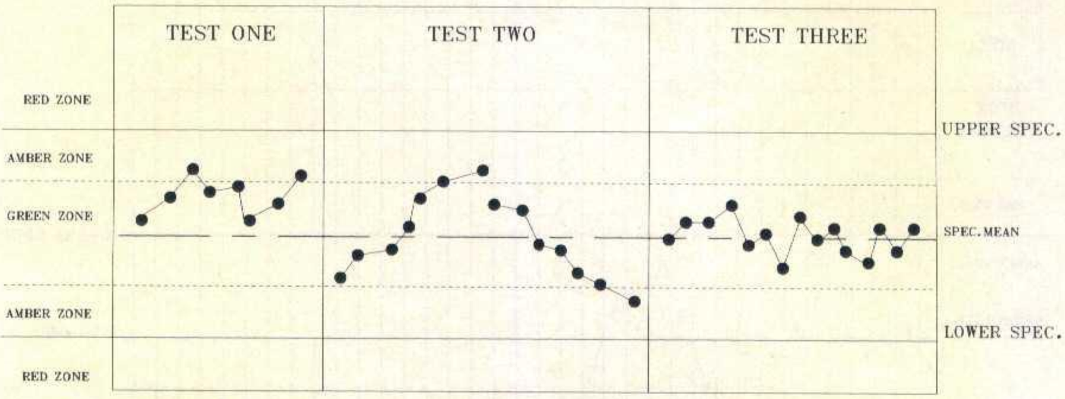

Figure 4. Patterns – tests 1, 2 and 3

Using the preliminary control chart

Having drawn up the chart and developed an understanding of the signals and patterns we now address the implementation and use, according to the procedure as laid out in Figure 5 (below).

It would be wise to identify the important product or process characteristics by making use of methods such as

consecutive points from the process falling in the green zone. Should this prove difficult to obtain, then this is an indication that the process is either not correctly centred and requires adjusting, or that the process is not capable of achieving the specification. Should this be the case it is imperative that either the process be changed and/or continuously upgraded, or the specifications reviewed and

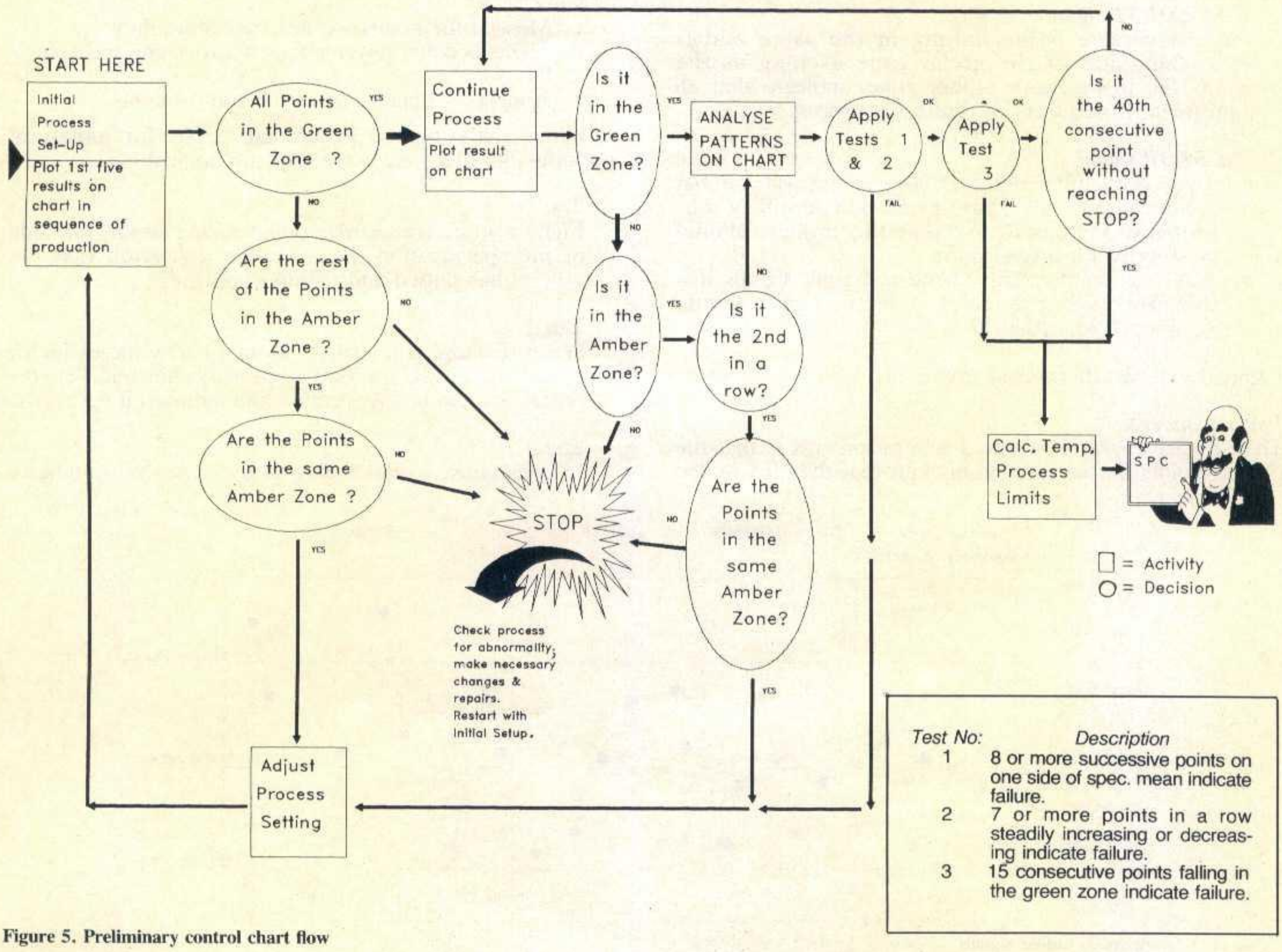

Figure 5. Preliminary control chart flow

Table 2

Process cap. A	Prob. of set-up B	Prob. of a 'green' C	Prob. of a 'go' D	Prob. of a second 'go' E
	B *	C * C =	D = D	E
200%	0.049	0.5467	0.026	0.0146
125%	0.270	0.7698	0.2078	0.1500
100%	0.488	0.8664	0.4228	0.3747
75%	0.792	0.9545	0.7560	0.7216
50%	0.987	0.9973	0.9843	0.9817

It is obvious that the more data collected, the more accurate your assumptions will be, and, therefore, the higher the probability of predicting the process capability.

Pattern analysis

Tests 1 and 2

These have already been discussed in the previous section entitled 'Pattern analysis' and further detailed information can be obtained in Western Electric's *Statistical quality control handbook* (fourth edition, 1975).

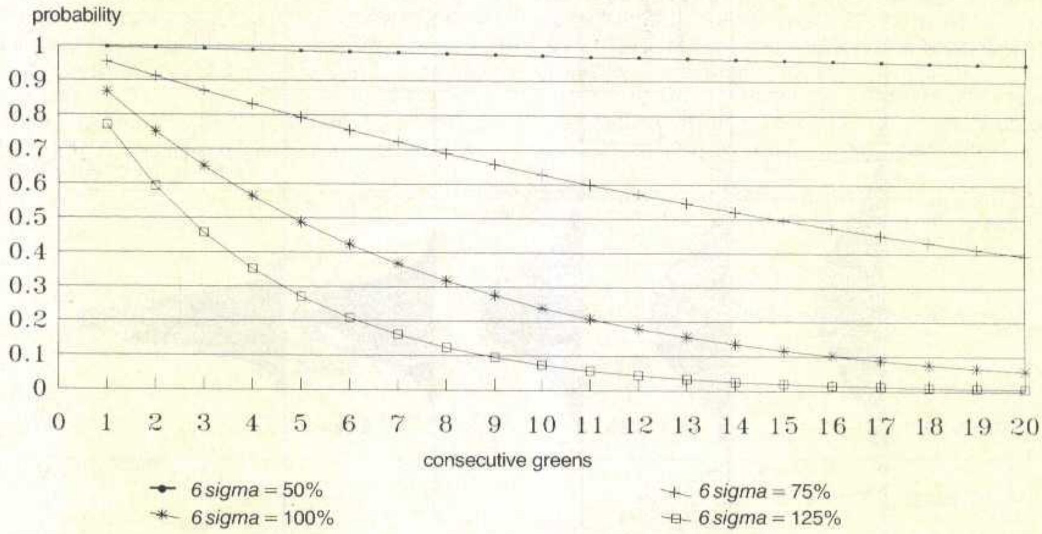

Figure 8. Probability of consecutive greens

Test 3

This test can be elaborated upon as 15 or more consecutive points falling in the green zone indicate that the process capability is potentially smaller than the specifications, which could render the preliminary control chart techniques insensitive and could allow assignable causes to remain undetected.

The graph in Figure 8 allows us to obtain a pictorial view of the related probabilities of getting from 1 to 20 consecutive greens at various process capability levels.

We can see from the graph in Figure 8 that, should we achieve 15 consecutive points in the green, it is highly probable (0.96) that the process variation is 50 per cent of the product specification. This would then require a more sensitive control limit and would necessitate the calculating of temporary statistical control limits (+/− 3 sigma) until such time as an accurate process capability can be established.

Conclusion

Although the preliminary control chart is strongly based on statistical theory, it is very simple to use and is extremely versatile. Its simplicity combined with its powerful impact makes this chart a dynamic new tool: for the commissioning of new plant and equipment, for the launching of an SPC programme or for implementing a supplier improvement programme.

To strengthen the analysis of the chart further, it is possible to include additional run chart analysis methods.[2] However, this does tend to complicate the preliminary control chart technique and has therefore been excluded from this introductory paper.

References

1 Shainin, D., 'Better than good old *X* and *R* charts asked by vendees', ASQC 38th Annual Quality Congress, May 14-16, 1984.

2 Ott, E. R., *Process quality control, troubleshooting and interpretation of data,* 1975 (McGraw-Hill).

Elwyn Lewis's biographical details can be found on page 105.