

Shewhart Control Charts

P Chart: Formulas



P Chart Formula (Variable)

Data

Defects (np)	Sample Size (n)	P
58	80	0.725
60	94	0.638
68	85	0.800
62	95	0.653
60	86	0.698
72	103	0.679
58	82	0.707
64	109	0.587
66	103	0.641
56	89	0.629
64	90	0.711
68	100	0.680
62	110	0.564
70	99	0.707
64	103	0.621
58	94	0.617
68	78	0.872
64	110	0.582
66	100	0.660
60	80	0.750
Total ($\sum n$)	1893	
$\sum np$	1268	

Calculation

$$\begin{aligned} \sum np &= 1268 & CL &= \bar{p} = \frac{\sum np}{n} \\ \sum n &= 1893 \end{aligned}$$

$$\bar{p} = \frac{\sum np}{n} = \frac{1268}{1893} = \mathbf{0.6698362388}$$

* Since the sample size (n) changes at each subgroup (per row), you will have to calculate the UCL and LCL for each data point. This example will just use the first row where the defect is 58 and sample size (n) is 80.

$$\begin{aligned} UCL &= \bar{p} + (3 * \sqrt{\frac{\bar{p} * (1 - \bar{p})}{n}}) \\ &= 0.669... + (3 * \sqrt{\frac{0.669... * (1 - 0.669...)}{80}}) \\ &= 0.669... + (3 * 0.05257799587) \\ &= 0.669... + (0.1577339876) \\ &= \mathbf{0.8275702264} \text{ (0.828 to 3.d.p) } \mathbf{82.8\%} \end{aligned}$$

$$\begin{aligned} LCL &= \bar{p} - (3 * \sqrt{\frac{\bar{p} * (1 - \bar{p})}{n}}) \\ &= 0.669... - (3 * \sqrt{\frac{0.669... * (1 - 0.669...)}{80}}) \\ &= 0.669... - (3 * 0.05257799587) \\ &= 0.669... - (0.1577339876) \\ &= \mathbf{0.5121022512} \text{ (0.512 to 3.d.p) } \mathbf{51.2\%} \end{aligned}$$

$$CL = \mathbf{0.67} \text{ (to 2.d.p) } \mathbf{67\%}$$

Plot the Percentage, CL, UCL and LCL as seen on the chart

Legend + Chart

np = number of defectives per sub group (per row)

n = sample size per sub group (per row)

P = defects divided by sample size (percentage: np/n)

$\sum np$ = sum of defects

$\sum n$ = sum of sample size

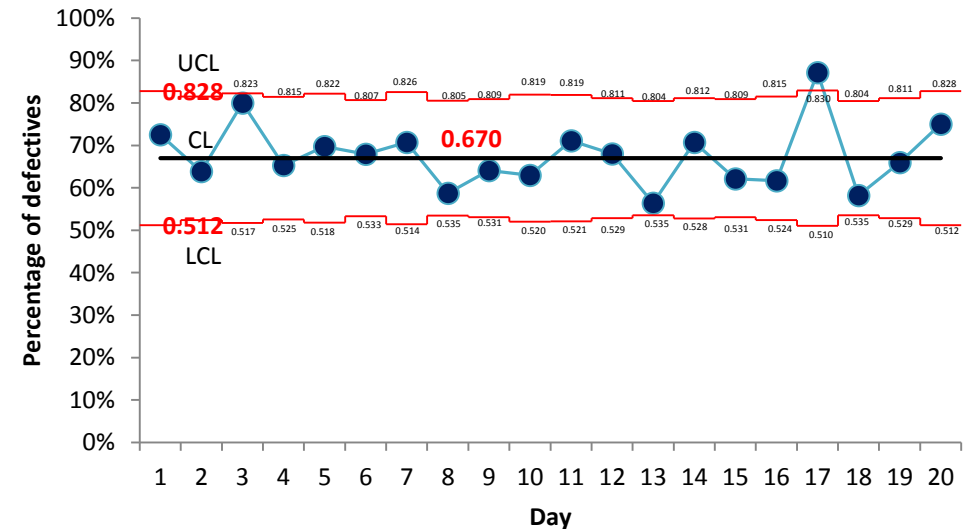
k = number of sub groups

UCL = upper control limit ($\bar{p} + (3 * \sqrt{\frac{\bar{p} * (1 - \bar{p})}{n}}$)

CL = center line (Mean)

LCL = lower control limit ($\bar{p} - (3 * \sqrt{\frac{\bar{p} * (1 - \bar{p})}{n}}$)

P Chart



P Chart Formula (Constant)

Data

Defects (np)	Sample Size (n)	P
58	100	0.58
60	100	0.6
68	100	0.68
62	100	0.62
60	100	0.6
72	100	0.72
58	100	0.58
64	100	0.64
66	100	0.66
56	100	0.56
64	100	0.64
68	100	0.68
62	100	0.62
70	100	0.7
64	100	0.64
58	100	0.58
68	100	0.68
64	100	0.64
66	100	0.66
60	100	0.6
Total ($\sum n$)	1893	
$\sum np$	1268	

Calculation

$$\sum np = 1268 \quad k = 20 \quad CL = \bar{p} = \frac{\sum np}{k}$$

$$\bar{p} = \frac{\sum np}{k} = \frac{1268}{20} = 63.4, \text{ convert to fraction: } \frac{63.4}{100} = 0.634$$

* Since the sample size (n) is constant at each subgroup (per row) you won't have to calculate the UCL and LCL for all data points.

$$\begin{aligned} UCL &= \bar{p} + \left(3 * \sqrt{\frac{\bar{p} * (1 - \bar{p})}{k}}\right) \\ &= 0.634 + \left(3 * \sqrt{\frac{0.634 * (1 - 0.634)}{100}}\right) \\ &= 0.634 + (3 * 0.0481709456) \\ &= 0.634 + (0.1445128368) \\ &= 0.7785128368 \text{ (0.779 to 3.d.p) } 77.9\% \end{aligned}$$

$$\begin{aligned} LCL &= \bar{p} - \left(3 * \sqrt{\frac{\bar{p} * (1 - \bar{p})}{n}}\right) \\ &= 0.634 - \left(3 * \sqrt{\frac{0.634 * (1 - 0.634)}{100}}\right) \\ &= 0.634 - (3 * 0.0481709456) \\ &= 0.634 - (0.1445128368) \\ &= 0.4894871632 \text{ (0.489 to 3.d.p) } 48.9\% \end{aligned}$$

$$CL = 0.634, (63.4\%)$$

Plot the Percentage, CL, UCL and LCL as seen on the chart

Legend + Chart

np = number of defectives per sub group (per row)

k = number of sub groups (per row)

P = defects divided by sample size (percentage: np/k)

$\sum np$ = sum of defects

k = number of sub groups

UCL = upper control limit $(\bar{p} + (3 * \sqrt{\frac{\bar{p} * (1 - \bar{p})}{k}}))$

CL = center line (Mean)

LCL = lower control limit $(\bar{p} - (3 * \sqrt{\frac{\bar{p} * (1 - \bar{p})}{k}}))$

P Chart

