p and np Control Charts

As a customer, you want to receive a product that meets your needs. However, you also want "quality" in terms of support of that product. These things include an accurate invoice, on-time delivery, knowledgeable support personnel, and having the phone answered when you call the vendor. These types of situations are often governed by attributes data. p and np control charts are two types of attribute control charts that can be used to monitor and improve these types of processes. Both these charts track the variation in yes/no types of data.

Purpose

The purpose of this module is to introduce p and np control charts - what they are, when they can be used, how to construct them and how to interpret them. The p and np control charts tell you if the process is in statistical control or if there are special causes present.

Attributes Data and Control Charts

We sometimes collect data that involve counts; for example, the number of injuries in a plant, the number of mistakes on an invoice, whether a delivery was on-time or not, or whether a product was in specification or not. These types of data are called attributes data. There are two types of attributes data: ***yes/no*** and ***counting***. With yes/no data, you are examining distinct items (such as invoices, deliveries, or phone calls). With counting type data, you are usually examining an area where a defect has an opportunity to occur. Both types of data are explained below.

Yes/No Data

For each item, there are only two possible outcomes: either it passes or it fails some preset specification. Each item inspected is either defective (i.e., it does not meet the specifications) or is not defective (i.e., it meets specifications). Examples of yes/no data are phone answered/not answered, product in spec/not in spec, shipment on time/not on time and invoice correct/incorrect.

If you have yes/no data, you will use either a p or np control chart to examine the variation in the fraction of items not meeting (or meeting) a preset specification in a group of items. You use the p control chart if the subgroup size (the number of items examined in a given time period) changes over time. You use the np control chart if the subgroup size stays the same

Counting Data

With counting data, you count the number of defects. A defect occurs when something does not meet a preset specification. It does not mean that the item itself is defective. For example, a television set can have a scratched cabinet (a defect) but still work properly. With counting data, you end up with whole numbers such as 0, 1, 2, 3; you can't have half of a count.

If you have counting data, you use a c or u control chart. The c control chart is used if the area stayed constant from sample to sample; the u control chart is used if the area did not stay constant.

If you don't have data based on counts, you have variables data. Variables data are taken from a continuum and are often referred to as continuous. Variables data can, theoretically, be measured to any precision you like. Examples of variables data include time, length, width, density, dollars, and height.

Understanding p and np Control Charts

Both the p and np control charts examine variation in yes/no type attributes data. There are only two possible outcomes: either the item is defective or it is not defective. The red bead experiment is an example of yes/no type data. In this experiment, there is a bowl containing white and red beads. A sampling paddle is used to select 50 beads from the bowl. In this experiment, 50 is the subgroup size. The subgroup size is the size of the sample – the number of beads sampled from the bowl. A bead is defective if it is a red bead. It is not defective if it is a white bead.

In this experiment, the subgroup size remained the same over time – 50 beads where sampled each time from the bowl. The np control chart can be used if the subgroup size is the same each time. The np control chart is monitoring the variation in the number of defective items in a subgroup when the subgroup size is constant over time. You plot the number of red beads (defective items) in each subgroup over time on the np control chart.

If the subgroup size varies, the p control chart must be used. For example, suppose one time we sampled 48 beads, the next time 52, the next 51, etc. Since the subgroup size varies, the p control chart must be used. You can also use the p control chart if the subgroup size is the same. The p control chart monitors the variation in the fraction of defective items in a subgroup whose size may or may not vary. You plot the fraction (or percentage) of red beads in each subgroup over time on the p control chart.

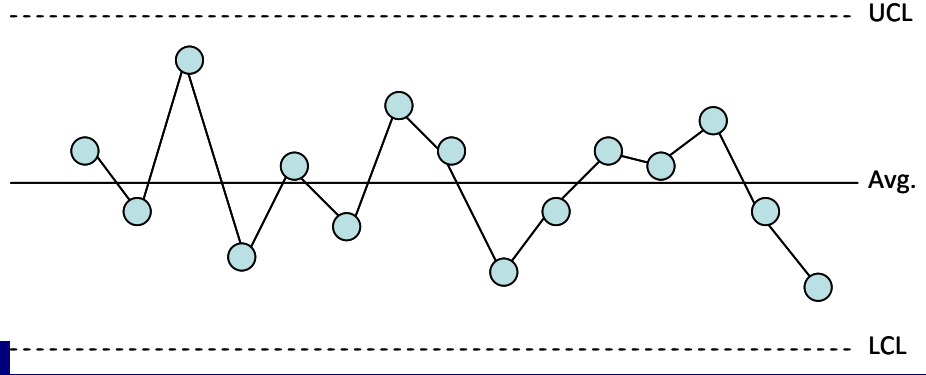
The control limits for the p and np control charts are based on the binomial distribution. The binomial distribution is a *theoretical* distribution of the number of successes or failures in a finite set of independent trials with a constant probability of success or failure. The key word in this definition is "theoretical." You are assuming that the underlying behavior of the process you are sampling is governed by the binomial distribution.

Both the p and np control charts involve counts. You are counting the number of defective items. There are four conditions that must be met for the binomial distribution to apply:

1. You are counting n distinct items.
2. Each item is independent.
3. Each item represents one of two outcomes (defective or not defective)
4. The probability of the outcome (defective or not defective) is the same for each item.

If these four conditions are met, the binomial distribution can be used to estimate the distribution of the counts and the p or np control chart can be used. The control limits equations are based on the assumption that you have a binomial distribution. Be careful here because condition 4 does not always hold. For example, some people use the p control chart to monitor on-time delivery on a monthly basis. You can't use the p control chart unless the probability of each shipment during the month being on time is the same for all the shipments. Big customers often get priority on their orders, so the probability of their orders being on time is different from that of other customers and you can't use the p control chart. If the conditions are not met, consider using an individuals control chart.

Yes/No Data



p and np Control Charts

"Making two people responsible guarantees mistakes."

- Dr. W. Edwards Deming

p and np Control Charts

- Customers
  - Quality product or service
  - Quality in support
- Attributes Data
  - Accurate invoice
  - On-time delivery
  - Knowledgeable support personnel
  - Phone answered
- Attribute Control Charts
  - p and np control charts
  - Yes/No data

Yes/No

Attributes Data

p or np

Control Chart