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Rational Subgrouping

You've learned that X-bar and R and S charts are constructed using rational subgroups.

A rational subgroup is a non-random sample that has the following properties: the observations are from a single process; the observations are from a stable process; the observations are time ordered, and the observations are independent from one another, that is, the value of one observation is not influenced by the value of another observation.

Usually, in statistics, we like to use random samples. Why don't we use random sampling with Shewhart control charts?

Our goal is to make the control chart more sensitive to detecting special causes. So we want to construct control limits based on only common cause variation.

If we select a random sample of parts, it is possible that the random sample includes both common and special cause variation. This results in wider control limits and a less sensitive control chart. With rational subgrouping, parts are selected in a way that minimizes the possibility that the subgroup contains a special cause.

The short-term, or within, estimate of the standard deviation from rational subgroups is likely to represent only common cause variation.

This results in tighter control limits and a control chart that is better at detecting special causes.

In an earlier video, you saw an example where consecutive parts were selected to form the rational subgroup. This type of rational subgrouping is often used for process monitoring and control with observational data, where data are collected as they become available.

But you might want to use control charts to explore time-ordered retrospective, or historical, data. Retrospective data can be useful in describing past process performance and are often used in problem identification and prioritization.

For some processes, instead of collecting data on a subgroup of consecutive parts, data on all parts or items are recorded. X-bar and R or S charts can still be used for these situations, with rational subgroups constructed on criteria such as shift, day, or week. For example, a rational subgroup can consist of all parts produced within a shift.

Rational subgrouping can also be used as an alternative to plotting individual values on an I and MR chart when the underlying distribution is not normal.

For example, take the variable CI, from the White Polymer Crisis Team data. In an exercise, you saw that the distribution of CI is left skewed. As a result, the control limits on the Individuals chart don't make sense, and it is difficult to understand the behavior of the process over time. In this situation, instead of plotting individual values, we'll group the observations into subgroups.

The data are time-ordered by shift, and there are four shifts per day. If the four shifts represent the same stable process, we can combine the data for the four shifts into a subgroup.

Recall that the central limit theorem tells us that sample means are approximately normally distributed. So these means will be more normally distributed than the raw data, even though the underlying data are skewed.

Let's see how the picture changes when we create an X-bar and R chart with subgroups of size 4.

The control limits now make much more sense. The process looks fairly stable, with one special cause at day 31.

We also see something unusual in the graph: the control limits for the last data point are wider than for the other data points. This is because control limits are based on the subgroup size. For the last subgroup, we have data for only two of the shifts. If you don't have the same number of observations for each of your subgroups, the widths of the control limits will vary with the subgroup size.

Take this example. Subgroup sizes are not constant. The smallest subgroup has 2 observations and the largest has 12.

Remember that the width of the control limits is based on two factors: the within-subgroup estimate of the standard deviation and the subgroup size.

The control limits are narrowest for the largest subgroup and are widest for the smallest subgroup.

Also note that, because the control limits are not constant, control limits are not reported in the Limit Summaries table. However, we can still conduct tests for special causes.

In this video, you've learned about rational subgrouping for variables control charts and learned how to use subgrouping if rational subgrouping is not feasible. In the next video, you learn about how to extend variables control charts to study both within- and between-subgroup variation using 3-way control charts.

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