Control Charts

An Important Tool in Quality Control to Save Money

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When the quality control team at a ready mixed company is not running around putting out fires or generally keeping busy with ensuring that they meet the company's production targets, there are real opportunities for being proactive with controlling their processes and contributing to the company's bottom line.

One of the important tools in quality control is a control chart. It is important to note that control charts do not control the process, but are a means of verifying that the process is in control and making changes if it is not. Variability of materials and concrete is unavoidable. The person in charge of QC needs to know what aspect of variability he can control with reasonable resources and what impact that change will have on the company's bottom line. The net result should have a positive impact to the latter.

Variability of materials or process may be attributed to **chance causes** or **assignable causes**.

Chance causes are attributed to the normal variability of the process. Chance causes are inevitable and beyond the control of the persons involved. There is no point investing money to control chance causes.

For example, one low strength result when nothing else has changed may be attributed to a chance cause.

Assignable causes are factors that can be eliminated, thereby reducing the overall variability. Assignable causes may be identified by studying one or more control charts.

For example, a series of low strength tests may be associated with a change in the sand grading during the same period. This is an assignable cause, which can be corrected by either using a different sand stockpile or adjusting the mixture proportions.

Control charts can be useful to distinguish assignable causes from chance causes. It is also important that a chance cause not be misinterpreted as an assignable cause, in which case the reason for the variability will be difficult to establish.

A simple control chart as shown in Figure 1 can be viewed as a statistical normal distribution (bell curve) turned sideways with the vertical axis being the test results and the horizontal axis being the successive test numbers.

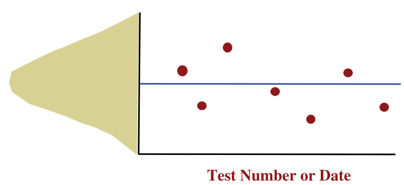

Figure 1. A Simple Control Chart

Control Charts can be used for the following:

- Early detection of potential problems
- Identifying assignable causes to decrease variability
- Establishing the process capability
- Reducing price adjustment costs
- Decreasing inspection frequency
- Providing a basis for changing the specification limits
- Providing a basis for product acceptance
- Permanent record of quality
- Instilling quality awareness

Run Charts

The simplest type of quality control chart is the run chart. The individual test results are plotted and checked against some control limits. The control limits might be specification tolerances plotted about a target value. It is, however, better to plot control limits tighter than the specification tolerances so that action can be taken before individual test results fall outside the specification tolerances. The control limits might be arbitrary or statistically based. For example, if the specification calls for air content at 6 ± 1.5%, arbitrary control limits may be set at ± 1%. Statistically-based control limits will be based on the standard deviation (S) calculated from recent data. For example, if the control limits are set at ±2 S, then a change in the process might be identified when more than approximately 1 in 20 tests (5%) fall outside the control limits.

The control limits on a control chart are not to be used to determine if the product is acceptable but to identify a change in the process and to initiate corrective action.

Running Average Charts

Running average of the most recent consecutive test results may be plotted on a control chart. Typically, a running average of 3 or 5 consecutive data points are plotted. The trend of a running average chart is more efficient in detecting changes but may cloud the reason for an individual bad result. It might be worthwhile plotting individual test results along with the running average to identify individual bad results as illustrated in Figure 2.

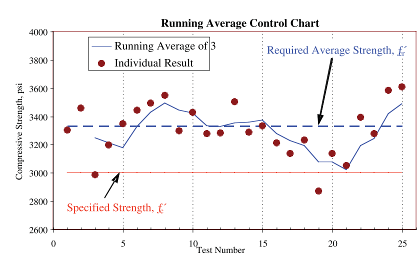

Figure 2. Control Chart showing Individual Results and Running Average of 3

While not plotted in Figure 2, control limits can be set for this chart. Control limits for running average plot should be tighter than that for individual results. The standard deviation, calculated from individual results, should be modified by dividing by $\sqrt{n}$, for charts of running averages, where n is the number of individual results being averaged.

While the positive control limit is not critical for specification conformance on strength, it is useful for determining, for example, that there might be a problem with batching excessive cement.

Statistical Control Charts

Statistical Control Charts (or Shewhart Charts) are better for distinguishing chance causes from assignable causes. The control chart for averages (X-bar Chart) and the control chart for ranges (R-Chart) are used together to identify process changes. The X-bar Chart is useful to detect when the process target or average changes and the R-Chart is used to determine when the process variability changes.

Statistical control charts are always based on the average and range of a subgroup of data where $n>1$, as opposed to a run chart where individual values ($n = 1$) are plotted. Upper and lower control limits (UCL and LCL) of ($\pm 3 S_{\bar{x}}$) are typically used to identify changes in the process average. $S_{\bar{x}}$ is the standard deviation of the averages of each subgroup of data. More than one test result ($n > 1$) in each subgroup is required in order to calculate the ranges for the R-Chart. The disadvantage is that a large amount of historical data is needed before the control limits for the Shewhart Chart can be established.

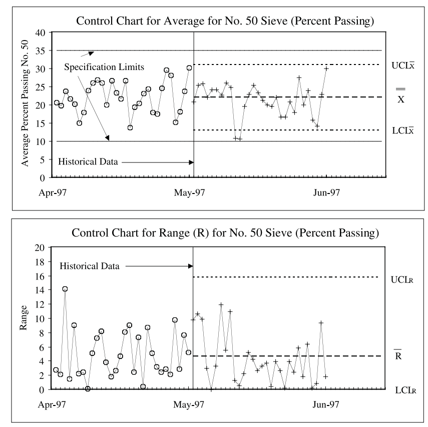

Figure 3. Example of Statistical Control Chart

Figure 3 illustrates the use of a statistical control chart that monitors the minus No. 50 material on sand used at a concrete plant. Two tests are conducted on each shipment. Once sufficient data is collected, the necessary statistics can be developed to establish control limits for the measured quantity.

The point at which action should be taken should also be defined. While interpreting X-bar Charts and R-Charts, it may be decided that ***a red flag*** will be raised if one data point (the average of a subset) falls outside the control limits, or if 5 to 8 consecutive subset averages fall on one side of the overall average. In the example in Figure 3, the action might be that the supplier is notified or the loader operator process of working the stockpile is evaluated. Periodically, it may be necessary to update the control limits from more recent data. This could be easily accomplished with spreadsheets or statistical software.

In conclusion, there are tools out there to better monitor the process of quality control. The question is do we have the time and resources to make the process work for controllable variations. ■

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